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Understanding prosody and morphology in school-age children's reading

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Abstract

We examined the unique contributions of prosodic awareness and morphological awareness to school-aged children's word reading and reading comprehension. A total of 110 elementary-age children from Grades 4 and 5 participated in the current study. To measure prosodic awareness, children were asked to listen to and reflect on the stress patterns of multisyllabic words and identify the syllable of the word that contained the primary stress. Two measures of morphological awareness were administered including morphological production and the nonword suffix choice task. Prosodic awareness and morphological awareness were significantly correlated in the low to moderate range. We found that both metalinguistic skills uniquely predicted word reading, and morphological awareness was the only predictor of word reading that also explained individual differences in reading comprehension. Furthermore, the relationship between prosodic awareness and word reading was partially mediated by phonemic awareness and morphological awareness, and the relationship between prosodic awareness and reading comprehension was fully mediated by morphological awareness and word reading. We conclude that prosodic awareness assessed at the word-level only affects word reading, which in turn supports reading comprehension. We also provide further evidence for the role of morphological awareness as a unique contributor to both decoding and meaning-making processes.

Keywords Prosody · Word reading · Reading comprehension · Phonological awareness · Morphological awareness

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Introduction

The primary goal of reading is reading for understanding. This involves basic word reading processes and higher-level comprehension abilities such as developing an accurate representation of the text, and drawing inferences between the text and the real world (Perfetti & Stafura, 2014). It is well understood that reading is supported by a number of skills, including phonological awareness, rapid automatized naming (RAN), and vocabulary knowledge (Kirby, Parrila, & Pfeiffer, 2003; Ouellette, 2006; Stahl & Murray, 1994). Some of these skills are referred to as metalinguistic abilities, defined broadly as individuals' awareness of and ability to manipulate different units of spoken language (e.g., Tunmer, Herriman, & Nesdale, 1988). Phonological awareness (PA) is a metalinguistic skill that is important in early reading acquisition; it refers to children's ability to think about and manipulate the sounds in spoken language such as phonemes, onset-rimes, and syllables (Castles, Rastle, & Nation, 2018). Another example of a metalinguistic skill is morphological awareness, which refers to individuals' awareness of the smallest meaningful units (morphemes) and ability to manipulate the morphemic structure of words (Carlisle, 2000). There are other skills involved in reading such as RAN or naming speed, reflecting processing speed, which is measured by individuals' ability to process familiar items such as a series of letters, digits, or objects accurately and efficiently (Norton & Wolf, 2012). Although these metalinguistic abilities and other language-related skills account for a significant amount of the variance in children's reading development (Castles et al., 2018; Kirby et al., 2012; Landerl et al., 2018), the relationship between established predictors and other metalinguistic skills that have emerged in the literature requires further investigation. The present study examines two metalinguistic skills that have received considerable attention in the reading research literature, prosodic awareness and morphological awareness. The investigation of each predictor has been individually examined in relation to a range of children's reading outcomes (e.g., Carlisle, 2000; Carlisle & Kearns, 2017; Kirby & Bowers, 2017; Spencer, Quinn, & Wagner, 2017; Wade-Woolley, 2016). However, there are a limited number of studies that have considered both prosodic awareness and morphological awareness in a model of reading, and these studies have been mainly focused on early reading (e.g., Deacon, Holliman, Dobson, & Harrison, 2018; Holliman et al., 2014; Kim & Petscher, 2016).

For the current study, we extend this prior research on early readers and focus our investigation on upper elementary school-aged children in Grades 4 and 5. These more experienced readers continue to encounter unfamiliar, multisyllabic words such as content-specific vocabulary, which require attention to phonological information such as prosodic patterns for accurate word production and understanding the meaning of a word to support comprehension processes (Kehoe, 2001; Wood, Wade-Woolley, & Holliman, 2009). Prosodic awareness (PrA) refers to children's ability to reflect on and manipulate the rhythm of spoken language (Thomson & Jarmulowicz, 2016). Morphological awareness (MA) refers to children's understanding that words are made up of meaningful units, and ability to manipulate these units (Carlisle, 2000). MA contributes to word knowledge directly when children attend to and apply knowledge about the structure of morphemes when they encounter words during reading, which in turn facilitates reading comprehension (McBride-Chang, Wagner, Muse, Chow, & Shu, 2005; Kirby et al., 2012). The three aims of the study are to: (a) examine the relationship between PrA and MA, (b) investigate the independent contributions of PrA and MA to word reading and reading comprehension, and (c) explore the causal relations between PrA and reading achievement.

Prosodic Awareness and Reading

It is widely understood that phonological abilities are strong determinants of children's reading success (e.g., Castles et al., 2018; Chall, 1983; Melby-Lervåg, Lyster, & Hulme, 2012; Scarborough, 1998). Phonological awareness (PA), as traditionally defined, refers to an individual's awareness of sounds in spoken language including phonemes, onset-rimes, and syllables (Adams, 1990; Stahl & Murray, 1994). This *segmental* PA explains the greatest variance to word reading in the primary grades, reaching ceiling effects by about third or fourth grade for typical readers (Kilpatrick, 2015; Kirby et al., 2012). Phonological abilities are necessary but not sufficient for reading success, as other cognitive constructs such as naming speed and morphological awareness play a more incremental role as children's reading skills becomes more developed (Ehri, 1995; Castles et al., 2018). Recently, the notion that PA should be expanded to include *suprasegmental* phonology has been gaining traction (Holliman, Wood, & Sheehy, 2008; Wade-Woolley & Heggie, 2015; Wang & Arciuli, 2015; Wood & Terrell, 1998). This growing research provides evidence for the unique role of suprasegmental PA and reading. These conclusions challenge literacy researchers to revisit traditional definitions and measurement of PA in the field that have been largely focused on segmental PA, to include suprasegmental PA in both research and practice.

Suprasegmental PA rests atop segmental PA and is realized in aspects of speech rhythm, intonation, word stress, loudness, and rate (Kent & Read, 2002; Wood & Terrell, 1998). Long recognized as a critical component of oral language and one of the earliest cues for speech segmentation in infancy (Graf Estes & Bowen, 2013; Johnson & Jusczyk, 2001; Mattys, Jusczyk, Luce, & Morgan, 1999), suprasegmental PA is manifested as prosodic information operating at the word level (e.g., differentiating *desert* and *dessert*), the phrase level (e.g., differentiating *Let's eat, Grandma* from *Let's eat Grandma*), and the discourse level (e.g., emphasizing contrastive, new, or notable information).

While traditional segmental PA tasks evaluate a child's ability to blend or manipulate phonemes (e.g., */b/ /a/ /t/* → *bat*), measures of PrA focus on suprasegmental information. For example, Wade-Woolley (2016) employed a task in which participants listened to pre-recorded words and were asked to identify the syllable within the word that contained the primary stress or "main beat". Other measures of PrA involve matching words to low-pass filtered utterances based on word stress patterns (Whalley & Hansen, 2006), judging intonation and timing (Holliman et al., 2014), and evaluating qualities of oral reading prosody (Benjamin & Schwanenflugel, 2010).

Suprasegmental PA has been studied in languages including English, Chinese, Spanish, and Italian. It has been found to be a significant correlate of emergent and skilled reading achievement in typically-developing children (e.g., Beattie & Manis, 2014; González-Trujillo, Defior, & Gutiérrez-Palma, 2012; Holliman, Wood, & Sheehy, 2010; Sulpizio, Burani, & Colombo, 2015; Veenendaal, Groen, & Verhoeven, 2014; Wade-Woolley & Heggie, 2015; Zhang & McBride-Chang, 2014) and also explains individual differences in reading among children and adults with dyslexia (e.g., Goswami et al., 2013; Leong, Hämäläinen, Soltész, & Goswami, 2011) and language impairment (Beattie & Manis, 2013).

