Awareness and Analysis: How Morphological Processes Predict Growth in Early Reading Comprehension

by
Katharine Zinger

A Thesis submitted to the Faculty of Graduate Studies of
The University of Manitoba
in partial fulfilment of the requirements of the degree of

MASTER OF ARTS

Department of Psychology
University of Manitoba
Winnipeg

Abstract

Reading comprehension is essential for academic and educational success. The present study examines how distinct aspects of understanding and manipulating morphemes, the smallest units of meaning in written and spoken language, contribute to children's emerging reading comprehension. The majority of the research on the role of morphological processes in literacy focuses on morphological awareness, the ability to reflect on, process, and manipulate morphemes in language. However, a recent multidimensional perspective posits distinct aspects of morphological processing including morphological awareness and morphological analysis. In contrast to awareness, morphological analysis refers to the process of using morphemes to infer meaning from unfamiliar or morphologically complex words. New research has emphasized morphological analysis as a unique predictor of gains in reading comprehension when previous studies emphasized the dominant link between morphological awareness and reading comprehension. The current longitudinal study sought to provide clarity to these contrasting findings and examined the relative contributions (concurrent and predictive) of awareness and analysis in emerging reading comprehension from Grades 1 to 3. This was accomplished by using data from 171 children from Winnipeg public schools collected across five time points, using a structural equation modeling (SEM) design. Results showed evidence of early concurrent relationships between morphological awareness, analysis, and reading comprehension in Grade 1 and 2, with morphological analysis continuing to have a concurrent relationship with reading comprehension in Grade 3. Predictive links were found from earlier morphological awareness to subsequent waves of reading comprehension in each of the three grades. Morphological analysis did not directly predict subsequent reading comprehension across waves; however, findings may provide initial support for a shift in how these processes relate to one another while reading comprehension skills are emerging and strengthening. Theoretical and practical implications are discussed.

Keywords: Reading comprehension, morphological awareness, morphological analysis, longitudinal research, child development.

Acknowledgements

I would like to express my sincerest gratitude to my advisor Dr. Richard Kruk for his endless guidance, support, and encouragement throughout the completion of this project. I am also incredibly grateful and appreciative of the knowledge and expertise provided by the members of my committee, Dr. Melanie Glenwright and Dr. Johnson Li. Many thanks to the agencies who have provided financial assistance over the course of this thesis, including the Government of Canada (Canada Graduate Scholarship - Social Sciences and Humanities Research Council), the University of Manitoba (Tri-Council Supplement Award) and Research Manitoba (Master's Studentship Award – Social Science and Humanities). I would also like to thank the current and past members of the Early Years Reading Lab for their contribution to this project and support throughout its completion.

Table of Contents

List of Tables

List of Figures

Awareness and Analysis: How Morphological Processes Predict Growth in Early Reading Comprehension

Throughout school, reading comprehension is a requirement for academic success. In terms of reading outcomes, comprehension is a main priority throughout education. Competent reading comprehension skills allow readers to understand and make connections with what they read allowing for a stronger and richer educational experience; these skills are essential components of reading development. The reading comprehension skills gained throughout elementary school can impact students' access to information and their ability to achieve academic and individual goals. It is important that the aspects that contribute to the development of literacy skills be thoroughly examined to help enhance the understanding of the process of acquiring the skills necessary for reading comprehension and to support reading comprehension difficulties.

Reading is a form of communication through written language, and as such it is unsurprising that a child's understanding of language affects their reading achievement (Carlisle, 2003). In order to understand written and spoken language children must have an understanding of morphemes. Morphemes are the smallest grammatical units of words and their meanings that make up the foundation of language (e.g., "reading" includes two morphemes: "read" and "ing") (Carlisle, 2003; Kirby et al., 2012). Understanding how morphological skills develop throughout early childhood, and which aspects of morphological processing contribute to the development of early reading comprehension, is important to optimize students' acquisition of these skills and provide support to children who struggle with reading comprehension at developmentally appropriate times. In this study, a longitudinal design is used to examine which dimensions of morphological processing contribute to the development of children's early reading comprehension. The goal of this research is to establish how these skills develop over time and to decipher which aspects of morphological processing, awareness, analysis or both, contribute to children's reading comprehension ability at different stages from Grade 1 to Grade 3 (ages 6 to 9)[1].

---

[1] For the remainder of this paper, grades and ages may be used interchangeably depending on how it has been referenced in the literature cited. The following are typical ages associated with each grade in Canada and the United States: Kindergarten (5-6); Grade 1 (6-7); Grade 2 (7-8); Grade 3 (8-9); Grade 4 (9-10); Grade 5 (10-11); Grade 6 (11-12); Grade 7 (12-13); Grade 8 (13-14); Grade 9 (14-15).

Morphological Processes and Reading

Morphemes, the smallest meaningful units in language (i.e. base words and affixes), are used as the building blocks of words. In English, understanding morphemes allow readers to produce and alter the meaning of words, as well as to use this understanding to break down larger unfamiliar words into their morphological components and infer meaning (Carlisle, 2003). As children begin to develop an understanding of morphemes and their semantic meanings, they can recognize morphemes in unfamiliar words, thus contributing to their further development and understanding of language (Carlisle, 2003). Approximately 80% of English words are comprised of multiple morphemes making the understanding and familiarity of morphemes a critical aspect in allowing readers to decode novel words and extrapolate their meaning (Anglin, 1993; Hiebert et al., 2018; Kirby & Bowers, 2017). Understanding morphemes provides children with segments of regularity when they encounter complex or unfamiliar words (Levesque et al., 2021). Research shows that once individuals are familiar with morphemes, words are morphologically organized and stored in permanent memory enabling efficient retrieval of these words and their meanings (Elbro & Arnbak, 1996; Kuo & Anderson, 2006). Once these skills develop further, children are able to break down complex multimorphemic words into individual morphemes to extrapolate meaning and obtain information that can be used for reading, writing, and speaking (Carlisle, 2003). This understanding of- and memory for morphemes contributes to the ability to correctly identify, understand, and produce language.

