Early development and predictors of morphological awareness: disentangling the impact of decoding skills and phonological awareness.

Abstract
Background: Morphological Awareness (MA) has been demonstrated to be influential on the reading outcomes of children and adults. Yet, little is known regarding MA's early development.
Aim: The aim of this study is to better understand MA at different stages of development and its association with Phonological Awareness (PA) and reading.
Methods and Procedures: In a longitudinal design the development of MA was explored in a group of pre-reading children with a family risk of dyslexia and age-matched controls from kindergarten up to and including grade 2.
Outcomes and Results: MA deficits were observed in the group with literacy difficulties at all time points. PA was only found to make a significant contribution to MA development at the early stages of formal reading instruction. While first-grade decoding skills were found to contribute significantly to MA in second grade.
Conclusions: Evidence supporting a bidirectional relation was found and supports the need for adequate MA intervention and explicit instruction for "at risk" children in the early stages of literacy instruction.

1.1 Introduction

Reading is a vital skill acquired in the first years of formal education and has been argued to be an essential skill learned in early elementary school (e.g. Lyon & Moats, 1997). For most children, the transition from an oral to a written language system is relatively effortless. However, for a small proportion of children, in the absence of any explanation, this transition presents some difficulties. In cases where these literacy struggles remain unexplained and persistent, they are referred to as the developmental condition of dyslexia (Snowling, 2000). Research has been unsuccessful in identifying a single causal variable associated with the expressed literacy difficulties of individuals with dyslexia which has led to the adoption of a multi-deficit approach in examining the root causes of dyslexia (Pennington, 2006). While not denying the often observed phonological impairments associated with the literacy struggles of individuals with dyslexia, research has begun to explore alternative cognitive variables which may account for additional variance in explaining the literacy struggles of these individuals. One such variable, morphological awareness (MA), which is the explicit awareness and ability to manipulate and reflect upon the morphemic structure of words, is a cognitive variable that has been suggested as both a potential risk and/or protective factor. As the orthography of English embodies both phonological and morphological information (Chomsky & Halle, 1968), it is reasonable to assume that an explicit awareness of both morphological awareness and phonological awareness would be required in the development of adequate reading abilities (Berninger, Abbott, Nagy, & Carlisle, 2010; Deacon & Kirby, 2004; Rastle, Davis, Marslen-Wilson, & Tyler, 2000).

Although a few studies have demonstrated that MA is acquired prior to the onset of formal reading instruction (Berko, 1958, Casalis & Louis-Alexandre, 2000; Law et al., 2016), little is still known about MA's development and early attainment. As children who later are found to develop dyslexia exhibit early literacy struggles and pre-reading phonological awareness (PA) deficits, an understanding of how these deficits influence MA's early development is crucial in understanding MA's role in dyslexia. Thus, in a longitudinal design of children with and without literacy difficulties, this study investigates morphological awareness' development and association with phonological awareness and early literacy acquisition in children. A better understanding of early MA will help in addressing MA's role as a risk and/or protective factor in the development of dyslexia and reading difficulties of children.

1.2 Dyslexia

Dyslexia is a lifelong neurodevelopmental disorder characterized by severe reading and/or spelling impairments (Vellutino, Fletcher, Snowling, & Scanlon, 2004). It has been well established in the literature that a major contributing variable of the expressed literacy problems lay within a deficit in the development of —or access to— phonological representations (Snowling, 2000; Tønnessen, 1997). Manifestations of this phonological deficit have been observed in: difficulties with the retention of information in the phonological loop of working memory; reduced speech in noise perception; poor lexical retrieval, and a reduced capacity to manipulate the phonemic structure of words (Wagner & Torgesen, 1987).

Over the past several decades, reading research has amassed an impressive body of evidence demonstrating the importance of phonological awareness (PA) in literacy achievement. PA's strong association with reading has been observed across various alphabetic languages and has been found to exist despite individual differences in age, vocabulary knowledge, reading experience, and IQ (Bradley & Bryant, 1983; Kirby, Parrila, & Pfeiffer, 2003; Melby-Lervåg, Lyster, & Hulme, 2012). As a group, dyslexic readers have been shown to perform more poorly than normal reading controls on a variety of measures involving the perception, manipulation, production and retrieval of phonological information (e.g. Melby-Lervåg, Lyster, & Hulme, 2012 and Snowling, & Stackhouse, 2013). Yet, the presence of a phonological deficit is not capable of explaining all the behavior symptoms which define dyslexia, leading researchers to examine alternate cognitive deficits to aid in the explanation of the behavior symptoms (Pennington, 2006).