Reading researchers have extended the application of metalinguistic awareness to include suprasegmental PA and have assessed whether awareness of prosodic information is related to reading development (e.g., Deacon et al., 2018; Harrison, Wood, Holliman, & Vousden, 2017; Holliman, Mundy, Wade-Woolley, Wood, & Bird, 2017; Holliman et al., 2014; Wade-Woolley & Heggie, 2016). The role for PrA is particularly evident in decoding longer words containing multiple syllables, because accurate pronunciation of words includes applying primary stress to the correct syllables and the associated vowel reduction in unstressed syllables (Jarmulowicz, 2006; Heggie & Wade-Woolley, 2017). Wade-Woolley (2016) examined the role of phonemic awareness and PrA in reading of mono- and multi-syllabic words in a group of Grades 4 and 5 readers. These word lists contained unfamiliar words, which required children to decode them by sounding out phonemes, parsing words into syllables, and correctly assigning primary stress. Wade-Woolley (2016) showed unique contributions of PrA beyond phonemic awareness to both short and long word reading. More importantly, PrA predicts reading beyond the contributions of *segmental* PA to further underscore its inclusion as a phonological component in theoretical models of reading (e.g., Goswami, Gerson, & Astruc, 2010; Holliman et al., 2014; Wade-Woolley & Wood, 2006; Whalley & Hansen, 2006; Wood & Terrell, 1998; Wood et al., 2009; Wade-Woolley & Heggie, 2016).

Theory of PrA

Wood and Terrell (1998) posited that PrA contributes to reading primarily at the word level in phonological decoding. Wood et al. (2009) proposed a theoretical model to explain the relationship between PrA and word reading ability in typically developing readers. The pathway model relevant to the constructs in our study begins with the periodicity bias, referring to children's ability to attend to prosody, or the rhythmic aspects in their first language (Cutler & Mehler, 1993). It has been proposed that children's awareness and attention to the aspects or features of their native language, such as the stress patterns in the English language, is innate and implicit (Wood & Terrell, 1998). These spoken word recognition processes then serve as a foundation for when children develop explicit phonological representations (Wood & Terrell, 1998). The model proposes direct effects of PrA on spoken word recognition processes that support vocabulary knowledge, and vocabulary indirectly supports reading and spelling through rhyme awareness and phonemic awareness. Further, PrA is hypothesized to have a direct effect on spoken word recognition and indirect effect on reading through rhyme awareness, MA, and phonemic awareness (via phonemic identification).

Wood et al. (2009) explained the need to control for phonemic awareness (or segmental PA) when investigating the unique contributions of PrA to reading because the nature of PrA tasks necessarily involves phonological abilities. When children are asked to work with the sounds within words, it is easier to identify sounds in stressed syllables than in unstressed syllables (Weber, 2018; Wood et al., 2009). Further, word stress awareness is necessary in reading longer, multisyllabic words. The connection with rhyme awareness relates to children's ability to identify onset-boundaries (Holliman et al., 2014) using information such as the pattern of strong and weak syllables because stressed syllables have higher pitch and intensity than unstressed syllables. Lastly, the relationship between PrA and MA becomes increasingly important among experienced readers who read longer words that are morphologically complex (Wood et al., 2009). For example, patterns of word stress change as a result of the addition of certain suffixes (e.g., *Equal*, *eQUALity*), and they remain unchanged for others (e.g., *proTECT*, *proTECTion*). The awareness of word stress, or PrA, is an important aspect of lexical quality that is connected to other metalinguistic skills that are known predictors of reading success. In our study of upper elementary students, we combine the three constructs of segmental PA, PrA, and MA in a model of reading, and explore the directional relationships proposed in Wood et al.'s (2009) theory of PrA.

Morphological Awareness and Reading

More recently, there has been considerable attention on the role of morphology in children's reading. Morphological awareness (MA) refers to an individual's knowledge of the smallest meaningful units of words, and the ability to manipulate the morphemic structure of words (e.g., Carlisle, 2000; Kirby et al., 2012). MA is strongly correlated with vocabulary knowledge, word reading, and reading comprehension, and predicts reading skill over and above other known predictors (Deacon, Kieffer, & Laroche, 2014; Kirby & Bowers, 2017; Muse, 2005). MA contributes to literacy in a number of ways including supporting reader's analysis of word forms, inferring word meanings of complex words from familiar parts, and the use of syntax to help with comprehension (Nagy, Carlisle, & Goodwin, 2013). Nagy et al. (2013) suggested that MA is a stable predictor of reading throughout the elementary grades, and the role of MA on reading increases through the upper elementary years. The impact of morphological instruction and interventions on language and literacy outcomes of school-age children and literacy difficulties has been reported in several meta-analyses (Bowers, Kirby, & Deacon, 2010; Goodwin & Ahn, 2010, 2013). Specifically, Goodwin and Ahn (2013) found significantly higher literacy scores for children who had morphological instruction compared to those who did not, and MA instruction had significant moderate effects on decoding, PA, morphological knowledge, vocabulary, and spelling. Similar significant moderate effects were found for children with literacy difficulties who received morphological interventions, in which children showed improvements on PA, MA, vocabulary, reading comprehension, and spelling (Goodwin & Ahn, 2010).

It is well established that MA is related to a range of literacy skills and achievement outcomes (e.g., Nagy et al., 2013), and more recent research has examined the direction of these associations. For example, Levesque, Kieffer, and Deacon (2017) assessed several path models to determine the direct and indirect effects of MA on reading comprehension in Grade 3 English-speaking children. They tested a multiple mediation model to examine the direct contributions of MA to reading comprehension, and the indirect contributions through word reading, morphological decoding, morphological analysis, and vocabulary. PA and nonverbal ability were included in the model as control variables. The first MA task assessed children's derivational morphology adapted from Carlisle (2000) (e.g., *farm*. My uncle is a ____ [*farmer*]). The second MA measure was the Word Analogy task (Kirby et al., 2012), which required children to inflect or derive a new word from a base word to complete a pattern (e.g., sleep: sleepy:: cloud: ____ [*cloudy*]). Both tasks assessed children's ability to manipulate the morphemic structure of words.

Children's abilities to decode and analyze the meaning of morphologically complex English words were included as mediators in the model. For morphological decoding, children read aloud low frequency derived words and pseudowords. For morphological analysis, children were asked to infer the meaning of a word by attending to the morphemic components, and match the word to one of four definitions (Deacon, Tong, & Francis, 2017). Levesque et al. (2017) concluded that the best fitting model included direct effects of MA on reading comprehension, as well as indirect effects of MA through morphological analysis. In addition, morphological decoding fully mediated the relationship between MA and word reading, and word reading fully mediated the relationship between morphological decoding and reading comprehension. Moreover, MA predicted reading comprehension above and beyond PA and word reading, and diminished the prominent relationship typically found between vocabulary and reading comprehension (Ouellette, 2006; Quinn, Wagner, Petscher, & Lopez, 2015). The role of MA in literacy skills can also be extended to the relationship between prosody and morphology. Skilled readers rely on phonological decoding and morphological knowledge to decompose low frequency multimorphemic words. These processes facilitate children's accurate pronunciation, which necessarily involves the correct placement of primary stress. Studies that have included both prosody and morphology are reviewed in the following section.

Primary Stress in Multisyllabic Words: Links between Prosody and Morphology

Importantly, morphology is intimately related to lexical prosody, or the placement of primary stress. The critical relationship between MA and PrA is best illustrated when deriving multisyllabic words with a class of suffixes such as "– ity", "– tion", and "– ic" (Jarmulowicz, Taran, & Hay, 2007). These suffixes have a near-obligatory effect on word stress; these suffixes draw word stress from its location in the base word to the syllable before the suffix. For example, the word *calorie* has primary stress on the first syllable, and a derivation with the suffix "– ic" results in primary stress being shifted to the second syllable (e.g., *CAlorie* → *caLORic*). As academic vocabulary increases, school-aged children increasingly encounter low frequency, multisyllabic, and multimorphemic words. Phonological changes such as primary stress shifts during morphological analysis are important to the quality of lexical representations.