Reading comprehension requires a set of complex skills. Reading comprehension is the ability to extrapolate, comprehend, and interpret information from written text (Gough & Tunmer, 1986). The Simple View of Reading is a theory that posits that reading comprehension is the result of two broad categories of skill: decoding and language comprehension (Gough & Tunmer, 1986). Reading comprehension does not develop at a single point or age in child development, instead, it develops alongside the acquisition of language and literacy processes (Kirby, 2007). The end goal of reading comprehension generally improves with age as children acquire both reading and language skills; however, early reading comprehension is possible once children are able to decode words and understand the meaning of text (Gough & Tunmer, 1986). Early and emerging reading comprehension skills have been demonstrated in children who are in the earliest stages of reading development in Kindergarten and Grade 1 (Foorman et al., 2015; Silva et al., 2015), and understanding morphemes has been shown to be a critical skill in

language and literacy development to facilitate reading comprehension at this young age (Ramirez et al., 2014).

The understanding of morphological units is critical to the development of reading and children's morphological skills are shown to be consistently related to their reading comprehension abilities (Carlisle & Goodwin, 2013; Carlisle & Kearns, 2017; Duncan, 2018; Levesque et al., 2021). Phonological awareness is an aspect of linguistic awareness that involves the mapping of sounds onto symbols to decode language, whereas morphological processing contributes to children's ability to infer and manipulate the meaning of spoken language and written text (Kieffer and Lesaux, 2012; Kuo & Anderson, 2006). Morphological processing supports the process of decoding and understanding language and likely works in conjunction with phonological awareness, orthographic processing, and semantic/syntactic understanding throughout normal development to facilitate reading comprehension and language production (Carlisle, 2003). Despite skills in morphological processing contributing to reading growth, morphology is still underrepresented in concepts of reading development and intervention (Carlisle, 2010; Carlisle & Kearns, 2017; Ehri, 2020; Kuo & Anderson, 2006).

Additional research is required to illuminate more completely the role and importance of morphological processes in children's reading development. Being unable to understand morphologically complex words poses a significant barrier to children's reading comprehension (Levesque et al., 2021). Morphological processing and the understanding of morphemes contribute greatly to the development of reading skills and are unique contributors to reading comprehension beyond the contributors of phonological awareness, word decoding, vocabulary, and nonverbal cognitive ability (Deacon et al., 2014; Nagy et al., 2003). A growing evidence base demonstrated the effectiveness of explicit teaching of morphological skills on reading outcomes (Bowers et al., 2010; Goodwin & Ahn, 2013; Nagy et al., 2014; Ramirez et al., 2014); however, morphological instruction can take many forms, and as such, there is a need to better understand how specific morphological processes contribute to reading comprehension to guide instruction at different developmental periods.

The Multidimensionality of Morphological Processes

Recent research has emphasized a multidimensionality of morphological processing with differing contributions to reading (Goodwin et al., 2017; Goodwin et al., 2020; Levesque et al., 2021; Tighe & Schatchneider, 2015). Morphemes provide multidimensional information, acting

as a connector between phonology and orthography with word meanings; therefore, a distinction between the dimensions of morphological processing is appropriate (Levesque et al., 2021; Kirby & Bowers, 2017). In research, making the distinction between different aspects of morphological processing is important when examining the relationship between morphological processing and reading. This would allow a full understanding of the theoretical and practical implications of the relationship between morphological processing and reading; however, the distinction between different aspects of morphological processing is relatively new in reading research. Previously, morphological awareness has been the most common dimension of morphological processing examined in reading research. Morphological awareness is conceptualized as the ability to reflect on and manipulate morphemes and the understanding that morphemes are the building blocks of language (Carlisle, 2000, Kirby et al., 2012; Kuo & Anderson, 2006). The majority of studies examining the contribution of morphological skills to reading outcomes have focused on morphological awareness without making a distinction between morphological awareness and other dimensions of morphological processing. Within a multidimensional framework, a more recently conceptualized dimension of morphological processing is morphological analysis. Morphological analysis refers to the process of using morphemes to infer meaning from unfamiliar and/or morphologically complex words (Baumann et al., 2002; Carlisle, 2007; Levesque et al., 2019; Levesque et al., 2021; Pacheco & Goodwin, 2013). Therefore, distinct aspects of morphological processing may be contributing differently to reading comprehension throughout development.

Morphological Awareness

The majority of research examining the role of morphological processes in literacy has focused on morphological awareness, but typically without considering other dimensions and aspects of morphological processing. Morphological awareness is used to gain an understanding of word formation rules in spoken and written language (Carlisle, 2003). Included in this conceptualization of morphological awareness is the understanding of the relations among words and the ability to use this knowledge to manipulate morphemes to produce language for different contexts (for example, being able to choose the correct form of walk-walked-walking to fit within a sentence context) (Carlisle, 1995; Kuo & Anderson, 2006).

Morphological awareness is the skill that allows readers and speakers to understand word structure and formation and manipulate the smallest unit of meaning, morphemes, in language

(Carlisle, 2003). Morphological awareness is typically measured in research by tasks that require participants to orally manipulate morphemes or identify morphemes in words (e.g. "Enter", "He greeted me when I ___." [Entered], or "Is there a little word in ___ that means something like ___? [Pulled – Pull]" (Carlisle & Fleming, 2003). Based on this conceptualization of morphological awareness, it is reasonable to assume that one's awareness of the units of meaning that make up language and ability to use morphemes to produce language would contribute to the understanding of meaning in texts and support reading comprehension, especially as children's understanding of written language is developing (Carlisle, 2003).

The majority of research examining the relationship between morphological awareness and reading comprehension has focused on older children, whose foundational reading skills are more developed than those of younger children. Literature examining this relationship has demonstrated that morphological awareness contributes to reading comprehension both concurrently and as a unique predictor in middle- to late-elementary school years (Kieffer et al., 2016; Nagy et al., 2006). However, there is also evidence that even young children demonstrate sensitivity to morphological irregularities and that morphological awareness contributes to early reading comprehension (Deacon, 2008; Deacon & Bryant, 2006; Ramirez et al., 2014; Treiman & Cassar, 1996). The relationship between morphological awareness and reading comprehension has been demonstrated in younger children who are concurrently developing reading and morphologically related skills even in the earliest period of children's educational attainment. Deacon et al. (2018) examined the direct contribution of children's morphological awareness to reading contribution from age 5 to 7 when reading-related skills are developing. They found that morphological awareness made a significant contribution to reading comprehension even after controlling for word-level reading.