1.3 Morphological awareness

Of the metalinguistic processes available to readers, morphology, in contrast with phonology, has received noticeably less consideration and has often been treated as a consequence of the poor reading experience and/or a phonological defect associated with dyslexia (Snowling, 2000; Vallutino & Fletcher, 2005). Research across a multitude of languages and age groups has found that dyslexics often underperform across a variety of measures of MA when compared with chronologically age-matched peers while, at the same time, being found to perform similar to or better than younger reading age-matched controls (Casalis, Colé, & Sopo, 2004; Fowler, Liberman, & Feldman, 1995; Robertson, Joanisse, Desroches, & Terry, 2012; Tsesmeli & Seymour, 2006). These findings suggest that MA deficits are not causal to dyslexic's reading struggles and may be a consequence of poor reading experience or a more primary deficit, like the phonological deficit often associated with dyslexia. Alternatively, several studies have proposed that morphological awareness may be a relative strength in individuals with dyslexia, offering means of achieving some level of compensation (Burani et al., 2008; Cavalli, Duncan, Elbro, El Ahmadi, 2016; Elbro & Arnbak, 1996; Law, Wouters & Ghesquiere, 2015). Although MA and dyslexia have been investigated across various ages, research examining the presence of MA deficits in children with dyslexia or literacy impairments prior to or during the early years of literacy acquisition are lacking, thus limiting our understanding of early MA development and its relation to early literacy difficulties.

Studies have demonstrated that an awareness of morphemes, the smallest linguistic units retaining meaning, contributes to word recognition, spelling, and reading comprehension, independent of orthographic processing, phonological awareness, RAN, and vocabulary (Carlisle, 2000; Casalis & Louis-Alexandre, 2000; Deacon & Kirby, 2004; Kirby et al., 2012; Roman, Kirby, Parrila, Wade-Woolley, & Deacon, 2009).

Theoretically, there are a number of reasons why MA would be a factor in reading success, and by extension, reading failure. Firstly, the majority of the vocabulary that individuals are daily exposed to are morphemically complex, with an estimated 60% of the new words acquired by school-aged children containing relatively transparent morphological structures (Nagy & Anderson, 1984). Furthermore, many multi-morphemic words in the English language exceed what can be read in a single fixation. It is thought that the decomposition of the morphological structure would enable, and thus speed up, processing while reading (Elbro 1989). Support for this has been provided by several priming studies that have suggested the lexicon be morphologically organized (Diependaele, Sandra, & Grainger, 2005; Feldman, 1991; Leikin & Zur Hagit, 2006). In addition to aiding lexical processing, such segmentation assists in the pronunciation of letter sequences. For instance, segmentation along the morpheme boundary supports the accurate pronunciation of the ‘ea’ in ‘reach’, where it is processed as one phoneme, versus the ‘ea’ in ‘react’, which is pronounced separately due to its placement in two adjacent morphemes (Bowers, Kirby, & Deacon, 2010).

Secondly, phonics alone cannot explain many of the linguistic inconsistencies in English, while inconsistencies may make sense from a morphological perspective (Nunes, Bryant, & Bindman, 2006). For instance, we do not spell *health* as *helth,* which would be consistent with phoneme-grapheme correspondence rules, but it is written as *health* to maintain the spelling of the root morpheme *heal*.

Lastly, morphemes retain syntactic and semantic information that is thought to aid in the comprehension of new or infrequent words. For instance, an understanding of the base morphemes ‘magic’ and ‘ian’ would help to facilitate the comprehension of ‘magician’ as referring to a person who produces magic. The syntactic and semantic information provided by the morpheme has been demonstrated to aid in vocabulary acquisition (Nagy, Berninger, & Abbott, 2006; Singson, Mahony, & Mann, 2000; Sparks

& Deacon, 2015), in the reading comprehension of children (Carlisle & Feldman, 1995; Deacon & Kirby, 2004) and in adults (Nagy et al., 2006; Wilson-Fowler & Apel, 2015).

The relationship between MA and reading may not be so straightforward. A recent study by Deacon, Benere, and Pasquarella (2013) provided evidence for a bi-directional relation between MA and reading. In a longitudinal study, Deacon and colleagues followed one hundred second grade students through to third grade. To gather insight into the temporal relationship between MA and reading, analyses included autoregressor controls. Deacon and colleagues reported that early MA of children was associated with gains in reading to the same extent MA was found to contribute to later reading, thus offering support to the existence of a bi-directional relationship. These findings led Deacon and colleagues to claim that morphological awareness is partly obtained through reading accuracy. Longitudinal studies, however, examining the relation between reading and MA are currently lacking, thus limiting our understanding of reading influences MA over time, especially in the early stages of literacy acquisition. The use of a longitudinal prospective design encompassing a pre-reading population would allow for the verification of whether the postulated MA deficits of individuals with dyslexia precede the literacy problems and whether the onset of literacy instruction influences the growth of MA.

1.4 Early acquisition and development of MA

Studies of pre-reading children have demonstrated that MA is acquired prior to the onset of formal reading instruction (Berko, 1958, Casalis & Louis-Alexandre, 2000; Law et al., 2016). However, this early attainment is often limited to aspects of inflectional morphology, such as tense markers '–ed' and the simple derivations which do not involve phonological shifts (e.g. 'jump' to 'jumper') (Berko, 1958; Carlisle & Feldman, 1995), while on the other hand, studies have shown that growth in derivational morphology, which is not entirely predictable or transparent, continues after the onset of reading and endures until high school (Nagy, Diakidoy, & Anderson, 1993).