A growing number of studies have examined phonemic awareness (segmental PA), PrA and MA together as key predictors of children's reading achievement. Holliman et al. (2014) directly tested Wood et al.'s (2009) conceptual model of prosody's relationship to word reading and spelling in 75 readers between 5 to 7 years of age. PrA was a composite score made up of measures of word stress, intonation, and timing. For word stress awareness, children heard a target word followed by two different low-pass filtered sound files and were to identify which sound file shared the same stress pattern as the multisyllabic word. For intonation, they judged whether an utterance represented a question (rise) or a statement (fall). For timing, children decided whether the timing or duration of two utterances was the same or different. MA was measured using a morphological derivation task, and the phonemic awareness measure was a phoneme deletion task (e.g., *chair* without initial phoneme /č/ → *air*).

With age controlled, Holliman et al. (2014) found that PrA was significantly correlated with vocabulary, rhyme awareness, phonemic awareness, MA, word reading, and spelling. MA was significantly correlated with all predictors, and with reading and spelling. Holliman et al. (2014) reported a poor model fit, and added additional pathways to conclude that the contributions of PrA to word reading were fully mediated by vocabulary and rhyme awareness. MA had direct effects on both word reading and spelling, and fully mediated the relationship between phonemic awareness and word reading, and that between vocabulary and word reading. However, no direct relationship was found between PrA and MA, with vocabulary fully mediating this relationship.

Kim and Petscher (2016) investigated several alternative models of PrA's contributions to word reading and reading comprehension in an older group (n = 370) of elementary readers between 6 and 9 years old. PrA was measured using an adapted version of Holliman, Wood, and Sheehy's (2012) word stress task. Participants were to identify the location of the stressed syllable across 24 disyllable words. Half of the items had primary stress on the first syllable and the remaining items had primary stress on the second syllable. The MA sentence completion task involved children applying morphological rules to add an inflection to a base word or derive a new word from the provided base words in order to complete the sentence. Kim and Petscher (2016) found that PrA was a significant correlate of word reading, listening comprehension, and reading comprehension. The best fitting model revealed significant indirect effects of PrA on word reading, fully mediated by MA and segmental PA. Other significant direct effects on word reading included letter naming, however, no direct effects were found for naming speed or working memory on word reading. For reading comprehension, no direct effects were found between PrA and reading comprehension and the relationship between PrA and reading comprehension was fully mediated by listening comprehension and word reading.

There are only a few longitudinal studies that have examined the long-term effects of both PrA and MA on reading. Holliman et al. (2010) found that PrA was a unique predictor of word reading and phrasing (a measure of oral reading fluency) 1 year later, after accounting for age, vocabulary, phonemic awareness, and rhyme awareness in 5–8 year old children. Deacon et al. (2018) also accounted for MA in their model, and explored MA and PrA measured at 6 years of age as predictors of reading comprehension measured 2 years later at 8 years old. PrA was a composite score of children's awareness of word stress, intonation, and timing (Holliman et al., 2014). For the MA task, children were instructed to derive a new word from the base word in order to complete the sentence. However, no item responses required primary stress shifts. The reading outcomes included word reading, passage reading accuracy, and reading comprehension. Deacon et al. (2018) reported no unique contributions of PrA to any reading outcomes and common variance was not assessed. However, MA emerged as a significant predictor of word reading after accounting for segmental PA, which explained unique variance in the final step. MA also explained individual differences in passage reading accuracy and reading comprehension after accounting for the effects of word reading. Although this is further evidence for the early contributions of MA to various reading outcomes during reading development, the predictive contributions of PrA to reading remain mixed and continue to be explored and debated in the literature.

The contributions of MA to the reading model, and the relationship between PrA and MA, suggest that this relationship could be further examined using mediation analysis or path models to explore causal models of the effects of PrA and MA on reading. The different results reported across studies may also be due in part to the methodological challenges encountered in developing age-appropriate PrA measures, and the variability in the types of words contained within reading outcome tasks (e.g., monosyllabic/morphemic, multisyllabic/morphemic). Holliman et al. (2017) examined PrA as a predictor of multisyllabic word reading accuracy in 7–8 year old children. The multisyllabic words were 50 low-frequency words that ranged from two to five syllables in length. Holliman et al. used the *DEEdee* task (Whalley & Hansen, 2006) as their PrA measure, in which children were presented a book title such as *The Jungle Book* followed by two *DEEdee* phrases (e.g., *DEE dee DEEdee* [Bob the Builder] versus *dee DEEdee DEE* [The Jungle Book]). Children were instructed to choose the phrase that matched the prosodic pattern of the book title. The MA task was a sentence completion task administered orally by the researcher. Children were asked by the researcher to derive words from a base word (e.g., *If you clean*, *you are a* ______ [*cleaner*]). The regression analyses showed that MA and PrA each made unique contributions to multisyllabic word reading after controlling for segmental PA, vocabulary, and short-term memory. Taken together, these studies suggest that PrA is correlated with a range of metalinguistic skills that in turn have direct effects on reading outcomes, whereas MA independently contributes to reading above and beyond other known cognitive predictors.

In the current study, we focus on PrA and MA among older readers in Grades 4 and 5. Children in upper elementary grades may have stronger PrA and their PrA may be related to better reading outcomes (Wade-Woolley & Heggie, 2016), however, there is not enough evidence in the existing literature supporting this hypothesis in upper elementary grades. Further, MA is hypothesized to be a mediator between PrA and achievement outcomes in Wood et al.'s (2009) theory of PrA suggesting that the covariance between PrA and reading is accounted for by other predictors such as segmental PA and MA. Although this indirect relationship between prosody in reading was found in children as young as 5 and 6 years of age (Holliman et al., 2014; Kim & Petscher, 2016), the increasing involvement of prosody in reading morphologically complex words (e.g., Clin, Wade-Woolley, & Heggie, 2009; Jarmulowicz, Hay, Taran, & Ethington, 2008) suggests that these relationships may change across development. Of particular interest is examining the relationship between PrA and MA and investigating how each of these metalinguistic skills contributes to reading outcomes in the presence of established predictors of reading (e.g., vocabulary, nonverbal ability, naming speed, and segmental PA).

Current Study and Research Questions

The majority of studies that include both PrA and MA have focused on the early stages of reading development from Kindergarten to Grade 3 (e.g., Holliman et al., 2014; Kim & Petscher, 2016). To address some of the methodological challenges in prior studies, we use an age-appropriate measure of PrA containing a range of multisyllabic and multimorphemic words, examine the relations between PrA and MA to reading outcomes in an older sample of Grades 4 and 5 upper elementary children, and investigate the direct and indirect contributions of PrA and MA to reading after controlling the effects of segmental PA and known cognitive predictors. We include four established cognitive predictors present in previous studies as control variables in our models, i.e., nonverbal ability, verbal ability, naming speed, and segmental PA (e.g., Kirby, Georgiou, Martinussen & Parrila, 2010; Norton & Wolf, 2012; Ouellette, 2006). For instance, both Kim and Petscher (2016) and Holliman et al. (2014) focused on young children within a similar age range, and common constructs in their path models included prosody, morphology, and segmental PA. Kim and Petscher (2016) also accounted for the effects of naming speed, letter naming, and working memory in their word reading model, whereas, Holliman et al. (2014) accounted for rhyme awareness and verbal ability in their model of word reading. Kim and Petscher (2016) measured prosody using a word stress task of disyllable words, whereas Holliman et al. (2014) included tasks that measured word stress, intonation and timing often involving matching words to low-pass filtered utterances (i.e., words that have phonemic information removed). Holliman et al. (2014) illustrated direct effects of prosody on verbal ability, but no direct effects on MA or segmental PA, whereas, Kim and Petscher (2016) showed significant direct effects of prosody on MA and segmental PA and significant correlations between prosody with naming speed, letter naming, and working memory. It is important to account for the effects of both naming speed and verbal ability in older readers because differences on either literacy skill may contribute to individual differences in reading (Araújo, Reis, Petersson, & Faísca, 2015; Ouellette, 2006). MA is strongly associated with verbal ability and both skills support word reading and reading comprehension processes (Levesque et al., 2017; Spencer et al., 2017). There is strong evidence for the independent contributions of naming speed in reading across orthographies (Georgiou, Parrila, Cui, & Papadopoulos, 2013; Zhang and McBride-Chang, 2014). Naming speed is frequently measured as the time taken to read out loud sets of letters or numbers (Wagner, Torgesen, & Rashotte, 1999). The speeded component of naming supports automaticity and reflects the rapid retrieval of orthographic and phonological representations of a word important for decoding and reading fluency (Georgiou et al., 2013). Given the strong associations between PrA and MA and established predictors of reading (e.g., verbal ability, naming speed, segmental PA), the effects of established predictors will be accounted for prior to examining the contributions of PrA and MA in each model of reading.

