Rhythmic Awareness in Reading Development: The Influence of Prosodic Sensitivity on Word Identification

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The present study examines the role of prosodic sensitivity in word-level reading development. Prosody, which refers to linguistic rhythm, has received very little attention from reading researchers. But awareness of, and attentiveness toward, the rhythmic aspects of language have a potentially facilitative effect on phonological awareness (PA), lexical retrieval, and word identification. This study considers the nature of prosodic sensitivity in the broad context of language, and then narrows to an exploration of the role of prosody in the development of word-level reading. A sample of 23 participants completed three testing sessions designed to measure prosodic sensitivity, PA, speed of lexical retrieval, and word identification skills. Four separate hierarchical regression analyses are used to test the hypothesis that prosodic sensitivity contributes to word-level reading abilities by facilitating both PA and rapid lexical retrieval. Results of the study confirm the hypothesis, suggesting that both PA and rapid lexical retrieval mediate the correlation between prosodic sensitivity and word identification skills. These findings may have

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considerable pedagogical implications. It appears that rhythmic awareness plays a considerable role in word-level reading, and training in rhythmic awareness may be an avenue that educators want to explore.

The attainment of successful reading skills is one of the most important and predictive components of educational development. A substantial portion of research in educational psychology has focused on the factors that influence successful reading acquisition, with great emphasis on the segmental aspects of phonology. Segmental accounts of reading acquisition describe the basic elements underlying the skill and why they are important. Previous research has made significant contributions to our knowledge in the field, establishing many of the processes that facilitate reading acquisition, but it has not identified all factors responsible for individual differences in reading abilities.

Most models of reading acquisition emphasize the role of phonological processes in reading, such as phonological awareness and lexical retrieval (Dally, 2006). The relationship between these types of phonological processes and successful reading acquisition is well documented in developmental literature, but the factors that contribute to phonological awareness and lexical retrieval have often been overlooked (Wood, 2006). The current research examines the contribution of prosodic sensitivity to these two forms of phonological processing as they relate to reading.

Phonological Awareness

Phonology, the study of the sound system of language, has been a major focus of research on reading in the past few decades. Phonology has two subparts: segmental phonology, which focuses on individual and successive sounds, and prosody (suprasegmental phonology), which focuses on the features superimposed on the individual segments (Schreiber, 1991). Phonological awareness (PA) refers to the ability to recognize and manipulate the rhymes and phonemes in words, both aspects of segmental phonology. Most of the reading research involving phonology has focused on PA. Despite the important contributions this research has made, segmental accounts of reading development may not answer all our questions about successful reading acquisition, individual deficits in reading abilities, and the substrata underlying PA. To provide answers to the questions that remain, another level of analysis is needed (Wade-Woolley & Wood, 2006). The current study focuses on suprasegmental phonology, or prosodic sensitivity.

Prosodic Sensitivity

A recent line of scientific inquiry in reading research has demonstrated the role of prosodic sensitivity in the development of reading proficiency (Whalley & Hansen, 2006). Prosodic sensitivity refers to the awareness of linguistic rhythm. It has three main elements: (1) lexical stress, which determines the syllable or phoneme in a word that gets emphasized, (2) intonation patterns, which refer to the fall and rise of pitch that form the contextual basis of a phrase, and (3) pause patterns that occur between words, at the end of a line of text, or anywhere that would be indicated by a punctuation mark in written text. Prosody encompasses the tempo, rhythm, and stress of language (Whalley & Hansen, 2006).

Prosodic sensitivity in oral language development. The influence of prosody in the development of oral language is well established, and acquisition of oral language is a necessary precursor to reading development. Prosodic cues are among the first utilized by newborn children to bootstrap their language acquisition (Wanner & Gleitman, 1982; Whalley & Hansen, 2006). Sensitivity to the prosodic properties of speech explains infants' preferences for infant-directed speech with exaggerated prosodic features (Werker, Pegg, & McLeod, 1994). Prosodic cues facilitate language acquisition by helping segment speech into words, phrases, or syllables, informing syntactic structure, and emphasizing content words and salient information (Whalley & Hansen, 2006).

Prosodic sensitivity builds the foundations for language acquisition, paving the way for literacy development. Oral and written languages chiefly require the same comprehension processes, and, consequently, they are intimately connected (Hoover & Gough, 1990; Whalley & Hansen, 2006). However, the prosodic cues in written language contexts are not as informative as in spoken language contexts. The prosodic information guiding comprehension is more difficult to assess in written language, especially for lexical stress because it is not indicated by markings or punctuation. Whalley and Hansen (2006) suggest that written language comprehension places greater demands on prosodic sensitivity than those required for spoken language. Prosodic sensitivity in the development of oral language is not enough to explain its role in reading development. Written language comprehension requires more inference and a greater awareness of linguistic rhythm.