In a study of pre-reading children, Berko (1958) used an oral, non-word completion task that asked children to produce an inflection or simple derivation from a target non-word in order to complete a sentence (i.e. Here is one WUG; now look there are two of them, there are two _____ [WUGS]). Berko noted evidence of an incomplete form of MA at this stage of development due to the fact that children as young as five-years-old were able to complete this task, yet struggled with tasks requiring more complex morphological transformations. Evidence has been provided suggesting that because of age and increased print exposure and reading instruction, a child's morphological awareness is expanded due to the introduction of a wider range of morphologically complex words (Berninger et al., 2010; Carlisle & Fleming, 2003; Nagy & Anderson, 1984). In a longitudinal study, Carlisle and Fleming (2003) found that although five to six-year-old children were capable of performing simple morphological decomposition of familiar words, they did not possess any explicit knowledge of the lexical or syntactic information contained within the affixes, yet by third grade, these skills had progressed.

1.4.1 Impact of phonological awareness on early morphological awareness

Early MA acquisition has been shown to be dependent on an individual's pre-reading PA, independent of vocabulary (Carlisle and Nomanbhoy, 1993; Cunningham and Carroll, 2015; Law et al., 2016). Chiat (2001) argued that as children are exposed to speech in context, they segment the target speech stream into available phonological components, which are capable of being generalized or related to the context at hand. This mapping between relevant phonological units and contextual cues allows for the formation of generalizable semantic and syntactic units of information and therefore spurs on morphological learning, for instance, the learning of the morpheme *'-ing*.' Early on, children begin to recognize and segment the phonological unit '*–ing'* from speech in addition to taking note of its co-occurrence with generalizable actions which are present in the same context. Through repeated exposure, mappings between speech units and meaning are formed (i.e. "look at the man jumping" while a man is seen jumping (Law et al., 2016)). Studies have demonstrated that more complex phonological shifts between base and derived form are unattainable for many children first learning to read (e.g. divide and division, invade and invasion), while gains in PA and an increased sensitivity to the phonemic structure of language aid in the learning of morphophonemic rules, thus furthering morphological learning (Carlisle & Nomanbhoy, 1993).

Support of phonology's early influence on MA development has been demonstrated through correlational evidence, for instance, by Casalis and Louis-Alexandre (2000), who reported strong links between pre-reading measures of PA and MA. In addition, a study by Cunningham and Carroll (2015) demonstrated pre-reading phonological processing's ability to predict MA in grade one students. More recently, Law et al., (2016) addressed questions concerning PA's relationship at various grain sizes (syllable, onset/rime, and phoneme) with measures of auditory processing and MA, independent of reading experience. Law and colleagues demonstrated that prior to reading instruction, there is evidence of the existence of both MA and PA deficits in children with a family risk of dyslexia. An investigation into the relationship of these two deficits provided evidence suggesting that the observed early pre-reading MA of children with a family risk of dyslexia was a function of the individual's pre-reading PA deficit.

Further support of PA's involvement in MA acquisition has been provided through intervention studies that have demonstrated gains in MA skills through PA instruction in both typically developing kindergarten children and those with speech impairments (Casalis & Colé, 2009; Kirk & Gillon, 2007).

Therefore, it is reasonable to assume that a pre-reading phonological impairment, typical of children who are later diagnosed with dyslexia, would impede the early acquisition and development of an individual's MA, and ultimately, impact future reading success. Questions remain, however, surrounding the continuity over time of PA's observed influence on MA acquisition during the first years of reading. Two recent studies have provided evidence of intact MA in some adults with dyslexia in the presence of a PA deficit, indicating MA's potential disassociation with the influence of PA observed earlier in life (Cavalli et al., 2016; Law et al., 2015).

1.5 The present study

In a longitudinal design, the present study set out to examine the development of MA starting in the pre-reading phase, through early literacy instruction until the development of decoding skills. Early MA acquisition was assessed in relation to both PA and the early development of decoding skills in a sample of children who later were found to have literacy difficulties in second grade, and a group of typically developing readers with no family history of dyslexia.

For this research project, we followed a group of children who were initially described in a previous study that examined pre-reading children with a family risk of dyslexia and non-risk controls (Law et al., 2016). In this study, we will retrospectively reclassify these participants based on literacy difficulties that were observed in second grade to determine MA deficits' relation to the behaviorally observed literacy difficulties across time. Based on the findings of Law et al., (2016) demonstrated early MA deficits of high-risk children along with past research showing MA deficits in poor and dyslexic readers later in life (Casalis, Colé, & Sopo, 2004; Fowler, Liberman, & Feldman, 1995; Law, et al., 2015, Robertson, Joanisse, Desroches, & Terry, 2012; Tsesmeli & Seymour, 2006), we expect to find an association between literacy difficulties and MA deficits across all time points of this longitudinal study, from kindergarten to second grade.

Secondly, the longitudinal design will allow for an examination of MA achievement over time from kindergarten to second grade, within groups, providing insight into how MA changes from kindergarten till grade 2. Based on previous findings reporting an early association of PA and MA (Cunningham and Carroll, 2015; Law et al., 2016) along with the high association of PA deficits and reading difficulties in children (Law et al., 2016; Snowling, Gallagher, & Frith, 2003), we expected to observe MA deficits coexisting with PA deficits in kindergarten, first and second grades in individuals who later are found with literacy difficulties.