Three research questions guide our study: (a) What is the relationship between PrA and MA? We hypothesize that these two metalinguistic skills will be moderately correlated, based on findings of Deacon et al. (2018), Kim and Pestcher (2016), and Holliman et al. (2017) that reported a range between $r = .13$ to $r = .46$. Our second question: (b) What contributions do PrA and MA make to word reading, after accounting for other known cognitive predictors and each other? Based on the findings of Holliman et al. (2010, 2014, 2017), and Kim and Petscher (2016), we hypothesize that PrA and MA will each make a significant contribution to word reading. In addition, we expect our mediation analyses to show significant direct effects of PrA on word reading, and indirect effects of PrA on word reading through segmental PA and MA.

Our last question: (c) What contributions do PrA and MA make to reading comprehension, after accounting for other known cognitive predictors and each other? We hypothesize that PrA will be a significant correlate of reading comprehension, based on the findings of Kim and Petscher (2016), which showed low correlations of $r = .17$ and $r = .20$. We hypothesize that MA will explain unique variance in reading comprehension, and MA will have both direct and indirect effects on reading comprehension through word reading based on findings reported by Kirby et al. (2012), Deacon et al. (2014, 2017), and Levesque et al. (2017). Moreover, we predict that MA and word reading will mediate any effects of PrA on reading comprehension.

Method

Participants

110 typically-developing elementary students (50 Grade 4, 60 Grade 5; 61 females and 49 males) from local public schools in Eastern Ontario participated in the study. All children were English-speaking and their ages ranged between 9.25 and 11.42 years. No additional demographic information was obtained (e.g., race/ethnicity, language of the home, socio-economic status). Participants were part of a larger study focused on the relationship between PrA and children's reading achievement. Each child participated in four individual sessions with a trained research assistant. Data were collected within a two-month time period in late spring 2014. Measures

in the study were divided into four different sets for each session and measures were administered in a fixed order, and this order had been determined with a view to maintain participant engagement and reduce fatigue. Written consent was obtained from parents/guardians, and there were no reports of any current or previous cognitive impairment or language difficulties that would make it difficult to participate in reading tasks. Ethics approval was obtained from the university ethics board and local school board. Children provided verbal assent prior to the beginning of each session. Each participant received a movie gift card at the end of the last session.

Measures

Nonverbal ability

We administered the Matrix subtest of the Wechsler Abbreviated Scale of Intelligence (WASI) to assess nonverbal ability (Wechsler, 1999). Children were presented with an incomplete picture, or abstract puzzle containing a missing piece and chose the segment among a series of five options presented at the bottom of the page that best completed the picture. The score was the number of correct answers. Children in the age range of 9 and 11 begin on item 5 and complete as many items as possible up to item 32. The termination rule is 4 consecutive errors within 5 consecutive items. The manual reports a split-half reliability of .88.

Verbal ability

Children's verbal ability was measured with the expressive vocabulary subtest of the WASI (Wechsler, 1999). The first four items involved participants naming pictures. For the remaining 38 items, children were asked to provide definitions for presented words shown in writing. For each item, children received a score of 2 representing an accurate definition with sufficient detail, 1 for a definition that represents a surface level understanding, or 0 indicating an incorrect definition or no answer was provided. Children in this age range stop on item 34, or discontinue after making 5 consecutive errors. The manual reports a split-half reliability of .92.

Naming speed

The Rapid Automatized Naming (RAN) Digits subtest of the Comprehensive Test of Phonological Processing (CTOPP; Wagner et al., 1999) was administered as a measure of naming speed. Children were presented with a page containing the digits 2, 3, 4, 5, 7, and 8, that were randomly presented across four rows of nine numbers for a total of 36 items. The score was the time taken to read the digits on the page. Children completed this a second time with a different arrangement of digits. The total score was the two reading times added together. The manual reports an alternate-form reliability of .90.

Segmental phonology

The first measure of segmental PA was the Elision subtest of the CTOPP (Wagner et al., 1999). For each item, participants repeat the word without the specified syllable or phoneme (e.g., Say *time*. Now say *time* without saying */m/*). There were a total of 34 items. The second measure was the Blending subtest of the CTOPP (Wagner et al., 1999). Children were presented with several syllables or phonemes and asked to combine them into words (e.g., *num-ber* → *number*, */n/ /ap/*→ *nap*). There were a total of 33 items. The discontinue rule for both measures were three incorrect items in a row. For each test, the score was the number of items correct. The manual reports a Cronbach's alpha of .80 for the CTOPP.

Morphological awareness

Two measures of MA were administered. The first was a morphological production task adapted from Carlisle (1988). Children heard a word followed by an incomplete sentence (e.g., *Help. My sister is always* ____.) They were asked to derive a new word using the root morpheme to complete the sentence (i.e., *helpful*). Each item was read aloud by the research assistant, and the child responded orally. Children's responses were scored as correct or incorrect. Although stress placement was not part of the scoring criteria, the accurate pronunciation of a word requires the appropriate application of stress. The score was the number correct out of 44 items. Children attempted all items for this measure. Cronbach's α was .89 for our study. The second measure was a nonword suffix choice task (Muse, 2005). Children were presented with a booklet containing incomplete sentences. Each sentence was accompanied with four choices with different suffixes (e.g., *Our teacher taught us how to* _______ *long words. Choices: jittling/jittles/jittle/jittled)*. The research assistant read the 18 items aloud as the child followed along, and the child circled their answer on the page for each item. Every item was attempted and the score was the number correct out of 18. Cronbach's α was .82 in our study.

Prosodic awareness

Our PrA measure taps into a participant's ability to identify word-level stress in multisyllabic words (Wade-Woolley, 2016). Children listened to pre-recorded English words, one at a time, through headphones. The 30 English words ranged between two and five syllables in length (e.g., *market, organization*). After hearing each word, they were to identify the syllable in the word that contained the primary stress, main beat, or strongest emphasis by repeating the syllable (e.g., *KNOW in knowledge*), or by indicating the position of the stressed syllable (e.g., *first syllable*). All items were attempted and the score was the number correct. Cronbach's alpha was .64 for our study.

Word reading

The Word Identification subtest from the Woodcock Reading Mastery Tests—Revised (Woodcock, 1998) assesses isolated word reading with 106 items. Grade 4 students begin on item 38 and Grade 5 students begin on item 56. Children must read the first six words correctly to move onto the next page. The discontinue rule is six consecutive errors. The score was the number of correct answers. The split-half reliabilities for word identification were reported at .97 for Grade 3 and .91 in Grade 5 in the manual.

Pseudoword reading

The Word Attack subtest from the WRMT-R (Woodcock, 1998) assesses decoding ability of up to 45 isolated pseudowords increasing in level of difficulty. Children read aloud all items and received a score for the number correct. The discontinue rule is six consecutive errors. The manual reports a split-half reliability score of .93.