Prosodic sensitivity in written language comprehension. Given the influence of prosodic sensitivity in children's oral language development, it seems reasonable to assume that it also influences reading comprehension (Dowhower, 1991; Schreiber, 1991). Fodor (1998) proposed an implicit prosody hypothesis, suggesting that readers establish the prosodic elements of text as they read it silently. A prosodic contour is naturally imposed on text as readers experience inner speech (Ashby & Clifton, 2005). Embedding of the prosodic elements of speech (such as appropriate tone, emphasis, and phrasal parsing) when reading text indicates that the text is interpreted and comprehended correctly (Schreiber, 1980). It is not enough for readers to quickly read lines of text; they have to read it with appropriate expression and phrasing. This is required for reading fluency (Kuhn & Stahl, 2003).

Dowhower (1991) identified six features of prosodic reading: pausal intrusions, length of phrases, appropriateness of phrases, final phrase lengthening, terminal intonation contours, and stress. Readers who use these markers have made the connection between written and oral language. They show the capability to transfer syntactic knowledge of speech to text by effectively applying these aspects when reading (Kuhn & Stahl, 2003). Children who have not yet achieved reading fluency tend to sight–word read or group words into phrases unnatural to spoken language (Dowhower, 1991).

It has been suggested that children rely more heavily on, and are more sensitive to, prosodic indicators of structure than adults (Schreiber, 1980; Wood, 2006). This may explain why some children have more difficulties in reading comprehension than in speech comprehension; they are more dependent on the prosodic cues of spoken language that are absent in written language contexts (Schreiber, 1980). The structural precedence hypothesis holds that, in text comprehension, the processing of structure precedes the analysis of meaning and paves the way for it (Koriat, Greenberg, & Kreiner, 2002). This hypothesis suggests that in cases of written language where there are few prosodic markers, if the structure of the text cannot be analyzed, then comprehension of meaning will not occur. Attention to the structural elements of language is just as important, if not more so, in comprehending written language as in oral language. The process of attending to the structural elements of language does not place great demands on comprehension of oral language, but it is decidedly more difficult in reading. Attention to the prosodic patterns in text processing helps the reader derive a structural frame for the text, allowing for their incorporation into a coherent semantic representation (Koriat, Greenberg, & Kreiner, 2002). The capability of quickly identifying each of the individual words in a line of text is not enough for fluency or comprehension; these reading goals are only achieved by sensitivity and attention to the various prosodic elements of the text.

Pause patterns in fluent sentence reading. Pause patterns are an essential prosodic feature for establishing the syntactic structure of language. The study by Koriat, Greenberg, and Kreiner (2002) showed that readers were able to assign natural prosody to unfamiliar text immediately upon its reading. The prosodic patterns applied were tuned to the syntactic structure of the sentence and were unaffected by the semantic content of the sentence; natural prosody was still applied when the sentences lacked semantic coherence (Koriat et al., 2002). Participants in the study were given two types of sentences that were syntactically similar, one with semantic coherence and another that was nonsensical. The pause patterns applied when reading each sentence were the same, as long as the structure was the same. These findings are consistent with the idea that syntactic structure is extracted independently of, and conceivably before, semantic processing (Koriat et al., 2002).

Previous research has demonstrated that words at the end of phrases are accompanied by longer pause durations than words in any other phrasal position (Cooper & Paccia-Cooper, 1980; Klatt, 1975; Nakatani, O'Connor, & Aston, 1981). This phenomenon is known as "phrase-final lengthening" (Ferreira, 1993). Word lengthening and the pause patterns applied are reflective of the syntax of a sentence. Thus, research on word duration and pauses might disclose syntactic representations formed during speech production. Sensitivity to the pause boundaries of language is a natural element of language comprehension and development. Hirsh-Pasek et al. (1987) found that infants preferred listening to speech with pauses at clause boundaries rather than pauses in other locations of utterances. Infants found unnatural speech unappealing, perhaps because they are attuned to the existence of clauses and the structure of language.

Research on sensitivity to punctuation and pause patterns has been mostly limited to the production of spoken language. This is because experimental online methods that can examine sensitivity to pauses during silent reading have been unavailable until recently. Steinhauer (2002) reviewed six event-related brain potential (ERP) studies demonstrating that the processing of both prosodic boundaries in natural speech and commas during silent reading can determine syntax parsing immediately. Both prosodic boundaries and commas elicited a similar brain response, referred to as the Closure Positive Shift, indicative of a common mechanism (Steinhauer, 2002). Attending to punctuation marks, which serve as indicators of phrasal rhythm, facilitates the assembly of propositions into meaningful and comprehensible chunks for transfer into long-term memory (Wade-Woolley & Wood, 2006).