Lastly, this paper will set out to address questions surrounding decoding skills' and PA's independent contribution to MA achievement over time. Based on past studies of PA's and MA's pre-reading relationship, it is expected that PA will be found to make a significant contribution to MA prior to, and after, the onset of formal reading instruction. Decoding skills are expected to have an additional influence on MA achievement above that of PA as a child gains reading experience as suggested by Deacon et al. (2013), thus providing evidence of one possible directional path where reading skill can be seen as influencing later MA, thus supporting the theorized bi-directional relationship of MA and reading proposed by Deacon et al. (2013).

2. Methods

2.1 Participants

Forty-four primary school children were attending the public school system in Ontario, Canada was assessed at three-time points as part of our longitudinal study ranging from kindergarten to the beginning of second grade. Initial recruitment involved children fitting into one of two categories, either being at high-risk (HR) for developing dyslexia, or being at low-risk (LR). The classification of a child being 'high-risk' was based on the child having at least one first-degree family relative with an official diagnosis of dyslexia. The low-risk control group was comprised of children with no family history of reading difficulties.

A parent questionnaire administered upon registration for the study provided information regarding the child's medical history, behavior and family history of reading and spelling (dis)abilities. Also, the survey used the seven-point ISCED-scale to access parental educational levels (UNESCO, 1997). All participants were found to have an adequate nonverbal IQ as defined by a standard score greater than 85 on the Raven's *Coloured Progressive Matrices* (Raven, 1998). Groups were found not to differ on measures of age, IQ, socioeconomic status (SES) and parental educational level. All children were native English speakers and had exhibited no signs of brain damage or long-term auditory or visual impairments. Groups were later checked and matched for intelligence, gender, age, hyperactivity symptoms, SES and educational environment. Participant characteristics are displayed in Table 1. For a more detailed description of participant recruitment and characteristics see Law et al., (2016).

2.2 Retrospective analysis

To allow for an investigation of performance differences across all tasks based upon behaviorally observed literacy problems, subjects were retrospectively divided into two groups: children with literacy difficulties, and children without literacy difficulties, based on their performance on literacy tasks at the start of second grade. For the purposes of this study, a child with literacy difficulties was defined as performing below the 10th percentile on two of the three-second grade literacy measures: word reading, spelling or non-word reading. Similar to Pennington & Lefly (2001), three criteria were used to avoid floor effects on the reading and spelling measures of such young children.

The resulting classification allowed for the creation of a literacy difficulty (LD) group consisting of 17 high-risk children and 4 low-risk children, as well as the formation of a control sample without literacy difficulties of 19 low-risk children. Four children of the original high-risk group were found not to meet the conditions for the label of having literacy difficulties. Past research has demonstrated that although normal reading children with a familial risk of dyslexia may statistically differ from high-risk poor readers across many cognitive and literacy measures, this group is often found to differ significantly from low-risk normal reading controls (Boets, Wouters, Van Wieringen, & Ghesquiere, 2007; Pennington & Lefly, 2001; Snowling, Gallagher, & Frith, 2003; Snowling, Valerie Muter, & Julia Carroll, 2013). Separate statistical analysis, as conducted in previous research, of these high-risk normal reading children would have been ideal, yet was not possible due to the size of the group (n = 4) being too small to provide a meaningful comparison. Due to the ambiguity shown in the literature surrounding this population (for a review see Snowling & Melby-Lervåg, 2016) and our inability to statistically compare this population with controls, it was decided to exclude these individuals from all group level analysis.

2.3 Materials and Procedures

Socio-economic status (SES). SES was assessed with the Family Affluence Scale II (FAS II) developed by the World Health Organization (WHO). This measure of family wealth consists of four parts scored as a composite measure ranging from 0-9. Past studies have demonstrated moderate internal reliability of this test (Cronbach's alpha = 0.58). Individual scores were transformed into categories ranging from low affluence (0-2), middle affluence (3-5) and high affluence (6-9) as demonstrated in Boyce, Torsheim, Currie, and Zambon (2006).

Decoding. For the creation of the decoding variable, we used the word reading and the word attack (non-word reading) subtests from the Woodcock-Johnson III (Woodcock, McGrew, & Mather, 2001). Both tasks were administered in the first and second grade. Standard procedures were followed during test administration. The word reading task consisted of 76 items while the non-word task contained 32 items, each task progressively increasing in difficulty. Following the manual instruction, a stop condition of 6 highest incorrect answers was applied. Subtest scores were derived from grade based norms. The mean of the z-scores from both word reading and non-word reading subtests was used in the creation of a composite score, as both measures were found to be significantly correlated (.825 and .859 in grade 1 and grade 2 respectively).

Spelling. For spelling, we used the spelling subtest of the Woodcock-Johnson III (Woodcock et al., 2001), containing 59 target stimuli progressively increasing in difficulty. A stop condition of the 6 highest incorrect answers was used. Scores were derived from grade based norms. Standard procedural instructions provided in the Woodcock-Johnson III Manual for administration and scoring were utilized. The reliability coefficient for this task was obtained utilizing the split-half method (Woodcock et al., 2001) and found to be high (.92).