Word reading fluency

The Test of Word Reading Efficiency (TOWRE) Sight Word Efficiency (Torgesen, Wagner, & Rashotte, 1999) assesses isolated word reading fluency within a 45 s time limit with up to 104 items that increased in difficulty. The score was total number correct. The TOWRE contains normative data for 6 to 24 years of age and has test–retest reliabilities of .82 to .97.

Pseudoword reading fluency

The TOWRE Phonemic Decoding Efficiency (Torgesen et al., 1999) subtest is similar to TOWRE Words with the exception that the words being read are unfamiliar pseudowords. Pseudowords ranged from one to four syllables. The score was the total number of correctly pronounced pseudowords out of 63 items. The manual reports test–retest reliabilities from .82 to .97.

Reading comprehension

Two measures of reading comprehension were administered. The Gray Oral Reading Test-Fourth Edition assesses oral reading rate, accuracy, and comprehension of short passages (Wiederholt & Bryant, 2001). Only children's comprehension scores were used. There were 14 passages of connected text, varying in length and content. After reading each passage aloud, participants answered 5 comprehension questions for that passage. The score was the total number of correct answers for the comprehension questions. Ceiling was reached when children received a score of 2 or less on the set of comprehension questions on any passage. The manual reports Cronbach's $\alpha = .90$ and test–retest reliabilities from .78 to .95. The second reading comprehension measure was the Passage Comprehension subtest of the WRMT-R (Woodcock, 1998). Participants read a series of short passages silently. Each passage contained a missing word, and they were to provide a word that would complete each passage. The termination rule was six consecutive errors. The manual reports a split-half reliability for the Passage Comprehension subtest of .73.

Data Analysis

For our first research question, the relationship between PrA and MA is examined using correlational analyses. For the present study, correlations will be described as low when *r* is above .1, moderate when *r* is above .3, moderately high when *r* is above .5, and high when *r* is .7 or greater (Cohen, 1992; Field, 2009). For our second research question, hierarchical multiple regression is used to investigate the independent contributions of predictors in our model to reading outcomes (Cohen, Cohen, West, & Aiken 2003; Field, 2009). We are most interested in examining whether PrA and MA each independently predict reading outcomes after accounting for established predictors. After controlling for age and grade (step 1), predictors will be entered into the model in different steps guided by previous studies (e.g., Deacon et al., 2018; Holliman et al., 2017; Kirby et al., 2012; Wade-Woolley, 2016). Verbal and nonverbal ability will be entered in the second step, followed by naming speed (step 3), and segmental PA (step 4). For word reading, the effects of PrA and MA will be examined in steps 5 and 6, and then the entries of each predictor will be reversed to examine their independent effects on word reading after accounting for each other. For reading comprehension, word reading will be entered in step 5, followed by PrA and MA in steps 6 and 7 and will be entered in reverse order similar to the word reading model. The final research question will be analyzed using mediation analyses (Baron & Kenny, 1986). This method is used to examine the relationship between an independent variable and an outcome variable in the presence of a third or mediating variable (Fairchild & McDaniel, 2017). In the present study, we are interested in the role of prosody in reading in the presence of multiple mediators including segmental PA and MA for word reading; and segmental PA, MA, and word reading for reading comprehension.

The advantages of multiple mediation analyses include (a) examining an overall effect for a model, (b) exploring the extent to which each predictor mediates the relationship between an independent and dependent variable in the context of other predictors, (c) accounting for multiple variables to reduce parameter bias, and (d) examining the magnitude of the indirect effects for all mediators (Preacher & Hayes, 2008). The mediation models are tested using version 3.1 of the program PROCESS (Hayes, 2018). Because PROCESS only reports unstandardized beta coefficients, we used standardized *z*-scores of the variables in our models so that all results would represent standardized beta coefficients. To conclude if the mediated effects within our models are statistically significant, we bootstrapped standard errors using 5000 resamples to calculate 95% confidence intervals (MacKinnon, Fairchild, & Fritz, 2007; Preacher & Hayes, 2004). Effects with confidence intervals that do not contain zero indicate significant effects and those that include zero are considered nonsignificant.

Results

Table 1 presents the descriptive statistics for all measures. Preliminary analyses involved data screening by examining descriptive statistics, histograms of distributions, stem and leaf plots, and tests of normality using Kolmogorov–Smirnov tests (Field, 2009). Outlier scores were any score that was 3 standard deviations above or below the mean and these scores were subject to winsorization (Ruppert, 2014). Winsorization is a method for transforming outlier scores that preserves the data point and ranking of the outlier scores, while ensuring that the distribution is not pulled positively or negatively in one direction (Field, 2009; Ruppert, 2014). Management of outlier scores is important for regression analyses including multiple regression and mediation analysis that assumes multivariate normality (Fairchild & McDaniel, 2017; Tabachnick & Fidell, 2001). Outlier scores were transformed to the next highest acceptable (non-outlier) score plus 1, or the lowest acceptable (non-outlier) score minus 1. The following measures had outliers that were transformed using winsorization: (a) nonverbal ability, (b) naming speed, (c) word reading fluency, (d) pseudoword reading fluency, (e) oral text comprehension, and (f) silent text comprehension. All subsequent analyses were performed using transformed variables.

Table 1 Descriptive statistics for all measures (raw scores) $N=110$

Variables	*M*	*SD*	*Min*	*Max*
Age	124.96	7.23	111	137
Predictors				
Nonverbal ability	19.60	6.58	3	30
Verbal ability	36.66	9.59	17	56
Naming speed (seconds)	34.30	6.94	20	54
Segmental phonological awareness				
Elision	14.75	4.46	4	20
Blending	12.66	3.67	6	20
Morphological awareness				
Production	25.88	7.12	7	40
Nonword suffix choice	10.89	4.37	2	18
Suprasegmental phonology				
Prosodic awareness	12.64	4.21	5	25
Reading outcomes				
Word reading				
Word identification	70.21	11.96	38	99
Word attack	28.50	8.29	8	42
TOWRE words	67.71	12.05	30	90
TOWRE pseudowords	31.57	13.41	6	61
Reading comprehension				
GORT-4	28.46	7.96	5	49
Passage comprehension	37.63	6.65	21	52

The correlation between segmental PA measures was in the low to moderate range, $r = .30$, $p < .01$, while the relationship between measures of MA (Production and Nonword Suffix, $r = .69$, $p < .001$), word reading (Word ID, Word Attack, TOWRE Words, TOWRE Pseudowords, $r = .73$ to $.86$, $p < .01$), and reading comprehension (GORT-4 and Passage Comprehension, $r = .58$, $p < .001$) were in the moderately high to high range. We derived composite scores for segmental PA, MA, word reading, and reading comprehension by averaging z-scores. Composite scores were used for all subsequent analyses. Table 2 presents the zero-order correlation matrix for predictors and reading outcomes.

Age was not a significant correlate with word reading or reading comprehension, however it was significantly correlated with verbal ability and MA. Grade was significantly correlated with word reading, verbal ability, naming speed, and MA. All remaining predictor variables were significantly correlated with both reading outcomes. PrA was correlated with word reading, $r = .36$, $p < .001$, and reading comprehension, $r = .25$, $p < .01$ in the low to moderate range. MA was highly correlated with word reading, $r = .76$, $p < .001$, and reading comprehension, $r = .78$, $p < .001$. The association between word reading and reading comprehension was high, $r = .71$, $p < .01$. Other notable associations above .60 include verbal ability and reading comprehension, $r = .64$, $p < .001$, and verbal ability and MA, $r = .77$, $p < .001$.