Previous longitudinal research examining morphological awareness as a contributor to the development of reading, has identified morphological awareness as a unique predictor of reading comprehension skills over time (Deacon et al., 2014; Foorman et al., 2012; Kirby et al., 2012; Kruk & Bergman, 2013; Levesque et al., 2017). Recently, this relationship has been confirmed throughout multiple developmental periods in longitudinal research. When examining the contribution of morphological awareness to reading comprehension in children of different ages and reading abilities, James et al. (2021) found that morphological awareness accounted for unique variance for children ages 6 to 8 and 12 to 13.

This empirical evidence supports the idea that stronger morphological awareness should help enable readers to accurately identify the semantic and syntactic role of words in context to enable reading comprehension. The role of morphological awareness, the familiarity with the structure and regularities of morphemes, likely supports the transition from emerging to expert reading ability (Castles et al., 2018; Levesque et al., 2021). However, these studies examined unidimensional conceptualizations of morphological processing focusing on morphological awareness only without considering the contributions of other morphological processes to reading comprehension.

Morphological Analysis

Morphological analysis, the process of using morphemes to infer meaning from unfamiliar and/or morphologically complex words, allows individuals to infer meaning based on the morphemic parts of words (Anglin, 1993; Baumann et al., 2002; Deacon et al., 2017; Levesque et al., 2019). It has been conceptualized as the ability to problem-solve word meanings by applying knowledge of morphological components (Crosson et al., 2021). For example, the word “unfairness” is made up of three morphemes: “un”, “fair”, and “ness”. As children gain a morphological understanding and become familiar with morphological regularities, they may be able to use this understanding to infer the meaning of morphologically complex words. Children who have never encountered the word “unfairness” before, may use their understanding of the morphemes that make up the word (“un”, “fair”, and “ness”) to extrapolate its meaning (Levesque et al., 2019; McCutchen & Logan, 2011; Pacheco & Goodwin, 2013). In research, morphological analysis is typically measured by asking participants to produce or choose definitions for morphologically complex words tapping into their ability to analyze multimorphemic words to derive meaning (Levesque et al., 2019; McCutchen & Logan, 2011; Pacheco & Goodwin, 2013).

The majority of English words are comprised of multiple morphemes, and these are the types of words that are encountered most frequently when reading (Levesque et al., 2021). As readers gain morphological knowledge, skills in morphological processing, and become increasingly familiar with morphological consistencies, morphological awareness and analysis may be useful at different points in development to support children’s reading and comprehending of novel or complex text. Morphological awareness, which involves processes required to parse down multimorphemic words into their constituent parts and manipulating

those parts, and morphological analysis, which involves processes that have a greater emphasis on inferring meaning, likely contribute differently to children's reading comprehension (Goodwin et al., 2017; Levesque et al., 2021).

Few studies have explored the distinction between awareness and analysis and their roles in reading comprehension and its development. Past research that has examined this distinction has typically examined this relationship with a focus on children in the mid- to late-elementary years who have more-developed reading skills (Levesque et al., 2017; Levesque et al., 2019). Deacon et al. (2017) evaluated the relationship between distinct aspects of morphological processing in children in Grade 3 and Grade 5 and found that morphological analysis and not morphological awareness uniquely contributed to participants' reading comprehension abilities, after controlling for phonological awareness, nonverbal cognitive ability, and word reading. Research involving older children found that children in Grade 5 and Grade 8 were able to extract meaning from morphologically complex words by choosing definitions for low-frequency unfamiliar words within a sentence context, and morphological analysis ability accounted for unique variance in reading comprehension (McCutchen & Logan, 2011). Recently, Goodwin et al. (2020) examined the contribution of distinct morphological processes to reading comprehension in Grade 8 students and found an additive contribution of both morphological awareness and analysis, suggesting that each aspect of morphological processing makes unique contributions to reading comprehension for this age.

Recently, Levesque and colleagues (2019) sought to determine which aspects of morphological processing contributed to gains in reading comprehension over time. They found that while morphological awareness contributed to improvements in morphological analysis, only morphological analysis contributed to reading comprehension from Grade 3 to 4, when controlling for prior ability. In contrast, morphological awareness, analysis, and reading comprehension were assessed in students in Grade 4 and 5 with a range in English proficiency and it was found that students with stronger English proficiency were better able to use morphological analysis to infer word meaning compared to those with limited English proficiency (Zhang et al., 2020). Regardless of English proficiency level, Zhang et al. (2020) found that the relationship between morphological awareness and reading comprehension was mediated by morphological analysis for these students.

Further research in this area is required to clarify the relationship between morphological awareness, analysis, and reading comprehension over time and to determine if there are important changes throughout development. Past conclusions may have come about by failing to distinguish between the distinct aspects of morphological processing. Hence, results from previous research could be reflecting the shared variance between the two aspects of morphological processing. To further clarify the understanding of the morphological contribution to reading comprehension in early development, research is needed to better understand how these two aspects of morphological processing, awareness and analysis, change over the course of development and how they contribute to the development of reading comprehension over time.

The conceptualization of distinct aspects of morphological processing makes it plausible that morphological awareness and morphological analysis may make separate contributions to reading comprehension at different points throughout development (Levesque et al., 2019; Levesque et al., 2021). For instance, morphological awareness may be especially useful early on in development when word-specific knowledge is emerging, and morphological analysis may be especially useful for reading comprehension later in development when children encounter more-complex words in sentence contexts and have acquired more vocabulary knowledge (Levesque et al., 2021; Zhang et al., 2020). Perhaps mid-elementary school (around age 8 to 9) may be a time in development where there is a shift from benefitting primarily from morphological awareness in the acquisition of basic reading comprehension gains in early childhood to benefitting primarily from morphological analysis in the acquisition of more advanced reading comprehension skills. However, these predictions are largely untested in the literature. More research is required to expand the understanding of the contribution of morphological analysis to reading comprehension cross-sectionally and longitudinally in younger ages when children are developing emerging skills.