Letter Knowledge. The letter writing and naming subtests of the *Wide Range Achievement Test* (WRAT3) (Snelbaker, Wilkinson, Robertson, & Glutting, 2001) was used to assess both the receptive and productive letter knowledge of the children in kindergarten. 15 uppercase English letters were used for both naming and writing. For the naming task, the children were presented sequentially with a series of 15 printed letters and were asked to name each letter. The letter writing task required the participant to write 15 letters that were orally presented by the test administrator. The reliability coefficient for this task was obtained utilizing the split-half method (Wilkinson, 1993) and found to be very high (.98).

Phonological awareness (PA). For all time points of testing, PA was measured using the phonological awareness subtest of the Clinical Evaluation of Language Fundamentals 4^{th} ed. (CELF-4) (Semel, Wiig, & Secord, 2003). The CELF-4 reports an overall internal consistency reliability coefficient alpha of .93. This subtest contained measures of 11 elements: syllable blending (SB), 3 syllable deletion tasks, syllable segmentation (SS), rhyme detection (RD), rhyme production (RP), phoneme blending (PB), initial phoneme identification (IPI), medial phoneme identification (MPI) and final phoneme identification (FPI). The PA score is based upon the total score of all summed subtests. The rhyme tasks, as well as the syllable blending and 2 syllable deletion tasks, were excluded from the calculation of PA for first and second-grade students due to a high proportion of control subjects reaching ceiling effect.

Verbal short-term memory (VSTM). VSTM was assessed by using two subtests: *The Number Repetition Subtest* from The Clinical Evaluation of Language Fundamentals 4th ed. (CELF-4) (Cronbach's alpha of .78) (Semel et al., 2003) and *The Non-word Repetition Test* from the Phonological Assessment Battery (PhAB) (a reported test-retest reliability of .68) (Frederickson, Frith, & Reason, 1997).

The Number Repetition Subtest required the child to immediately recall a series of orally presented digits with lengths of 2 to 9 digits. The test scores were recorded as the total number of correctly recalled lists. A maximum score of 16 was achievable for this test.

The Non-word Repetition Test required each child to repeat sequences of single syllable nonsense words, which were presented orally. Children were asked to repeat the sequence in the correct order. Testing progressed in difficulty through a progressive increase in sequence length from 2 to 6. A maximum score of 36 was achievable for this test.

Morphological Awareness. To measure MA we used the Wug test (Berko, 1958), The Wug test is a non-word task developed to evaluate the child's ability to apply a morphological change to mark inflections and derivations. During the test, the child is shown a simple picture depicting a creature or activity and is instructed to complete a statement that requires the addition of a suffix to the target pseudo-word, for example: "This is a WUG. Now there is another one. There are two of them. There are two _______." (Response: WUGS). The original test was adapted to minimize potential ceiling effects and to include a greater range of different morphological transformations, increasing the proportion of derivations. The original 33 items included in the Wug test were extended to 38 items by the addition of 4 derivational changes taken from Carroll, & Breadmore (under revision) which involved similar presentation procedures and picture stimuli as the original items. An example of one of the 4 items is: She was from a country called Korbland. She was a Korb and the language she spoke was … (korbish also korbese). A maximum score of 38 could have been obtained (Cronbach's alpha of .73). The resulting task involved 29 questions assessing inflectional knowledge while 8 questions involved deviational knowledge.

All tasks previously described were administered during the first eight weeks of each academic year and were conducted in a quiet classroom familiar to the child. At each time point the phonological awareness, verbal short-term memory, and morphological awareness tasks were administered. In kindergarten, the participants were administered the WRAT-III to assess letter knowledge, while literacy subtests of the Woodcock-Johnson III were employed in first and second grades. The measure of socioeconomic status was administered through the use of the initial intake questionnaire that was completed by each parent or guardian.

2.4 Statistical analyses

All variables were found to be normally distributed as checked by the Shapiro-Wilk's test for normality ($p > 0.05$) with the exception of MA at grade 2. To approach a normal distribution, this variable was transformed by a logarithmic transformation that led to a distribution that was found to be normal and so the transformed scores were used in the analyses. Homogeneity of variance was assessed by Levene's Test for Equality of Variances. Group comparisons were investigated based upon an independent samples *t*-test. The False Discovery Rate (FDR) procedure, a simple sequential Bonferroni-type procedure that has been proven to control for the false discovery rate for independent test statistics was utilized to avoid the likelihood of false positive conclusions (Benjamini & Hochberg, 1995). A two-way repeated measures ANOVA was conducted to determine whether there were statistically significant differences in MA over the three grade levels measured and between reading groups. Concurrent and predictive relationships were evaluated through the use of Pearson correlations to determine the relation between measures of morphological awareness, phonological awareness, and literacy. Hierarchical multiple regression, including auto-regressor controls, was used to determine the added values of PA and decoding skills on the prediction of first and second grade MA.