Our first research question addressed the relationship between PrA and MA. PrA and MA was significantly correlated at $r = .23$, $p < .05$. Our second research question tested a multiple regression model to examine the contributions of PrA and MA to word reading after accounting for known cognitive predictors (see Table 3, upper part). Hierarchical multiple regression was used to examine the unique effects of predictors entered into each step of the model of word reading (Cohen et al., 2003). Age and grade were entered in the first step. Verbal and nonverbal ability were entered in the second step, followed by naming speed in the third step, and segmental PA in the fourth step. PrA and MA were entered alternately in steps 5 and 6 to explore unique contributions when controlling for the other.

In the model predicting word reading, the total variance explained by all predictors was 73%, of which the control measures accounted for 61%. PrA explained an additional 3% in the fifth step, with MA uniquely predicting 9% in the last step. When the entries were reversed with PrA in the final step, PrA continued to explain 3% of the variance after accounting for MA (9%). In the final model, the two largest unique effects were for MA and naming speed. These results suggest that both automaticity and knowledge about the morphemic structure of words is related to stronger word reading abilities.

To address the third research question, we tested a second regression model predicting reading comprehension after accounting for word reading and known cognitive predictors (Table 3, lower part). We took the same approach and entered age and grade in the first step, followed by verbal and nonverbal ability in the second step. Naming speed was entered in the third step, and segmental PA in the fourth step. We entered word reading in the fifth step, followed by PrA and MA in the sixth and seventh steps. In total, our predictors explained 66% of the variance in reading comprehension. The control variables accounted for 55% of the variance, and word reading explained an additional 7% in the model. When PrA and MA were

Table 2 Correlations between all variables ($N = 110$)

Variables	1	2	3	4	5	6	7	8	9	10
1. Age	–	.82***	.16	.14	.05	.33**	−.14	.02	.28**	.03
2. Grade		–	.27**	.19	.10	.30**	−.23*	.03	.38***	.07
3. Word reading			–	.71**	.23*	.58***	−.49***	.54***	.76***	.36***
4. Reading comprehension				–	.35***	.64***	−.37***	.48***	.78***	.25**
5. Nonverbal ability					–	.25**	.05	.33**	.45***	.07
6. Verbal ability						–	−.21*	.42***	.77***	.19*
7. Naming speed							–	−.10	−.31**	−.09
8. Segmental PA								–	.54***	.22*
9. Morphological awareness									–	.23*
10. Prosodic awareness										–

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

Table 3 Hierarchical regression analyses predicting Word Reading and Reading Comprehension ($N = 110$)

Step and predictor	Entry β	ΔR^2	Final β	R^2
Word reading				
1. Age	−.19	.08**	−.10	.08**
Grade	.43*		.06	
2. Verbal ability	.56***	.30***	−.002	.38***
Nonverbal ability	.06		−.12	
3. Naming speed	−.39***	.14***	−.29***	.52***
4. Segmental PA	.34***	.09***	.18**	.61***
5a. Prosodic awareness	.19**	.03**	.17**	.64**
6a. Morphological awareness	.60***	.09***	.60***	.73***
5b. Morphological awareness	.63***	.09***		
6b. Prosodic awareness	.04**	.03**		
Reading comprehension				
1. Age	−.04	.03	.03	.03
Grade	.22		−.16	
2. Verbal ability	.61***	.42***	.12	.45***
Nonverbal ability	.20**		.06	
3. Naming speed	−.27***	.07***	−.11	.52***
4. Segmental PA	.19*	.03*	.002	.55***
5. Word reading	.43***	.07***	.22	.62***
6a. Prosodic awareness	.01	.00	.03	.62***
7a. Morphological awareness	.49***	.04**	.49***	.66**
6b. Morphological awareness	.49***	.04***		
7b. Prosodic awareness	.03	.00		

For both regression models, prosodic awareness and morphological awareness were reversed in the final steps; *PA* phonological awareness, *$p < .05$; **$p < .01$; ***$p < .001$

entered in the sixth and final steps, PrA was not a unique predictor after controlling for MA. However, MA contributed an additional 4% of variance to the model after all other predictors were accounted for. In the final model, MA was the only significant predictor in the model, indicating that children's morphological skills such as morphological analysis are integral for reading comprehension processes. Although PrA was not a unique predictor of reading comprehension, it was a significant correlate of reading comprehension suggesting that PrA has shared variance with other predictors that support reading comprehension.

Mediation Analyses

We followed up our regression analyses with two multiple mediation models to examine the direct and indirect effects of the prosody-reading relationship. We were interested in examining the extent to which the association between PrA and word reading was mediated by segmental PA and MA. The second mediation model examines PrA and reading comprehension, with segmental PA, MA, and word reading included as mediators. Baron and Kenny (1986) outlined four conditions for mediation: (a) the predictor must be significantly correlated with the outcome variable, (b) the predictor variable must be significantly correlated with the mediator, (c) the mediator variables are significant predictors of the outcome variable as evidenced in regression analyses, and (d) the mediator variables remove the total effects of the predictor variable on the outcome variable (full mediation). In many cases only the first three conditions are satisfied. Partial mediation occurs when a mediator reduces the total effects of the predictor and the predictor remains a significant predictor of the outcome variable after accounting for the relations between the mediator and outcome variable. All conditions were met for both proposed mediation models. PrA was a significant correlate of both reading outcome measures and the three mediators. Our three mediators were significant predictors of our reading outcomes, as reported in our regression analyses (see Table 3). Table 4 presents the total effects, indirect effects, total indirect effects, specific indirect effects, and contrasts for PrA and mediating variables for the two reading outcome measures.

The first mediation model included segmental PA and MA as mediators between PrA and word reading (Fig. 1). Our results revealed that PrA had significant effects on segmental PA, $\beta = .18$, $t(107) = 2.30$, $p < .05$, and MA, $\beta = .20$, $t(107) = 2.35$, $p < .05$. In the full mediation model predicting word reading, PrA, $\beta = .17$, $t(105) = 2.96$, $p < .01$, segmental PA, $\beta = .17$, $t(105) = 2.08$, $p < .05$, and MA, $\beta = .65$, $t(105) = 8.87$, $p < .001$, were significant predictors explaining 79% of the total variance of word reading. While our results show a decrease to the total effects of PrA

Table 4 Mediation of the effect of prosodic awareness on word reading through segmental PA and MA ($N = 107$), and the effect of prosodic awareness on reading comprehension through segmental PA, MA, and word reading ($N = 108$)

Effects	Word reading			Reading comprehension		
	95% BC CI			95% BC CI		
	Point estimate	Lower	Upper	Point estimate	Lower	Upper
Total effect	.33			.22		
Direct effect	.17			.02		
Total indirect effect	.16	.04	.29	.20	.07	.33
Indirect effects						
Seg. PA	.03	.001	.08	.01	− .03	.04
MA	.13	.02	.24	.11	.02	.22
WR	–	–	–	.09	.02	.18
Contrasts						
Seg. PA vs. MA	− .10	− .21	.01	− .10	− .22	− .01
Seg. PA vs. WR	–	–	–	− .08	− .19	− .0002
MA vs. WR	–	–	–	.02	− .08	.15

PrA prosodic awareness; *Seg. PA* segmental phonological awareness; *MA* morphological awareness; *WR* word reading; *BC* bias corrected; *CI* confidence intervals; Indirect effects with confidence intervals that do not include zero are significant at $p < .05$