Lexical stress and word identification. Another reliable indicator of prosody relevant to reading is lexical stress. It is less easily perceived than pause patterns, especially in the case of written text, because text does not explicitly encode lexical stress. However, there is less variation in lexical stress than in sentence prosody, because each word has specific stress information that underlies its identity (Ashby & Clifton, 2005). Whereas sensitivity to pause patterns is vital for the parsing of ambiguous sentences, sensitivity to lexical stress explains how the difference between compound nouns (like 'blackbird') and noun phrases ('black bird') are distinguished (Blumsteing & Goodglass, 1972). Stress can be lexically contrastive; the syllable that gets emphasized in homophonic words (e.g., DEsert vs. desSERT) helps discriminate between the two (Wade-Woolley & Wood, 2006). In spoken language contexts, stress assignment supports parsing decisions by identifying word boundaries. Attention to stress assignment is the largest determinant of word-level prosodic sensitivity. The focus of the current research is lexical stress and its relation to reading at the word level.

Wood (2006) examined how children respond to manipulations of lexical stress. Poor readers had special difficulties when the stress patterns of a word were reversed. Children who performed better on reading comprehension measures were better at coping with the changes to lexical stress. Also, Arciuli and Cupples (2006) found that typically-stressed words exhibited advantages in processing over atypically stressed words in naming and lexical decision tasks. The stress typicality effects were just as strong in the lexical decision tasks, which do not require phonological output, as in the naming tasks, which do require phonological output. This suggested that the effects of stress typicality occurred before phonological processing (Arciuli & Cupples, 2006).

However, other research has suggested that sensitivity to stress patterns has a potentially facilitative effect on phonological decoding (Wood & Terrell, 1998). Using eye-tracking technology, Ashby and Clifton (2005) explored how the prosodic feature of lexical stress affects phonological decoding in reading. They found that gaze durations during silent reading were largely unaffected by word frequency. Instead, mean gaze durations were affected only by the number of stressed syllables in a word. The readers obviously processed lexical stress during silent reading. Results were explained in terms of phonological decoding. The eyes remained fixated on a word until all its phonological units were assembled, and words with more stressed syllables required more assembly.

Ashby and Clifton (2005) interpreted the results of their study as indicating a post-lexical effect of stress. Gaze durations are considered to indicate how long it takes for complete lexical access. First fixation times for target words did not vary with the number of stressed syllables, but mean gaze durations did. The interpretation offered by Ashby and Clifton (2005) is at odds with the analysis made by Arciuli and Cupples (2006), who claimed that stress sensitivity is pre-lexical and occurs prior to phonological assembly. It is important to note that lexical stress affected only error responses in the study by Arciuli and Cupples (2006); it did not affect response times. The time needed for lexical access was unaffected by stress typicality, but atypically-stressed words resulted in more naming and lexical decision errors. The Ashby and Clifton (2005) study looked only at the amount of time needed for lexical access. More research is needed to show exactly how prosodic sensitivity and phonological awareness interact to promote lexical access.

Prosodic sensitivity and the course(s) to word identification. Of particular interest to the current study is the route or routes by which prosodic sensitivity may influence word identification. Research has indicated that word identification, especially in the case of pseudowords or low frequency words, relies heavily on phonological decoding, or sounding out. The processes that elicit pronunciation of letter strings, decisions about lexical status, or semantic judgments, rely on the previous attainment of a coherent phonological code (Lukatela, Carello, Savic, Urosevic & Turvey, 1998). The idea is that, in word recognition, the phonological information presented in the word is compared with the phonology of potential lexical candidates in the mental lexicon (Lindfield, Wingfield, & Goodglass, 1999). However, it is not the case that phonological decoding fully accounts for word identification.

Orthographic decoding combines with phonological decoding to facilitate word recognition (Badian, 2005). Orthographic decoding is considered a fast processing of large or whole-word units based on their letter patterns. The current research considers these two types of decoding when examining the relation of prosodic sensitivity to word identification. Specifically, phonological decoding is known to depend on PA, and orthographic decoding is believed to depend on rapid lexical retrieval. The current study will investigate whether the relation between prosodic sensitivity and word identification is mediated by PA and/or rapid lexical retrieval.