The Present Study

Longitudinal research examining the distinction between aspects of morphological processes and their contribution to reading comprehension is in its infancy. The present longitudinal study builds upon past cross-sectional research by examining how two aspects of morphological processing, awareness and analysis, contribute to reading comprehension throughout early elementary school, from Grades 1 to 3 (age 6 to 9). The majority of research

examining the relationship between distinct aspects of morphological processing and reading comprehension did so with students in mid-late elementary school years (Beyersmann et al., 2012; Dawson et al., 2018; Levesque et al., 2017). The present study examined this relationship at an earlier point in the developmental trajectory of reading comprehension acquisition and provides clarity on how the two aspects of morphological processing contribute to reading comprehension in early development. This is achieved by examining participants' performance on measures of morphological awareness, morphological analysis, and reading comprehension longitudinally across Grades 1 to 3. Measures used include a measure of morphological awareness requiring participants to produce larger multimorphemic words from root words to fit sentence context, a measure of morphological analysis requiring participants to infer meaning from morphological complex words, and standardized measures of word and passage comprehension. This study used archived data from 171 children with varying reading abilities from 12 Winnipeg elementary schools. Data were collected across five waves of testing that took place every six months. Measures were collected at five-time points, which allowed for a more in-depth analysis of how these morphological processing abilities develop and how their relationship to reading comprehension change over time.

Hypotheses and Rationale

The recent finding that morphological analysis, rather than morphological awareness, predicts reading comprehension in Grades 3 to 5 includes children older than those in the present study (Levesque et al., 2019). The current study examines the developmental trajectory of this relationship during an earlier point in development from Grades 1 to 3 (ages 6 to 9). Given the gap in research examining the multidimensional aspect of morphological processing and its impact on reading comprehension growth for this younger age group, making specific predictions was challenging. Findings could indicate that this relationship found previously in older students does not hold for younger students who are developing emerging morphological processing and reading comprehension skills.

Conceptually, the morphological contribution to reading comprehension skills may shift as children grow older, which may be evident during this period from Grade 1 to Grade 3. In early development, it may be that morphological awareness develops first in its support of reading before morphological analysis develops and becomes a more important link to children's reading comprehension in mid-elementary school. It has been demonstrated that the most growth

in acquiring morphological awareness skills occurs within the first three or four grades of school (Berninger et al., 2009) when children are making big gains in reading and vocabulary development (Ramirez et al., 2014). When children are developing emerging reading skills in the initial grades of school, Grades 1 and 2, the demands of reading comprehension are relatively simple compared to the demands of reading comprehension placed on children by Grade 3 when text becomes relatively more complex and children encounter words more frequently in complex sentences. As reading becomes more fluid and children make the switch from learning to read to reading to learn, which takes place around Grade 3, the morphological processing skills required for reading comprehension may shift as well (Chall, 1983).

Theoretically, it appears that morphological awareness is required especially during early years in the development of reading comprehension at a foundational level when children are concurrently developing both morphological and reading-related skills (Deacon, 2008). Morphological awareness may be a broader skill required to obtain the more precise morphological analysis skills, and that morphological analysis may have a stronger link to reading comprehension once these foundational skills are developed (Levesque et al., 2021).

Throughout these first few years of school, children may move from primarily word-level reading comprehension to more text-level reading comprehension and there may be a shift in how morphological awareness and analysis are related to reading comprehension. Once children have gained strong morphological awareness skills, they may have the foundational understanding of morphemes necessary to enable a shift to benefit more from morphological analysis to decipher morphologically complex words from their smaller morphemic units (Levesque et al., 2017). This shift would enable them to extract greater meaning from complex text. Morphological analysis may be particularly useful for advanced reading comprehension improvements, as children are exposed to more morphologically complex words with a greater demand on the reader to infer meaning (Levesque et al., 2021; Xie et al., 2019). Starting in Grade 3, the majority of words that children encounter in reading are considered morphologically complex (Anglin, 1993; Levesque et al., 2019). Therefore, the role of morphological analysis in reading comprehension may be stronger in later years of reading development given that the understanding of less-familiar morphologically complex words is specifically required for comprehension compared to written words encountered in the earlier years of reading development.

Based on these prior findings, it was hypothesized that within the earlier waves of testing, in Grades 1 and 2, morphological awareness would be an important concurrent predictor of reading comprehension when literacy skills are emerging. On the other hand, morphological analysis may be an important concurrent predictor of reading comprehension in Grade 3 when children encounter more morphologically complex words, signifying a shift from morphological awareness to analysis in facilitating reading comprehension as children acquire stronger reading skills (Levesque et al., 2019). Predictive relationships are explored to examine whether there is a shift from morphological awareness to morphological analysis predicting reading comprehension in subsequent waves beginning in Grade 3 (Levesque et al., 2019), with the expectation that awareness will predict growth in reading comprehension from waves 1 (in Grade 1) to wave 4 (beginning of Grade 3), and that analysis will predict growth from wave 4 to wave 5 (the end of Grade 3).

The expected results indicating the hypothesized relationship between morphological awareness, morphological analysis, and reading comprehension across the 5 waves as stated previously are depicted in the model in Figure 1 (Appendix B). It was previously found that morphological awareness predicted morphological analysis, which in turn predicted reading comprehension from Grade 3 to Grade 4 (Levesque et al., 2019) and also that morphological analysis may mediate the relationship between morphological awareness and reading comprehension (Zhang et al., 2020); these potential relationships are also explored in the current study.

Gaining the understanding of the link between morphological processes and reading comprehension could be used to guide educational practices. For instance, if my hypotheses were supported indicating a strong relationship between aspects of morphology supporting reading comprehension, this may encourage the use of morphological interventions that emphasize awareness in earlier grades and analysis in later grades. There is growing literature demonstrating the effectiveness of improving reading outcomes by teaching morphological processing skills (Bowers at al., 2010; Goodwin & Ahn, 2013; Nagy et al., 2014; Ramirez et al., 2014); however, morphological instruction can take many forms and there is much to be gained from a better understanding of how the mechanisms of distinct morphological skills contribute to reading comprehension at different developmental periods.

Methods

This study used secondary archived longitudinal data, collected from 2003 to 2007 as part of a larger longitudinal study examining the many factors that are involved in reading acquisition and development in children. The developmental trajectory of the predictive and concurrent relationships among morphological awareness, morphological analysis, and reading comprehension were examined throughout the five waves of this longitudinal study.