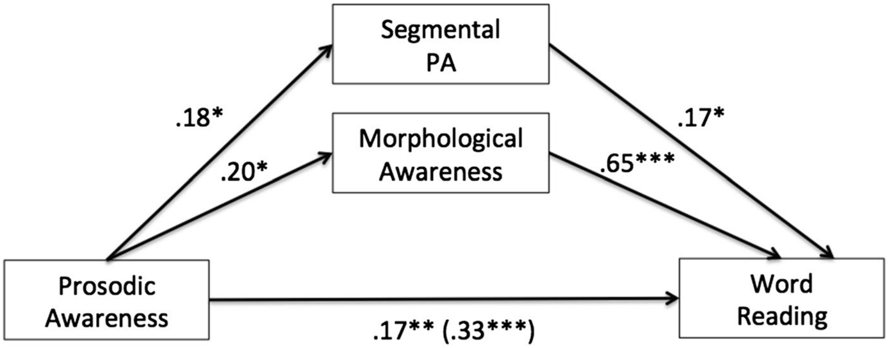

Fig. 1 The multiple mediation model shows the effects of prosodic awareness on mediators and the direct effect of prosodic awareness to word reading. The effect of prosody on word reading that is reduced by mediators is reported followed by the effect of prosody on word reading without mediators is reported in parenthesis. *$p < .05$; **$p < .01$; ***$p < .001$

on word reading, PrA continued to have direct effects on word reading after accounting for mediators, $\beta = .36$, $t(107) = 3.93$, $p < .001$, to $\beta = .17$, $t(105) = 2.96$, $p < .01$. The total indirect effects model was significant with a total effect = .16, $SE = .06$, 95% CI [.04, .29]. Overall, the relationship between PrA and word reading was partially mediated by segmental PA and MA. The indirect effects in the model were significant, and no significant difference was found between the strengths of these two indirect effects. Post hoc power analysis was conducted using G*Power 3.1 (Faul, Erdfelder, Buchner, & Lang, 2009), and it showed that the power to detect the mediation effects at alpha = .05 level was above .99 for word reading. A second multiple mediation model was tested with the same predictors with the addition of verbal ability as a mediator, and the results showed that PrA had no direct effect on verbal ability and verbal ability had no significant direct effect on word reading once the effects of PrA, segmental PA, and MA were accounted for.

The second mediation model tested three mediators in the relationship between PrA and reading comprehension (Fig. 2). In addition to segmental PA and MA, word reading was included as a third mediator because of the contributions of word reading processes to reading comprehension. Our results (see Table 4) showed significant effects of PrA on segmental PA, $\beta = .18$, $t(106) = 2.28$, $p < .05$, MA, $\beta = .20$, $t(106) = 2.32$, $p < .05$, and word reading, $\beta = .34$, $t(106) = 3.97$ $p < .001$. Both MA, $\beta = .54$, $t(103) = 5.78$, $p < .001$, and word reading, $\beta = .26$, $t(103) = 2.77$, $p < .01$, were significant predictors of reading comprehension, however, PrA and segmental PA did not have significant effects on reading comprehension. The total effect of PrA on reading comprehension decreased to a nonsignificant effect, with $\beta = .22$, $t(106) = 2.59$, $p < .05$ decreasing to $\beta = .02$, $t(103) = .35$, $p = .76$. The total indirect effects model was significant with total effects = .22, $SE = .08$, 95% CI [.05, .38]. The only indirect effects that were significant were MA and word reading. Pairwise contrasts revealed that there were no differences in the strength of these indirect effects. Overall, our results indicate that the relationship between PrA and reading comprehension was fully mediated by MA and word reading to explain 80% of the

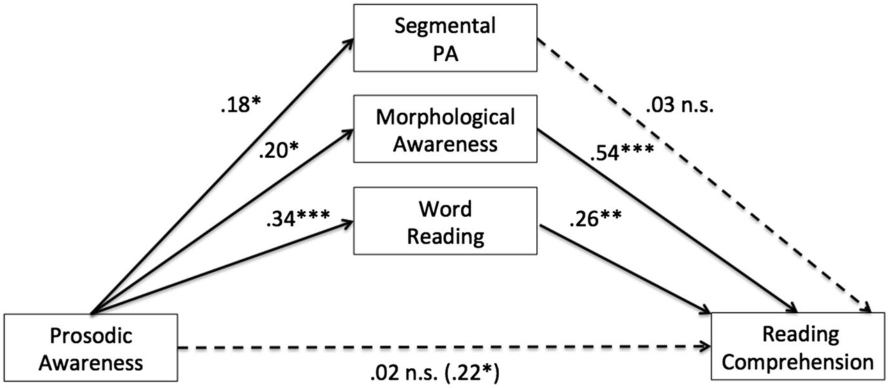

Fig. 2 The multiple mediation model shows the effects of prosodic awareness on mediators, and the direct effect of prosodic awareness to reading comprehension. The effect of prosody on reading comprehension that is reduced by mediators is reported followed by the effect of prosody on reading comprehension without mediators is reported in parenthesis. $*p<.05$; $**p<.01$; $***p<.001$; *ns* non significant

variance of reading comprehension. Post hoc power analysis revealed that the power to detect the mediation effects at .05 level was above .99 for reading comprehension. A second multiple mediation model was tested with the same predictors with the addition of verbal ability as a mediator, and similar to the word reading model, the results showed that PrA had no direct effect on verbal ability and verbal ability had no significant direct effect on word reading once the effects of PrA, segmental PA, MA, and word reading were accounted for.

Discussion

The purpose of this study was to examine both PrA and MA in models of word reading and reading comprehension. PrA and MA were correlated in the low to moderate range. Both metalinguistic skills were unique predictors of word reading, above and beyond segmental PA and other known cognitive predictors. MA was the only predictor of word reading that continued to explain variance in reading comprehension. Our mediation models show unique direct and indirect effects of PrA on word reading through segmental PA and MA, and significant indirect effects of PrA on reading comprehension through MA and word reading.

Consistent with previous studies, we found a significant correlation between PrA and MA (Deacon et al., 2018; Holliman et al., 2017; Kim & Petscher, 2016). These results extend Wood et al.'s (2009) theory of PrA to more experienced readers. Children in upper elementary grades encounter longer words across content areas that contain multiple syllables and multiple morphemes that are hard to pronounce. PrA and MA may be related because children attend to PrA when there are changes to linguistic information (e.g., vowel reduction, word stress), and when reading morphologically complex words. Our MA production measure included words appropriate for upper elementary students, with over half the items involving derivational suffix changes that result in shifts in primary stress (e.g., *eLECtric* → *elecTRIcity*). For the mediation model, we hypothesized that PrA contributes to MA. It is plausible that this relationship may be reciprocal in nature among more experienced readers. Children's acquisition of derivational morphology familiarizes children with stress patterns associated with suffix changes, and morphological knowledge may also reinforce PrA (Jarmulowicz et al., 2008).

We provide evidence that both morphological and phonological processes are metalinguistic skills that are unique predictors of word reading abilities beyond the initial stages of reading, and should be considered in models of reading. The findings of our regression analyses are similar to findings found for younger readers between 7 and 8 years old (Holliman et al., 2017). At the word level, prosodic information such as word stress may contribute to the quality of lexical representations. The correct application of stress is a critical component in decoding lower frequency, multisyllabic words (Heggie & Wade-Woolley, 2017; Wade-Woolley, 2016). Further, PrA represents phonological processing at the suprasegmental level that may be a stronger predictor of reading in more experienced readers.

MA explained a significant amount of variance in the model of word reading after accounting for both levels of PA. Our findings are consistent with numerous studies that demonstrate the contributions of MA in word reading and decoding (e.g., Deacon et al., 2018; Holliman et al., 2017; Kirby et al., 2012; Levesque et al., 2017). MA encompasses multiple subskills such as morphological decoding, which involves decomposing morphologically complex words to support efficient and accurate pronunciations, which are all a part of the mental representations of words (Deacon et al., 2017). The strong correlations reported in our study between MA, vocabulary, word reading, and reading comprehension, $r = .76$ to .78, suggest MA is integrating phonological, orthographic, and semantic information to support decoding and meaning-making processes (Kirby & Bowers, 2017).