3. Results

3.1 Do children with literacy difficulties show MA deficits prior to formal reading instruction and in the initial years of reading development?

Tables 2 to 4 presents group differences and performance at each time point of measures of literacy tests, MA and PA. Independent t-tests found no group differences across measures of IQ, age, SES and hyperactivity ($p > 0.05$). No group differences were observed in kindergarten for the measure of letter knowledge.

Phonemic awareness was more heavily weighted in the construction of PA for measures in first and second grade. Many control subjects were found to have achieved a ceiling effect on some syllable level tasks and were removed from the construction of the PA variable. Group differences, assessed by means of an independent samples t-test, were found for both measures of VSTM and PA across all time points, with the exception of VSTM in kindergarten (adjusted $\alpha = 0.0375$). Similarly, group differences were found for all literacy measures and morphological awareness at each grade level.

3.2 Do we see a significant change in MA from kindergarten till grade 2?

Results of the two-way repeated measures ANOVA demonstrated statistically significant differences in MA over the three grade levels measured and between reading groups. There was sphericity for the interaction term, as assessed by Mauchly's test of sphericity ($p > .05$). A main effect of grade was found, $F(2,76) = 23.472$, $p < .001$, partial $\eta^2 = .382$, with MA increasing from kindergarten ($M = 19.82$, $SD = 4.28$) to first grade ($M = 22.10$, $SD = 3.62$) to second grade ($M = 24.65$, $SD = 4.50$). Post hoc analysis with a Bonferroni adjustment revealed that gains in MA were statistically significant from kindergarten to first grade (a mean difference of -2.26, 95% CI [-4.019, -0.500], $p = .008$), and from kindergarten to second grade (a mean difference of -4.853, 95% CI [-6.65, -3.049], $p < .001$), as well as from first grade to second grade (a mean difference of -2.594, 95% CI [-4.357, -0.831], $p = .001$). A main effect of the reading group was observed $F(1,38) = 11.566$, $p = .002$, partial $\eta^2 = .233$, where readers with literacy difficulties (M = 20.714, SE = 0.630) were found to perform worse on MA when compared with typical readers (M = 23.825, SE = 0.663). There was no statistically significant interaction between grade and reading status, $F(2,76) = .702$, $p = .457$, partial $\eta^2 = .020$.

3.3 Do PA and decoding skills make a significant contribution to MA development?

3.3.1 Relationship between early literacy, phonological awareness, and morphological awareness

Table 5 shows concurrent and predictive relationships between measures of morphological awareness, phonological awareness, VSTM and measures of literacy. All kindergarten measures were found to be significantly correlated, with the exception of letter knowledge's relationship with kindergarten MA and VSTM. Additionally, kindergarten MA was found to be significantly related to all measures across first and second grades. However, this does not apply to first grade VSTM. Additionally, MA in second grade was found to be significantly related to all first and second-grade variables, except first-grade VSTM. Second grade MA was not found to be related to kindergarten PA and letter knowledge.

To control for the influence of group, partial correlations were conducted across all variables and displayed in the lower left half of Table 5. Kindergarten MA maintained its previously significant relationships with other pre-reading measures. Kindergarten MA's predictive relationships were limited to first and second grade MA and PA and first-grade spelling. Additionally, partial correlations controlling for IQ resulted in the same pattern of findings displayed in Table 5.

3.3.2 Predicting later morphological awareness

A hierarchical multiple regression was run to determine whether the addition of PA improved the prediction of first grade and then second grade MA over and above age and IQ and autoregressive effects of kindergarten MA. See Tables 6 and 7 for full details on each regression model. The full model of IQ, age, kindergarten MA and kindergarten PA to predict first grade MA was statistically significant, $R^2 = .342$, $F(4, 39) = 5.071$, $p = .002$; adjusted $R^2 = .275$. The addition of kindergarten MA to the prediction of first grade MA led to a statistically significant increase in R^2 of .192, $F(1, 40) = 10.367$, $p = .003$. The addition of kindergarten PA to the prediction of first grade MA also led to a statistically significant increase in R^2 of .082, $F(1, 39) = 4.877$, $p = .033$.

The prediction of second grade MA was significantly increased through the addition of kindergarten MA to the model, after controlling for IQ and age, R^2 of .226, $F(1, 40) = 12.321$, $p = .001$. The addition of kindergarten PA to the model did not offer a statistically significant increase in R^2 of .001, $F(1, 39) = 0.039$, $p = .884$. The full model of IQ, age, kindergarten MA and kindergarten PA to predict second grade MA was statistically significant, $R^2 = .268$, $F(4, 39) = 3.567$, $p = .014$; adjusted $R^2 = .193$.