Participants

Children in Grade 1 were recruited from 12 diverse (urban and suburban) elementary schools within three public school divisions in Winnipeg, Manitoba, Canada. The children participated at five testing occasions: spring of Grade 1, fall of Grade 2, spring of Grade 2, fall of Grade 3, and spring of Grade 3. Each testing period was separated by approximately six months. The study began with 171 children in Grade 1 (77 female and 94 male) and by the final wave of testing, 137 participants remained. The mean age of participants at Wave 1 was 71.50 months (5.96 years) and at the final wave was 96.63 months (8.05 years). Prior to the first wave of data collection, participants' teachers were asked to nominate at-risk to average skilled readers, based on curriculum-based measures in order to ensure a wide range of initial reading abilities. Parent/guardian consent was provided for each participant and children provided verbal assent before each testing occasion. English was the primary language spoken at home for 154 of the participants in Wave 1 and 125 of the participants left in Wave 5. For further demographic information, refer to Table 1 in Appendix A.

Materials and Procedure

Students who participated completed the measures described below. The measures were administered by trained psychology undergraduate and graduate students from the University of Manitoba in quiet rooms at the children's schools. The measures for this study were administered as part of a larger battery of measures in four 30-minute sessions occurring on different days within a two-week time frame to minimize participant fatigue. Within-sessions, the measures were administered in the same order for each participant.

Morphological Awareness

To create a latent variable of morphological awareness, the Morphological Knowledge Test was used. The Word Analysis Test described below was originally intended to be used as

part of the latent variable for morphological awareness however it was not used in the final analysis due to its psychometric violations described in the data analysis section below.

Morphological Knowledge Test. This task is a modified version of a task used by Carlisle and Fleming (2003) and is used as a measure of morphological ability and derivational and inflectional knowledge. In this task, participants are presented with a word followed by an incomplete sentence. Participants are then asked to complete the sentence by using the appropriate form of the word provided. The task is made up of 48 items. There are 24 composed items which require participants to produce larger multimorphemic words from root words (e.g. "Enter", "He greeted me when I ___." [entered]) and 24 decomposed items which require participants to produce root words from larger multimorphemic words (e.g. "cutting", "I got my hair ___." [cut]) (See Appendix C for a full list of test items). The order of items was counterbalanced, and participants were provided with three practice items. To create a latent variable, two separate indicators were created by using the total raw score on participant performance on the composed items and the decomposed items. Internal reliabilities at Wave 1 were $\alpha = .78$ for the 24 composed items and $\alpha = .82$ for the decomposed items.

Word Analysis Test. This task is a modified version of tests used by Carlisle and Fleming (2003) and Aylward, et al. (2003) designed to determine how children distinguish one-morpheme words from two-morpheme words. In this task, participants are asked, "Is there a little word in ___that means something like ___?", with varying degrees of semantic overlap between items (See Appendix D for a full list of test items). Participants are provided with four training items. There are 18 items in total with six with the suffix "-y" (e.g., "sunny" – "sun"), six with agentives and instrumentals (e.g., "teacher" – "teach"), and six with past tense (e.g., "pulled" – "pull"). Each of the larger words is matched to a monomorphemic word that rhymes and are provided in a pair (e.g., "silly" and "hilly"). Participants are given an accuracy score for responding correctly to both items in a pair (e.g., "yes" to "hilly – hill," and "no" to "silly – sill".) Internal reliability at Wave 1 for the test items was $\alpha = .82$.

Morphological Analysis

Absolute Vocabulary Knowledge Test. This task is a modified version of a test used by Anglin (1993) as a measure of participants' morphological analysis ability by requiring children to infer the meaning of morphologically complex and/or unfamiliar words. In this task, participants were orally presented with ten low-frequency two-morpheme words (e.g., soaking,

treelet). They were asked to first define the word and then to construct proper sentences that demonstrate the words' correct meaning. Participants were given an accuracy score for their definition of the ten items, including a combination of root and suffix meanings, and a second score for their ability to use the item in a meaningful sentence for a maximum of 20 points total. The item difficulty was not determined prior to administration and therefore the items were not rank ordered based on determining characteristics. To create a latent variable of morphological analysis, three separate indicator scores were created. The three groups of indicator items were created based on the order they were presented to participants with every third score distributed into a different group (See Appendix E for a full list of test items). This was done to ensure a relatively equal number of definition and sentence scores were distributed in each group. Internal reliability at Wave 1 for the test items was .63. Reliability for the three indicator variables created was $\alpha = .70$.

Reading Comprehension

Woodcock Reading Mastery Test-Revised (WRMT-R). The WRMT-R is a diagnostic test that assesses reading achievement of several reading abilities (Woodcock, 1998). To measure participants reading comprehension ability, two subtests of the WRMT-R were used.

The Word Comprehension subtest is used to measure children's comprehension of increasingly complex words (Woodcock, 1998). Standard administration procedures were used: participants were asked to provide synonyms and antonyms for words as well as to provide appropriate words for increasingly difficult analogies for up to 146 items (up to 33 synonyms, 34 antonyms, and 79 analogies). The test was discontinued after six consecutive errors on each of the synonyms, antonyms, and analogies sets.

The Passage Comprehension subtest was used as a measure of children's comprehension of continuous text (Woodcock, 1998). Standard administration procedures were used: participants were presented with a series of up to 68 passages, each with a missing word. Participants were asked to read each passage silently and then provide a suitable word to fill in the blank. The test was discontinued after six consecutive errors. Total scores from the Word Comprehension and Passage Comprehension subtests were used in the analysis as separate indicators for the latent variable of reading comprehension. Raw scores were used to maintain information on developmental change. Split-half reliabilities for the word comprehension based on the normative sample ranged from .91 to .95 for the ages of participants (Woodcock, 1998).

For the passage comprehension subtest, split-half reliabilities based on the normative sample ranged from .92 to .94 for the ages of participants (Woodcock, 1998).

Control and Auxiliary Measures

Weschler Scales of Abbreviated Intelligence (WASI). Participant performance on the Vocabulary and Matrix Reasoning subtests from the Weschler's Scales of Abbreviated Intelligence were used to measure participants non-verbal and verbal intelligence **(**Wechsler, 1999). Standard administration procedures were used. The Vocabulary subtest includes 4-picture items and 38-word items. Participants were instructed to name the objects shown in the pictures for the first four items and were required to provide a definition for a word for the following items. The Matrix Reasoning subtest required participants to complete a visual puzzle in the form of a matrix with one missing section. Participants were required to choose an image that best fits the missing piece from five response options. The WASI subtests were used to ensure participants had the cognitive functioning necessary to understand instructions and participate in the measures. An IQ estimate was derived from a composite score of both WASI subtests and participants with standard scores below 75 were to be excluded; however, no participants met this exclusionary criterion. Reliability coefficients for internal consistency ranged from .86 to .92 over the ages involved in the study for the vocabulary and matrix reasoning subtests (Wechsler, 1999).