Our last research question focused on reading comprehension. PrA was not a unique predictor of reading comprehension, whereas MA was the only predictor of word reading that continued to explain additional variance in reading comprehension after controlling for word reading and known cognitive predictors including vocabulary and naming speed. Our findings are consistent with previous findings showing direct contributions of MA to reading comprehension (Deacon et al., 2018; Kirby et al., 2012; Levesque et al., 2017). The effects of MA on reading comprehension provide further evidence of the role of morphological knowledge in supporting decoding, and in turn facilitating comprehension processes (Jarmulowicz et al., 2008). One critical component of reading comprehension is knowledge about the meanings of words presented in text (Perfetti, Landi, & Oakhill, 2005). Children reading text may encounter words they do not know, in which case they must infer their meanings. They may look at a word and ask themselves: It is a word that I have seen before? Do I recognize parts of the word? Is there a prefix or suffix? Does the surrounding text help with understanding the meaning? Moreover, children may infer the meaning of a word by applying morphological knowledge (Bowers & Kirby, 2010), and knowing the meanings of words supports the reader with deciphering the meaning of the text.

We followed up our predictive models with two multiple mediation analyses to investigate the direct and indirect relations between PrA and reading abilities. PrA had a direct effect on word reading that was partially mediated by segmental PA and MA. Although PrA was a significant correlate of reading comprehension, this effect disappeared when phonemic awareness, MA, and word reading were included as mediators in the model. Thus MA and word reading fully mediated the relationship between PrA and reading comprehension. These mediation analyses demonstrated that PrA primarily contributed to word level processes, which in turn support reading comprehension, whereas MA contributed directly to both word reading and reading comprehension (Deacon et al., 2014; Kirby et al., 2012).

Contrary to the findings of both Kim and Petscher (2016) and Holliman et al. (2014), we found a direct relationship between PrA and MA, and PrA and word reading. Our findings are consistent with the pathways illustrated in Wood et al.'s (2009) theory of PrA, and extend their theory to upper elementary students. There are several methodological considerations in understanding these differences between prior studies and the current study. First, the word-level PrA measure used by Kim and Petscher (2016) asked children to identify the syllable with the primary stress in two-syllable words, whereas, our measure included two- to five-syllable words, thus challenging their PrA skills to a greater extent. Second, the children in the present study were several years older than those in Kim and Petscher's study and therefore should have seen more multisyllabic words. Third, our word reading composite was composed of isolated word reading and pseudoword reading in untimed and timed conditions, with a range of multisyllabic words from one and five-syllables. For instance, over 50% of the words read by our students on the word identification measure (Woodcock, 1998) were between three to five syllables in length. Kim and Petscher (2016) do not report the grade level norms for their 6 to 9 year old sample, however, the mean number of words read reported in their descriptive statistics for the Wechsler Individual Achievement Test-Third Edition (WIAT-III) suggests that over 80% of the words were one-syllable words, and the remaining items were two-syllable words (Wechsler, 2009). The developmental reading levels of the participants and the characteristics of the multisyllabic words within word reading, segmental PA, PrA, and MA measures may affect findings about the contributory role of PrA and MA in reading outcomes.

Implications for Instruction

It is important to acknowledge that the implications for instruction are limited by the characteristics of our study sample. However, we would like to take this opportunity to include a few considerations for assessment and intervention. First, educators and researchers are encouraged to consider opportunities to develop PrA in early literacy instruction. Phonological interventions that focus on prosody are limited in number and specific prosody interventions have been focused on children with communication disorders with very small sample sizes (e.g., Hargrove, Anderson, & Jones, 2009). There are promising findings from a 10-week speech rhythm based intervention for typically developing 4 and 5 year olds in which significant improvements to word reading abilities were retained 3 months later (Harrison et al., 2017). Our results for typically developing children in older grades show that PrA contributes directly to word reading processes indicating that PrA may be a dimension of phonology that needs to be considered more explicitly in the classroom in later grades. Further, the relationship between PrA and MA indicates the importance of considering how current morphological interventions may incorporate a focus on prosody. For example, Goodwin and Ahn (2013) described how morphological instruction may involve segmenting multisyllabic words into morphemes and blending morphemes with different prefixes and suffixes to create longer words (see also Kirby & Bowers, 2017, 2018). In reading long words, children may benefit from explicit discussion about suprasegmental PA such as stress-neutral and stress-shifting suffixes to support pronunciation efforts and their phonological representations of these words (Wade-Woolley & Heggie, 2015). Further, our findings are aligned with ongoing research showing the importance of incorporating morphological instruction in early reading development and continuing to focus on morphological instruction in supporting reading comprehension in later grades (e.g., Goodwin & Ahn, 2013). Bowers et al. (2010) described a variety of MA instruction including morphological analysis, morphological recognition, morphological production, and morphological problem-solving, which have led to improved literacy skills for all children, particularly those with weaker skills in reading. Moreover, there is strong evidence for the effects of morphological instruction in supporting children's reading; future studies should investigate the value of adding a prosodic component to morphological instruction.

Limitations and Future Directions

Several methodological limitations in this study are worth noting. First, the instruments used to measure PrA vary widely across studies with low to moderate reliability. For instance, Deacon et al. (2018) used a global measure of prosodic sensitivity including word stress, intonation, and syllable timing with reported reliability of .63. In comparison, our PrA measure involved identifying the syllable containing the primary stress in a multisyllabic word, which had a reliability of .64. Deacon et al. (2018) did not find unique contributions of PrA to word reading, and they reported correlations between PrA and segmental PA at $r = .51$, and PrA and MA at $r = .46$. Our findings revealed unique direct and indirect effects of PrA and MA on word reading, and lower correlations between PrA and segmental PA at $r = .22$, and PrA and MA at $r = .23$. Including multiple indicators of PrA and MA that are developmentally appropriate would improve construct validity and reliability of our measures.

Second, our results showed that MA was highly correlated with vocabulary, word reading, reading comprehension with $r\text{s} > .76$, $p < .01$. The strong correlations among these variables raise concerns about multicollinearity, however, all measures were standardized or adapted measures of previously used instruments. We created composite scores for the multiple measures that made up MA, word reading, and reading comprehension to reduce measurement error. The inclusion of other MA subskills such as morphological decoding and morphological analysis (Deacon et al., 2012; Levesque et al., 2017) may provide a more comprehensive account of how specific MA skills are contributing to word reading and reading comprehension.

Third, our sample was limited to Grades 4 and 5 students, and our sample size limited our ability to test the full theory of PrA (Wood et al., 2009). To examine the developmental continuum of these skills, a larger sample size is needed to replicate and evaluate the path models presented by Kim and Petscher (2016) and Holliman et al. (2014). Further research is needed to examine how the pathway models outlined in Wood et al. (2009) apply to readers as a function of age, reading experience, and reading skill. PrA at the word and phrase levels may support reading at different stages of reading development and in different aspects of reading. Recent research on Grade 5 poor comprehenders showed that children with intact decoding skills had deficits with both reading prosody and speech rhythm activities (Groen, Veenendaal, & Verhoeven, 2019). It would be fruitful to evaluate a developmental model that included both word-level and text-level PrA measures such as oral reading prosody to examine the associations with additional reading outcome measures including fluent reading of connected text, silent reading of connected text, re-tell, or summarization that assesses higher-level comprehension skills (Miller & Schwanenflugel, 2008; Schwanenflugel, Hamilton, Kuhn, Wisenbaker, & Stahl, 2004). Lastly, there is a paucity of longitudinal studies that examine the development of PrA and MA and their relationship to different reading outcomes. A longitudinal study involving cohorts of early and later elementary readers would show how segmental PA, PrA, and MA skills develop in tandem to support reading processes as children become more skilled readers.

Conclusion

The present study focused on prosody and morphology in Grade 4 and 5 children. Our findings revealed that PrA and MA each independently explained unique variance in word reading, and MA accounted for unique variance in reading comprehension. We also examined the relationship between PrA and MA and found that MA partially mediated the relationship between PrA and word reading, and fully mediated the relationship between PrA and reading comprehension. Other researchers are encouraged to consider the inclusion of prosody as a dimension of phonology that predicts reading in older children, and investigate the potential role of prosody in supporting morphological development.

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