To further understand the contribution of reading on later achievement of MA, an additional hierarchical multiple regression was run to determine the influence of first-grade decoding and PA on the prediction of second grade MA after controlling for age and IQ. The full model of IQ, age, first grade MA, PA and decoding to predict second grade MA was statistically significant, $R^2 = .336$, $F(5, 38) = 3.849$, $p = .006$; adjusted $R^2 = .249$. The addition of first grade PA did not lead to any significant change in R^2 of .040, $F(1, 39) = 2.046$, $p = .161$. After controlling for PA in the model, first grade decoding offered a statistically significant increase in R^2 of .093, $F(1, 38) = 5.321$, $p = .027$. By adding first grade PA last into the model, first-grade decoding was found to offer a statistically significant increase in R^2 of .133, $F(1, 39) = 7.784$, $p = .008$

Additionally, regression analysis, initially controlling for VSTM in addition to IQ and age, resulted in the same pattern of significant findings displayed in Tables 6 and 7.

4. Discussion

Morphological awareness has been demonstrated to significantly contribute to later reading and spelling success in both children and adolescent populations.

However, little is still known regarding the early precursors of MA development and the influence early reading acquisition, and pre-reading PA deficits have on MA development. Therefore, in a longitudinal design from kindergarten to second grade, the present study set out to broaden our understanding of MA at different stages of development and its association with Phonological Awareness (PA) and reading.

4.1 Do children with literacy difficulties show MA deficits prior to formal reading instruction and in the initial years of reading development?

The results of this study demonstrated that children who were found to have literacy difficulties in second grade also had difficulties in morphological awareness prior to reading instruction when compared to the control subjects, thus indicating that reduced MA performance is not solely consequential of poor reading experience. Additionally, group comparisons demonstrated that these deficits extend beyond the pre-reading phase and were observed in first and second grades after the onset of formal reading instruction. Also, PA deficits were found to co-exist with the observed MA deficits across each measurement time point.

Correlational analysis was used to further investigate the relationship between these two variables and found concurrent and predictive relationships between MA and PA throughout these early stages of development. As the pre-reading MA deficits precede reading instruction, two plausible assumptions can be derived. First, the deficits in pre-reading MA, in addition to the observed PA deficits, could suggest a more general metalinguistic deficit of the literacy difficulties group. This is unlikely as much of the literature relating to reading disabilities, specifically dyslexia, places PA deficits as a potential causal factor, while individuals with dyslexia are often found to perform equally or better on MA tasks when compared to reading skill matched controls. Such findings are often interpreted as an indication that MA deficits within the dyslexic population consequential of poor reading experience or the more primary phonological impairment often associated with dyslexia. Thus, an alternative and a theoretically more likely explanation may be offered in that the observed early MA deficits could be seen as a function of an individual's pre-reading PA. Evidence supporting this theory has been provided by recent studies of pre-reading children (Casalis & Louis-Alexandre, 2000, Cunningham and Carroll, 2015; Law et al., 2016). Also, such results offer support for Chiat's (2001) theory regarding PA's role in early MA attainment.

4.2 Do we see a significant change in MA from kindergarten to grade 2?

Regarding MA achievement over time, a group analysis involving all subjects demonstrated continued positive gains of MA year upon year. A main effect of the group was also observed indicating that the better performance of the control subjects was statistically significant. Contrary to what was expected, a lack of a significant interaction effect suggests that although the literacy difficulties group had poorer performance on the MA task, the development from kindergarten to second grade was similar to that of the control group. Before analysis, it was theorized that reading acquisition would influence MA development beyond kindergarten MA that is often found to be limited to an awareness of inflection. Therefore, as literacy attainment differences were found between groups, we had expected to find differences in MA growth patterns from first to second grade as reading instruction began, yet this was not the case. Although gains in the MA of children with literacy difficulties was found to parallel that of typically developing readers, initial deficits were found to remain over time. These results, along with past research that has demonstrated MA's influence on later reading gains (see Deacon and Kirby, 2004) and the effectiveness of MA instruction (for a review see Bowers et al., 2010) strengthens the argument for the need of targeted MA interventions for struggling early readers.

4.3 Does PA and decoding skills make a significant contribution to later MA achievement?

To directly evaluate reading skill's involvement in the development of a child's MA, a regression analysis controlling for intelligence, age and the autoregressive effect of previous MA achievement was conducted. Results of our regression analyses revealed PA was only found to make a significant contribution to MA development at the early stages of formal reading instruction. The kindergarten measure of PA was found to predict 8.2% of the unique variance of first grade MA, yet was not found to predict any variance in second grade MA. As reading instruction begins, PA's initial influence on later MA performance diminishes while decoding skills become more influential, as seen in the regression predicting second grade MA.

Prior to the onset of reading instruction, a child is involved in the mastery of inflections in addition to basic derivational principles. These early mastered derived forms are primarily phonetically and semantically transparent (e.g. *jump* and *jumper).* As a child's learning of more complex and less phonologically transparent derivations progresses, a more explicit awareness of the morphological structure and orthography of words is required. It has been argued that the learning of such irregularities is best acquired through print exposure rather than through spoken language (Casalis & Louis-Alexandre, 2000; Kuo & Anderson, 2006). It may be that complex morphological representations, and an understanding of many derivations only become fully specified through exposure to the written form (Templeton & Scarborough-Franks, 1985) as morphemes are more consistently spelled than they are pronounced (e.g., Bowers & Kirby, 2010). Additionally, it has been estimated that morphologically complex words compose nearly 40% of the new words encountered by children in text (Nagy et al., 1993; Nagy & Anderson, 1984).