Comprehensive Test of Phonological Processing (CTOPP). Participant performance on the Elision subtest of The Comprehensive Test of Phonological Processing (Wagner et al., 1999) was used as a measure of phonological awareness. Standard administration procedures were used for the subtest. The Elision subtest consists of 20 items. Participants were required to repeat a target word aloud and then repeat it with specific phonemes omitted (e.g., "bold," without saying /b/). Split-half reliabilities ranged from .89 to .92 for the ages of participants (Wagner et al., 1999).

Data Analysis

Overview

Statistical analyses were completed using IBM SPSS Statistics version 27 and MPlus version 8.7. The data were analyzed using a structural equation modelling (SEM) approach. Specifically, a 5-wave Cross Lagged Panel Analysis using Full Information Maximum Likelihood Estimation (FIML) was used to examine the predictive and concurrent relationships among the constructs of

morphological awareness, morphological analysis, and reading comprehension. Each construct was specified as a latent variable at each of the five-time points. Two separate indicators of reading comprehension, two indicators of morphological awareness, and three indicators of morphological analysis were used to create latent variables (variable indicators are further described in the Methods section). Both first-order autoregressive effects and cross-lagged effects were included in the models and correlations among the residuals of the same constructs across the five waves of testing were included to consider the covariance among the residuals (Marsh et al., 1999).

In order to evaluate model fit, modelling statistics were examined. It is suggested that to evaluate how well a model approximates the data a number of absolute and relative measures of fit should be examined (Little, 2013). These include measures of absolute fit such as the Root Mean Square Error of Approximation (RMSEA) and the Standardized Root Mean Square Residual (SRMR) as well as a measure of relative fit, the Comparative Fit Index (CFI), all of which were considered when evaluating model fit. The cut-off values indicating good fit are generally considered to be: RMSEA ≤ .06, SRMR ≤ .08, and CFI ≥ .95 (Kline, 2016; Zhang et al., 2019). In addition to examining the modelling statistics, a nonsignificant chi-square (χ^2) statistic may also indicate good model fit; however, this can be problematic in SEM designs as it is largely influenced by sample size and degrees of freedom and is therefore often significant even with well-fitting models (Little, 2013). The absolute and relative measures of fit are considered acceptable alternatives to the chi-square statistic.

Competing models were evaluated by systematically removing or altering the pathways in the model based on statistical fit and considering theoretical rationale. In order to compare the models and determine whether they provide statistically different fit, the chi-square difference test ($\Delta\chi^2$) which compares the difference between models' χ^2 statistics and a change in the CFI value (ΔCFI) was used while also examining change in the fit statistics described above (Cheung & Rensvold, 2002). A $\Delta\chi^2$ test *p*-value of ≤ .05 and/or a ΔCFI difference of .01 indicates that there is a significant difference between models (Cheung & Rensvold, 2002).

Missing Data Analysis

A total of 36 participants were lost due to attrition by the fifth and final wave of testing. An important consideration when examining long-term attrition is whether participants who participated in all five waves of data collection differ from those who were lost on the measures

of interest (Gustavson et al., 2012). The primary reason for missing participants was due to children moving to different schools and they were therefore not available for subsequent testing sessions, or children missing a testing session due to being absent from school on the days that testing took place.

A missing data analysis was conducted to examine whether there were systematic differences between participants with complete data versus those with incomplete data on key measures to identify whether the data were missing at random or not missing at random (Enders, 2010). A series of independent samples *t*-tests were completed to compare the initial scores of reading comprehension and morphological processes of the group of participants with missing data (n = 36) to those who completed the five waves of the study (n = 135). There were significant differences between the two groups on all variables of interest with the group with missing data performing worse on all variables at the initial time point: word comprehension ($t(169) = 3.29$, $p = .001$), passage comprehension ($t(169) = 3.07$, $p = .002$), the Morphological Knowledge Test as a measure of awareness ($t(169) = 4.08$, $p < .001$), and the Absolute Vocabulary Knowledge test indicator 1 ($t(169) = 2.15$, $p = .033$) and indicator 2 ($t(169) = 3.62$, $p < .001$) as measures of analysis. Therefore, this indicates the data are considered to be missing not at random (MNAR) and that there were systematic differences between the two groups of participants initially.

In addition to using the traditional full information maximum likelihood procedure in order to account for the systematic differences between the attrition and non-attrition groups, relevant auxiliary or covariates were used to account for the systematic missingness (Enders, 2010). The inclusion of auxiliary variables is often used to help decrease bias associated with systematic missing data and to make estimates on incomplete data by improving FIML (Collins et al., 2001; Enders, 2010). Auxiliary variables are those not intended to be used to test hypotheses but are correlated with the main variables included in the analysis. After examination, two auxiliary variables were used for the analysis: phonological awareness (CTOPP Elision subtest) and vocabulary (WASI Vocabulary subtest). Phonological awareness and vocabulary have an established relationship with linguistic abilities and reading comprehension and were both significantly correlated with all outcome measures at wave 1 (at <.001) (Hogan et al., 2005; Nation et al., 2007). Through a series of univariate ANOVAs on initial variables it was found that the combination of phonological awareness (elision) and

vocabulary eliminated the statistical difference between the attrition and non-attrition groups on the measures of morphological awareness, morphological analysis, and reading comprehension. Therefore, phonological awareness and vocabulary were used as auxiliary variables to account for the systematic differences among the attrition and non-attrition groups.