Indeed, there is already some evidence that prosodic sensitivity relates to both PA and rapid lexical retrieval. Whalley and Hansen (2006) looked at the relationships between prosodic sensitivity, phonological awareness, and word-level reading abilities. Results showed a significant correlation between performance on measures of prosodic sensitivity and on word identification tasks. Phonological awareness was more strongly correlated with word identification, but performance on the prosody tasks predicted unique variance in word identification after controlling for PA. Prosodic sensitivity was also significantly correlated with phonological awareness.

Also, Lindfield et al. (1999) showed that lexical stress may facilitate word recognition through lexical retrieval. They presented participants with the initial 50 milliseconds of a word and then used a bypass filter to "gate" the further information. The rest of the word was heard in a way that signaled the number of syllables in the word and its stress pattern, but not any segmental or phonological information. Participants were to guess what the word was. Errors made by the participants indicated that they were processing the prosodic cues given. The erroneous words they responded with had the same lexical stress, duration, and number of syllables. How quickly the participants were able to identify the correct word was dependent on the amount of prosodic information given. Lindfield et al. (1999) concluded that processing of the prosodic pattern of a word is activated early on in lexical retrieval, and the prosodic features then act as a framework to facilitate the retrieval of phonological information.

Rationale for the Current Study

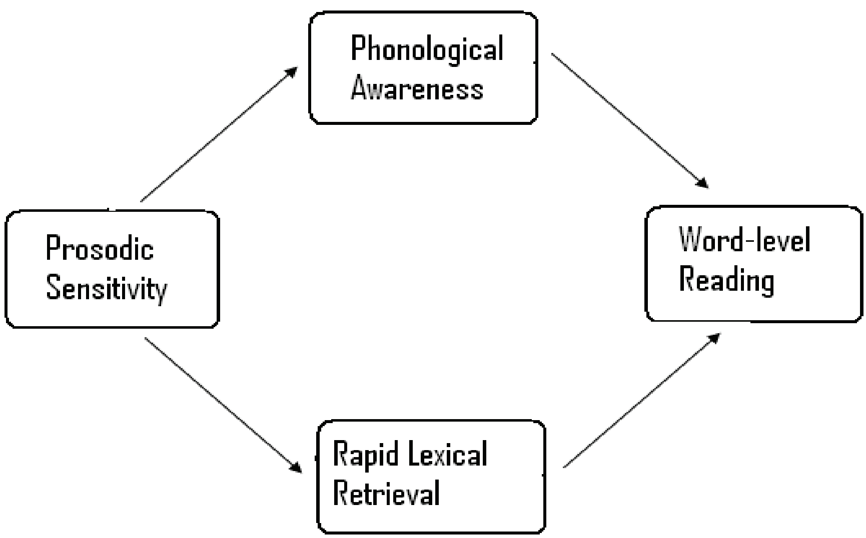
Results of the studies by Whalley and Hansen (2006) showed that prosodic sensitivity may have an influence on word identification through phonological awareness. Goswami et al. (2002) claimed that sensitivity to rhythmic properties in language contributes to word level reading skills by facilitating the development of accurate phonological representations that underlie PA. However, Whalley and Hansen (2006) also found that prosodic sensitivity contributed to word-level reading skills beyond a role in supporting phonological awareness. There are two possibilities for the additional contribution to word identification: (1) either prosodic sensitivity has an additional unmediated influence on word-level reading, or (2) there is another mediator not accounted for in the Whalley and Hansen study (2006). Lindfield et al. (1999) proposed that sensitivity to the prosodic elements of language supports word identification skills by facilitating the retrieval of words from the mental lexicon. This might account for the additional variance in word-level reading skills not attributable to phonological awareness. Thus, rapid lexical retrieval might be a second mediator of the relation between prosodic sensitivity and word identification.

The current study replicates Whalley and Hansen's research (2006), and examines the hypothesis that there are two mediators of the relation between prosodic sensitivity and word identification—PA and rapid lexical retrieval. The correlation between performance on rapid naming tasks (indicative of rapid lexical retrieval) and performance on a word-identification task depicts the relationship between speed of lexical retrieval and word-level reading. Prosodic sensitivity is then compared to rapid lexical retrieval to see whether the two correlate. Lastly, the two mediating variables (PA and lexical retrieval) are controlled for to test whether prosodic sensitivity has any direct relation to word-level reading, or if there is any additional variance in word-level reading skills after the mediators are eliminated as factors.