The results of this study are unique as they provide evidence of one possible directional path where reading skill can be seen as influencing later MA whereas past correlational and longitudinal research has demonstrated the opposite situation where MA has been found to predict later reading achievement (Carlisle, 2000; Deacon & Kirby, 2004; Kirby et al., 2012; Roman et al., 2009). Taken together, the findings of this study offers support for the bi-directional relationship between word reading skills and MA as proposed by Deacon, Benere, and Pasquarella (2013). Specifically, our results assist in supporting Deacon's claim that morphological awareness is partly obtained through reading accuracy.

The presence of a bi-directional relation between MA and early reading skills may be detrimental for dyslexic children, specifically those whose reading problems predominantly stem from a PA deficit. Pre-reading PA has been demonstrated in past research to be a predictor of early reading acquisition (Bradley & Bryant, 1983; Kirby et al., 2003; Melby-Lervåg et al., 2012) and early MA development (see the results of this study in addition to Casalis & Louis-Alexandre, 2000, Cunningham and Carroll, 2015; Law et al., 2016). In the case of a child with a pre-reading PA deficit, a situation could arise where both MA and early literacy attainment would be negatively impacted. In the presence of a bi-directional relationship between MA and early reading skills, such a situation could theoretically establish a negative feedback loop. Theoretically, an individual's poorly developed MA skills would negatively impact their early reading gains, while poor reading would potentially limit their MA growth.

4.4 Limitation

There are several limitations to our work. The participants selected for this study were recruited on a voluntary basis, solicited through flyers sent home with the child from school. It could be argued that such a recruitment method could yield a higher concentration of educationally motivated parents or parents concerned about their child's literacy success. Moreover, the relatively small sample size of this study could potentially limit the extent to which the findings can be generalized. Additional limitations emerge from the measures included in our study. The Wug task, a pseudo-word task, was used to rule out any effect from root word familiarity (i.e. vocabulary). It could be argued that a more correct mean of reducing the potential confounding of vocabulary in the assessment of morphological awareness would be to introduce a measure of vocabulary as a covariate. An intrinsic relationship between morphological awareness and vocabulary exists (Spencer et al., 2015). Therefore, controlling for the variance of performance on a vocabulary measure would remove a substantial portion of the expected relationship between reading and morphological awareness (Kuo & Anderson, 2006). Therefore, to reduce such a loss, this study was limited to the degree in which variance in vocabulary could be controlled for within our predictive models. Although it is worth noting that in similar studies, such as Cunningham and Carol (2015), prediction of morphological awareness was found to be independent of vocabulary.

Although care was taken to adapt the Wug task to include a greater proportion of derived forms (20% of items), it should be noted that this task was not equally balanced for inflections and derivations. Therefore, a separate discussion of the specific development of a child's sensitivity to inflectional and derivational forms was not permitted by the design of this task. Future research implementing separate derived and inflected testing measures would be required to allow for a better understanding and discussion of the development of these specific forms.

Nearly half of the participants reached a ceiling effect on the letter knowledge task which limited our ability to use this measure for analysis. It would have been ideal, for instance, to include letter knowledge in the regression analyses to see whether the premises of literacy could be predictive of later MA in grade one. However, future studies should take care in the selection of letter knowledge tasks and the age at which these tasks are administered to avoid such restraints.

Lastly, our study is limited in our conclusions and discussion regarding the bi-directionality of the MA and word reading as the goal of this study was to evaluate the MA over time and reading's influence on MA achievement. An analysis of MA as a predictor of word reading was not presented in this study due to the lack of morphologically complex target words presented within the non-word and word reading tasks. As the tasks were designed to progressively increase in difficulty, most children were not presented with any target reading word containing any morphological complexity. As a result, it would be difficult to conclude that any variance in MA would potentially predict that the reading variable was not due to the application of morphological awareness during the reading task. Future research would benefit from the addition of specially designed word reading lists containing morphologically complex words at suitably difficulty levels to allow for a better assessment of MA's relationship in word reading.

Future research in morphological awareness development and its association with literacy outcomes could benefit from an increased sample size as well as the inclusion of a wider array of control variables to account for any possible influence of a third variable. Although our study took great care in controlling for group differences in educational environment, parental education and SES background, the observed associations of this study could be due to additional unmeasured variables such as a child's language environment at home, vocabulary or orthographic knowledge. It is worth noting that in this respect all research involving associations between variables has this limitation.

4.5 Educational implication

Intervention studies involving morphological awareness have provided evidence that training in morphological awareness increases reading skill in English (Bowers et al., 2010; Carlisle, 2010; Goodwin & Ahn, 2010). Such evidence has demonstrated the potential value of explicit instruction of morphemes to children. Our results have shown the existence of a pre-reading MA deficit in children who are later found to have literacy difficulties. Such findings indicate that these children with literacy difficulties do not only approach learning to read with a deficit in their phonological awareness, but also in their morphological knowledge, thus indicating a need for the early explicit teaching of morphemes to children to aid in reducing any adverse influence such an early MA deficit could have on literacy development and attainment.

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