Results

Descriptive Statistics

Prior to conducting the main analyses, descriptive statistics were examined. Participant ages at each timepoint are reported in months to consider aspects of developmental change throughout the duration of the study: Wave 1 (M = 81.00, SD = 4.34); Wave 2 (89.24, SD = 4.04); Wave 3 (M = 94.68, SD = 4.04); Wave 4 (M = 102.07, SD = 3.99); Wave 5 (M = 106.61, SD = 3.84). Descriptive statistics were examined for measures of reading comprehension, morphological awareness, and morphological analysis at each timepoint and the number of participants present, means, standard deviations, and minimum and maximum statistics are reported in Table 2. Patterns of relative growth were observed across the five waves of testing for each measure. Refer to Tables 3, 4, 5, 6, and 7 (Appendix A) for correlations among indicator variables for each wave of testing.

Initially, data were inspected for violations of statistical assumptions. Upon inspection, it was found that The Word Analysis Test (WAT) showed violations to assumptions of normality. In later waves of testing, the WAT data violated assumptions of normality. In particular, there were high levels of negative skewness and the data were not evenly distributed with the presence of leptokurtosis potentially related to ceiling effects in the later waves. Even in earlier waves of testing, children were performing quite well on the WAT and this was even more pronounced in later waves of testing. In addition to these violations of statistical assumptions, the WAT was significantly correlated with the other measures of both morphological awareness and analysis and when model variations were run with the inclusion of the WAT indicator, this resulted in a non-positive definite error in the Mplus output indicating correlations of greater of >1 among the latent variables of morphological awareness and analysis which makes the results uninterpretable (Kline, 2016). Possible explanations for this issue include non-normal distribution, small sample size, too many parameters indicated in the model, or a mis-specified model (Kline, 2016).

Table 2

Means and, Standard Deviations for Measures of Reading Comprehension, Morphological Awareness, and Morphological Analysis Across Waves

	Wave 1		Wave 2		Wave 3		Wave 4		Wave 5	
Variable	*N*	Mean (SD)	*N*	Mean (SD)	*N*	Mean (SD)	*N*	Mean (SD)	*N*	Mean (SD)
WC	171	8.87 (10.28)	157	18.60 (12.67)	155	24.70 (12.94)	141	31.73 (12.59)	137	35.62 (11.58)
PC	171	10.33 (8.81)	149	18.30 (9.33)	151	22.08 (9.75)	141	27.28 (8.71)	134	30.00 (7.48)
MKT	171	27.42 (6.92)	149	32.46 (5.99)	152	34.80 (6.49)	137	39.07 (4.76)	135	40.38 (4.31)
AVKT	171	2.73 (2.12)	151	3.21 (2.43)	153	3.90 (3.14)	139	5.45 (3.00)	133	7.23 (3.43)
**WAT*	*170*	*12.68 (3.20)*	*148*	*14.65 (3.07)*	*152*	*15.70 (2.32)*	*139*	*16.19 (1.75)*	*135*	*16.60 (1.60)*

Note. WC = Word Comprehension (Woodcock Reading Mastery Test-Revised); PC = Passage Comprehension (Woodcock Reading Mastery Test-Revised); AVKT = Absolute Vocabulary Knowledge Test; WAT = Word Analysis Test; MKT = Morphological Knowledge Test.**WAT was not included in final analyses due to violations of psychometric assumptions.*

The WAT was originally proposed to be used as a single indicator of morphological awareness at each timepoint with the Morphological Knowledge Test (MKT); however, it is unclear whether the WAT is a strong indicator of awareness. Although the test has good reliability, its data was not normally distributed and caused problems in the data analysis when it was included. Including the WAT data was not necessary in order to test the hypotheses as the MKT on its own is a valid measure of morphological awareness. Simplifying the indicators of morphological awareness by omitting the WAT data resulted in the data converging normally in Mplus.

Cross-Lagged Panel Models

A series of cross-lagged panel analysis models were undertaken in order to test the hypotheses specified in this study and examine the relationship between the latent variables of morphological awareness, morphological analysis, and reading comprehension across this early developmental period in the acquisition of reading comprehension. Autoregressive links for each of the latent variables are included throughout the five waves of testing to account for prior level of skill and to explore the stability in these variables overtime, with larger coefficients indicating greater stability (Kearney, 2017). Inclusion of the two relevant covariates identified in the missing data analysis, phonological awareness and vocabulary, were entered in all models as auxiliary variables.

Initial Model: Autoregressive

To establish an initial model, the first model that was tested included all autoregressive paths between the latent variables to explore the presence of stability in reading comprehension, morphological awareness, and morphological analysis across the five waves of testing. As seen in Figure 2 (Appendix B), all 12 autoregressive paths were statistically significant as expected, indicating stability over time for each of the latent variables. Figure 2 also displays the coefficients for each indicator associated with the latent variables. The measurement model indicated that all indicator variables were appropriate for the latent variables and statistically significant at p <.001. Although all of the autoregressive paths were significant, this model did not produce a good fit: $\chi 2(542) = 891.234$, $p < .001$, RMSEA = .061, CFI = .928, SRMR = .106. Since this model provided an inadequate fit of the data, it was justified to explore the addition of predictive and concurrent links.