Hypothesis

The study tests the hypothesis that prosodic sensitivity is significantly correlated with each of the other three variables: rapid lexical retrieval, PA, and word identification. The anticipated model (see Figure 1) depicts two mediators between prosodic sensitivity and word-level reading. The hypothesis is that prosodic sensitivity contributes to word-level reading skills by facilitating both PA and rapid lexical retrieval. It is not expected that prosodic sensitivity will predict unique variance in word identification after the two mediating variables are controlled.

Figure 1. *Hypothesized model of the relationship between prosodic sensitivity and word-level reading depicting two proposed mediators—PA and rapid lexical retrieval.*



Method

The study used a non-experimental correlational design. The study examined four variables: (1) prosodic sensitivity, obtained as the proportion of correct answers on rhythmic awareness tasks, (2) phonological awareness, taken as a composite score from the Elision and Blending Words subtests of the Comprehensive Test of Phonological Processing (CTOPP), (3) rapid lexical retrieval, taken as a composite score from the rapid naming subtests of the CTOPP, and (4) word identification, scored by the Word Identification subtest in the Woodcock Reading Mastery Test Revised (WRMT-R).

Participants

Thirty-three children participated in the study. They were second- and third-grade students in the public school system of Tuscaloosa County, Alabama who were not receiving special education services in their schools. The children's ages ranged from 7 to 9 with a mean age of 8 years. All participants performed above an age-equivalent of 5 years 0 months on the Verbal Scale of the Kaufman Brief Intelligence Test-2 (KBIT-2) to be included in the study. For those who did not meet this criterion, testing was discontinued. Children received a small prize for each session of participation.

Tests and Measures

Kaufman Brief Intelligence Test-2 (KBIT-2, Kaufman & Kaufman, 2005). The KBIT-2 is a popular test used to quickly assess IQ for ages 4-90. It has two scales that generate a verbal, a non-verbal, and a composite IQ score. The verbal scale has two subtests: Verbal Knowledge (a picture-naming test) and Riddles (gives definitions of words for examinee to guess). The non-verbal scale has one subtest, Matrices, which measures one's understanding of relationships among visual stimuli, both meaningful (persons, places, and things) and abstract (symbols or patterns). The KBIT-2 correlates highly with the Wechsler Abbreviated Scale of Intelligence (WASI, The Psychological Corporation, 1999), as well as the Wechsler Intelligence Scale for Children (WISC-III) and the Weschler Adult Intelligence Scale (WAIS). Internal-consistent reliability is high for the verbal scale (.91), the nonverbal scale (.88), and the IQ composite scale (.93).

Comprehensive Test of Phonological Processing (CTOPP, Wagner, Torgesen, & Rashotte, 1999). The CTOPP is one of the most frequently used tests in research on phonological awareness/decoding/memory. Two subtests of the test are used in the current study, Phonological Awareness and Rapid Automatic Naming. The subtests of the CTOPP are based on experimental tasks used to study phonological processing in published literature. It has been reviewed by experts and repeatedly tested on a large population of subjects. It has a strong concurrent correlation with the Test of Word Reading Efficiency (TOWRE), and its criterion-prediction validity has been confirmed in a longitudinal study by Wagner et al. (1994). A confirmatory factor analysis assures that CTOPP matches the model on which it is based, and the correlations are especially strong for PA and Rapid Automatic Naming. Internal consistency is good for PA (.90) and Rapid Automatic Naming (.88).

1. Phonological Awareness. A composite of two tasks of the CTOPP provides a measure for PA. The Elision Task requires participants to verbalize a word and then to speak it again when a phoneme has been deleted (e.g., "Say cup. Now say cup without the /k/"). In each trial, the resulting word is a well-formed English word. The Blending Words Task is used to assess individuals' ability to combine sounds to form words. The examiner presents a whole word sound-by-sound with overtly exaggerated segments between the sounds. Participants are required to recall all the individual sounds and forge them together to pronounce the word. Both PA subtests are made up of increasingly difficult items, and testing continues until a discontinue criterion is met. The raw score total for the PA subtests is used in data analysis.

2. Rapid Automatic Naming. There are four rapid naming tasks in the CTOPP: Rapid Color Naming, Rapid Object Naming, Rapid Letter Naming, and Rapid Digit Naming. For this study, a composite of only the color and digit naming tasks is used to assess speed of lexical retrieval. In each of the naming tasks, participants view a series of rows of colors or numbers in a picture book. The participants are told to start in the top left corner and name them as quickly as possible until they have named all of the colors (or digits). The total time to name colors and digits is used as the measure of rapid lexical retrieval in the data analysis.

Word Identification. Word-level reading abilities are assessed using the Word Identification subtest in the Basic Skills Cluster of the Woodcock Reading Mastery Test-Revised (WRMT-R, Woodcock 1998). The

WRMT-R is a commonly used battery of tests used to measure all levels of reading skills. It has been reformulated by outside experts, teachers, and curriculum specialists to be comprehensive in content and difficulty. Split half reliability of .98 is reported. Concurrent validity is also very high when assessed by comparison to a multitude of other reading measures like the Iowa Tests of Educational Development. The subtests within the WRMT-R are significantly intercorrelated. The Word Identification subtest contains 106 words of increasing difficulty. Participants begin at an age-designated starting point and read each word until they meet a discontinue criterion. The raw score on the task is used as the measure of word identification in the data analysis.

Rhythmic Awareness. Two tasks are designed to assess awareness of rhythm in general and awareness of the rhythmic elements of language (prosodic sensitivity). The Beat Detection Task was not implemented in time to test the first eight participants, so performance on the Compound Nouns Task was used exclusively in the data analysis.

1. The Beat Detection Task is derived from the AM/beat perception task (Goswami et al., 2002). It measures general rhythmic awareness by assessing an individual's ability to distinguish between drum beats. Drum beats were created using audio editing software for creating and sequencing drum loops called Fruity Loops. Participants completed 28 trials, in which they listened to two sequences of drum beats and pressed a key for "yes" if they were the same, or "no" if they were different. The number of beats in each sequence varied from 3 to 7. Three-beat sequences are used in the practice items and early in the task, and 7-beat sequences are used in the middle trials, and 3-7 beat items are mixed in the last ten trials.

2. The Compound Nouns Task is adapted from a subtest of the Profiling Elements of Prosodic Systems (PEPS, Wells & Peppe, 2003). The task assesses prosodic sensitivity by testing an individual's ability to discriminate between compound nouns and noun phrases that differed only by the prosodic features of stress, intonation, and pauses. Participants are presented with a computer display of two picture sequences: one contains two items, and the other contains three (e.g., paintbrush and water; or paint, brush, and water). Participants hear an audio recording of a phrase and have to choose which picture sequence corresponds to the phrase. There are 20 trials in this task.

Scores for the number of correct items from the Beat Detection Task and the Compound Nouns Task are added together to achieve the total score for rhythmic awareness or prosodic sensitivity used in data analysis.

Procedure

Testing took place in a quiet room in either the child's school or the campus laboratory. Each participant was tested individually by a trained examiner. The tests used in the present study were a portion of a large battery of tests given in its entirety.

There were three testing sessions, with varying time length dependent on several factors, for each individual participant. The KBIT-2 was the first of the battery of tests to be administered. The Elision and Blending Words subtests of the CTOPP were given next, during the second session, followed by the Rapid Automatic Naming tasks. Participants completed the CTOPP in the second session. In the third session, the participants completed the WRMT-R and the rhythmic awareness tasks.

Results

Of the 33 children who participated in the study, data for 23 were included in the analyses. Data were excluded for 8 children who were administered the Compound Nouns Task with only two practice trials. Two extra practice trials were added later, and only subsequent data were included in the analyses. Data for one child were excluded due to examiner error in scoring the Word Identification subtest of the WRMT-R. One child's performance on the Rapid Naming tasks was considered an outlier, and data for the individual were filtered out.

Descriptive statistics for the four variables are listed in Table 1 below.

Table 1. *Means and standard deviations of phonological awareness, rapid naming, word identification, and rhythmic awareness measures.*

	N	Minimum	Maximum	Mean	Std. Deviation
CTOPP Phonological awareness sum of raw scores (40)	23	14	37	24.78	7.447
CTOPP Rapid naming sum of raw scores	23	105.57	232.54	160.7339	31.85527
WRMT R Word Identification raw score (106)	23	43	84	61.09	11.123
Proportion correct on Rhythmic Awareness Tasks	23	.450	1.000	.79348	.186050
Valid N (listwise)	23				

The means, standard deviations, and ranges for each of the measures were examined to determine whether performance was in the appropriate range for each measure. Any score greater than +/- three standard deviations from the mean was considered an outlier and eliminated, which resulted in the elimination of one participant's data.

Correlations among the experimental measures can be seen in Table 2 below. Significance tests were completed to determine the strength of correlations. Correlations with significance at the p<.01 and p<.05 levels were interpreted as reliable. As expected, word identification was significantly correlated with phonological awareness (r=.669) and rapid naming (r=-.746). Also, PA was significantly correlated with rapid naming (r=-.501). The correlation between performance on the rhythmic awareness tasks, indicative of prosodic sensitivity, and word identification was also significant (r=.459). Rhythmic awareness was positively correlated with PA (r=.558). The correlation between prosodic sensitivity and rapid naming was moderate (r =-.411), at least with such a small sample size.

Table 2. *Intercorrelations among measures of phonological awareness, rapid naming, word identification, rhythmic awareness (N=23).*

	CTOPP Phonological Awareness sum of raw scores (40)	CTOPP Rapid Naming sum of raw scores	WRMT-R Word Identification raw score (106)
Phonological Awareness			
Rapid Naming	-.501*		
Word Identification	.669**	-.746**	
Rhythmic Awareness	.558**	.411*	.459*

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

In order to determine whether prosodic sensitivity predicted unique variance in word identification, a four-part hierarchical regression analysis was carried out with word identification as the criterion variable. The predictor variables were phonological awareness (PA), rapid naming (i.e., lexical retrieval), and rhythmic awareness (i.e., prosodic sensitivity). In the first analysis, performance on the rhythmic awareness tasks was entered at Step 1. Rhythmic awareness accounted for 21.1% of the variance in word identification skills. In the second analysis, PA was entered at Step 1 and rhythmic awareness was entered at Step 2 to control for variation in word identification attributable to individual differences in PA. Results are illustrated in Table 3.

Table 3. *Regression analysis predicting word identification from rhythmic awareness, after controlling for PA.*

Input	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	Sig. F Change
PA	.669	.447	.421	8.465	.447	16.982	.002
Rhythmic Awareness	.677	.458	.404	8.590	.011	.397	.536

PA was a strong predictor of word identification skills, accounting for all but 1.1% of the variance in word identification attributable to rhythmic awareness. The contribution of rhythmic awareness to word identification dropped significantly, from 21.1% to 1.1%, when PA was partialed out. This suggests that PA mediates the relationship.

In the third analysis, performance on the rapid naming tasks was entered at Step 1 and rhythmic awareness was entered at Step 2 to determine the proportion of variance in word identification that could be attributed to performance on the rapid naming tasks. Results are illustrated in Table 4.

Table 4. *Regression analysis predicting word identification from rhythmic awareness, after controlling for rapid naming.*

Input	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	Sig. F Change
Rapid Naming	.746	.557	.536	7.577	.557	26.407	.000
Rhythmic Awareness	.765	.585	.544	7.514	.028	1.352	.259

Performance on the rapid naming tasks, indicative of speed of lexical retrieval, was also a strong predictor of word identification skills. After controlling for rapid naming, the contribution of rhythmic awareness to word identification dropped from 21.1% to 2.8%. This suggests that rapid naming is also a mediating variable of the relationship between prosodic sensitivity and word identification.

In the final regression analysis, both PA and rapid naming were controlled to see whether prosodic sensitivity predicted a unique variance in word identification skills. PA was entered at Step 1, rapid naming at Step 2, and rhythmic awareness at Step 3. Results are shown in Table 5.

Table 5. *Hierarchical regression analysis predicting word identification from rhythmic awareness after controlling for PA and rapid naming.*

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change
PA	.669(a)	.447	.421	8.465	.447
Rapid Naming	.820(b)	.673	.640	6.672	.226
Rhythmic Awareness	.821(c)	.673	.622	6.842	.000

a Predictors: (Constant), CTOPP Phonological awareness sum of raw scores (40)
b Predictors: (Constant), CTOPP Phonological awareness sum of raw scores (40), CTOPP Rapid naming sum of raw scores
c Predictors: (Constant), CTOPP Phonological awareness sum of raw scores (40), CTOPP Rapid naming sum of raw scores, Proportion correct on Rhythmic Awareness tasks

The proportion of variance in word identification attributable to rhythmic awareness was near zero after taking into account all the other measures. This suggests that the correlation between rhythmic awareness and word identification is almost entirely mediated by PA and rapid naming. Performance on the rapid naming tasks accounted for a significant proportion of additional variability in word identification after PA was partialed out, and performance on the rhythmic awareness tasks did not predict any unique variance in word identification.

Discussion

The purpose of the study is to explore the role of prosodic sensitivity in word-level reading ability. In examining the relationship between prosodic sensitivity and word-level reading ability, this study provided some evidence of the means by which sensitivity to linguistic rhythm facilitates word identification. Phonological awareness and speed of lexical retrieval have been indicated as predictors of word identification skills in previous studies. The findings in this study provide evidence that the relationship between prosodic sensitivity and word identification is mediated by these abilities.

Previous studies have indicated that prosodic sensitivity may have an influence on word identification by facilitating PA and an additional influence beyond its role in supporting PA (Whalley & Hansen, 2006). The current study replicated these results, and sought to determine what accounts for the additional variance in word identification not attributable to PA. Regression analyses revealed that this variance in word identification not attributable to PA was accounted for by performance on the rapid naming tasks. This finding validates the suggestion by Lindfield et al. (1999) that prosodic sensitivity may have an influence on word identification by facilitating rapid lexical retrieval. The results of the study conformed to the mediation hypothesis, indicating that prosodic sensitivity contributes to word identification skills by facilitating both PA and rapid lexical retrieval.

Word-level reading proficiency relies on more than just phonological decoding. Whereas the ability to distinguish and manipulate the individual phonemes in language remains the most consistent predictor of word-level reading, this study provides some evidence that prosodic sensitivity facilitates this ability. It appears that sensitivity to the tempo, stress, intonation, and pause patterns in language allows for, or enhances, the attainment of accurate phonological representations. These phonological representations permit phonological information to be compared to potential lexical candidates supporting rapid lexical retrieval (Lindfield et al., 1999). The range of lexical candidates is constricted by the syllabic stress information that is initially detected in word recognition. Prosodic cues such as stress and intonation provide perceptual cues to linguistic structure. Specifically, in word-level reading, the prosodic patterns provide cues for orthographic decoding, facilitating the rapid retrieval of words from the mental lexicon.

Although the current study illustrates the independent contribution of prosodic sensitivity to PA and lexical retrieval, it is likely that speed of lexical retrieval is also facilitated by PA. Prosodic sensitivity is at the foundation of both skills. It facilitates PA and rapid lexical retrieval independently, and it contributes to rapid lexical retrieval by facilitating the development of phonological representations.

An interesting distinction should be made between word recognition in spoken language and in written language contexts. Written language contexts do not have the rich phonological and prosodic cues that are prominent in spoken language (Whalley & Hansen, 2006). The phonological representations can be inferred in single-word reading simply by sounding out the word. The prosodic cues are also inferred, but perhaps with more difficulty. Some of the participants in the study were able to sound out each of the words in the word identification task, but they were unable to assign proper stress to the words. They could sound out the word, but they could not give a fluent reading of it. In the case of written language, stress assignment may indeed be post-lexical. If this is true, then stress assignment depends on the recognition of the word. Only after the word is identified can the proper prosodic contour be applied. This idea should be explored in future research.

The current research model could be expanded in future research to include both phonological coding and orthographic coding. Phonological coding involves the sounding out of word elements, while orthographic coding involves word identification by recognition of letter patterns. Past research has shown that phonological coding and orthographic coding contribute independently to word identification skills. PA is related to phonological coding, whereas lexical retrieval is related to orthographic coding. Future research should explore the role of prosodic sensitivity in influencing both skills.

This study provides convincing evidence that prosodic sensitivity facilitates word-level reading, but the findings should be replicated and expanded. The two rhythmic awareness tasks in the study have not been standardized, so there is no empirical evidence beyond this study indicating their reliability in measuring prosodic sensitivity. The findings should be replicated using different testing measures. Also, the data obtained in the study were taken from a sample of 23 second- and third-grade children. A larger and more diverse sample is needed to verify the results.

The study looked at only a select age range. Results may be different in earlier or later stages of reading development. It has been suggested that children are more reliant on prosodic features in language comprehension than adults (Schreiber, 1980). This explains why children have more difficulties with reading comprehension than spoken language comprehension, because written language provides less prosodic context (Whalley & Hansen, 2006). A similar study with older participants might yield data indicating that prosodic sensitivity has a weaker relationship with the other variables considered.

It is important to examine prosodic sensitivity in children of different ages. If prosodic sensitivity contributes to word identification by facilitating the development of accurate phonological representations that underlie PA, then a developmental progression of word-level reading skills may be expected (Goswami et al., 2002). Future studies can examine this idea by measuring prosodic sensitivity in children at earlier stages of reading development.

Despite these limitations, it still holds that there is a strong correlation between prosodic sensitivity and word-level reading abilities. Regarding pedagogical interests, the research shows that training in rhythmic awareness may be a valuable supplement to current instructional methods. An intervention study by Douglas and Willatts (1994) showed that musical training can have a significant impact on reading comprehension. A multi-dimensional reading program, promoting awareness of sounds and rhythm, combined with current instructional techniques may be more effective than less inclusive instructional methods (Douglas and Willatts, 1994). Given the results of these findings, some research in instructional methodology may be warranted. Experimenters may want to research ways to bolster prosodic sensitivity in young children. This further research may have broad pedagogical implications.

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