Model 1: Hypothesized Model

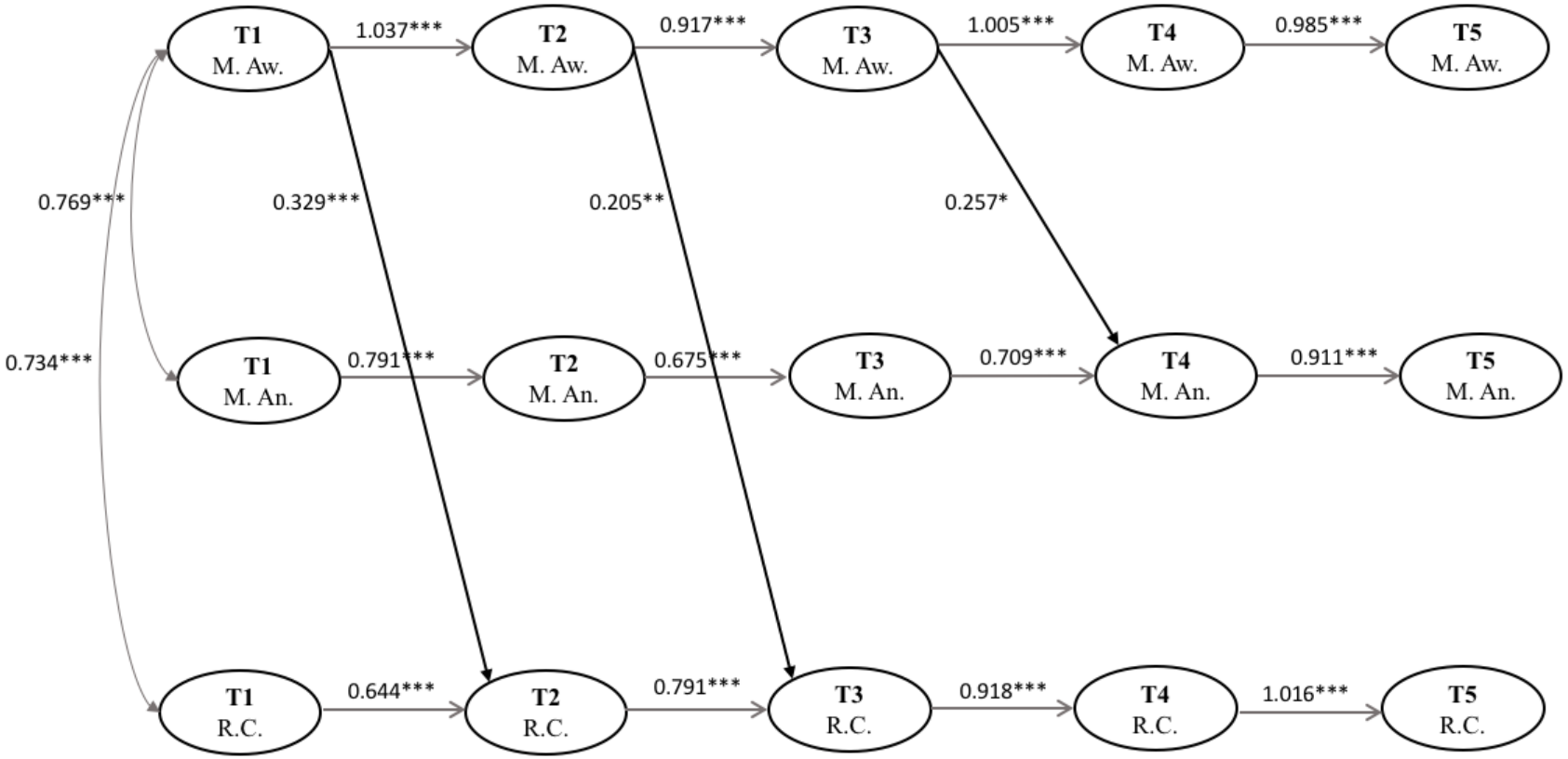
After establishing an initial model, the hypothesized model (seen in Figure 1) was explored by adding theoretically plausible paths to improve model fit. In this model, the 12 autoregressive links between the latent variables were retained from the initial model. To examine predictive relationships, 12 cross-lagged paths were specified between sequential waves (specified with cross-lagged paths between awareness to analysis and reading comprehension and analysis to awareness from wave 1 to wave 4 and a shift to awareness predicting analysis and analysis predicting awareness and reading comprehension at wave 5). To examine the relationship between variables at a single point in time, 10 concurrent links were specified by signifying correlations between variables (specified between awareness and analysis throughout the five waves, awareness and reading comprehension from wave 1 to wave 3 (end of Grade 2), and a shift to concurrent links between analysis and reading comprehension at wave 4 and 5 (Grade 3). Figure 3 displays the significant links found in the hypothesized model (insignificant links are excluded from the model for clarity). All autoregressive links were significant at $p <$ .001. Three cross-lagged predictive links were significant: awareness at wave 1 to reading comprehension at wave 2, awareness at wave 2 to reading comprehension at wave 3, and awareness at wave 3 to analysis at wave 4. Only two concurrent links were significant, both at wave 1: between awareness and analysis and between awareness and reading comprehension. Model fit statistics were as follow: $\chi^2(524) = 794.877$, $p < .001$, RMSEA = .055, CFI = .944, SRMR = .065, demonstrating overall good fit with some variation in fit strength. Compared to the initial model, adding in predictive and concurrent links improved the fit as indicated in a statistically significant $\Delta\chi_2$ test and a ΔCFI of 0.016 (see Table 8). This indicates that predictive and concurrent paths are helpful in understanding the relationship among the latent variables.

Model 2: Fully Specified Exploratory Model

The hypothesized model was expected to result in good model fit due to past literature and research in this area; however, as the comparison of the influence of morphological analysis and morphological awareness on reading comprehension has not been explicitly distinguished this early in the developmental trajectory, alterative models were considered as well. Since few pathways from the hypothesized model were significant, it was pertinent to explore a more fully specified model to ensure important significant pathways were not missed from the hypothesized model and to examine whether model fit could be improved.

Figure 3

Model 1: Results of the Hypothesized Model



Note. T = Time, M. Aw. = Morphological Awareness, M. An. = Morphological Analysis, R.C. = Reading Comprehension. Values represent standardized coefficients. *$p \leq .05$ **$p \leq .01$. ***$p \leq 0.001$. For sake of model clarity, latent variable indicators and insignificant links are omitted from the model.

Table 8

Model Fit Information

	χ^2	*df*	*p* value	RMSEA	SRMR	CFI	$\Delta\chi^2$	*df*	*p* value	ΔCFI
Initial Model	891.23	542	< .001	0.061	0. 106	0.928				
Model 1	794.88	524	< .001	0.055	0.065	0.944				
Model 2	788.28	525	< .001	0.054	0.068	0.946				
Model 3	783.72	524	< .001	0.054	0.064	0.946				
Difference between Initial Model and Model 1							97.71	18	<.001	0.016
Difference between Initial Model and Model 3							107.51	18	<.001	0.018

Note. Fit statistic cut-off values are: Chi-square $p > .05$, RMSEA ≤ .06, SRMR ≤ .08, CFI ≥ .95, chi-squared difference $p < .05$, and CFI difference > .01.

In this model, the 12 autoregressive links were retained from the previous models, 8 cross-lagged predictive pathways were indicated from awareness and analysis to subsequent reading comprehension timepoints throughout the five waves, and 15 concurrent links were entered between the three latent variables at each timepoint. Cross-lagged predictive links between morphological awareness and morphological analysis for subsequent waves were initially entered as well, however this model did not converge due to too many free parameters compared to available observations. The inclusion of these pathways is explored in Model 3 described below.

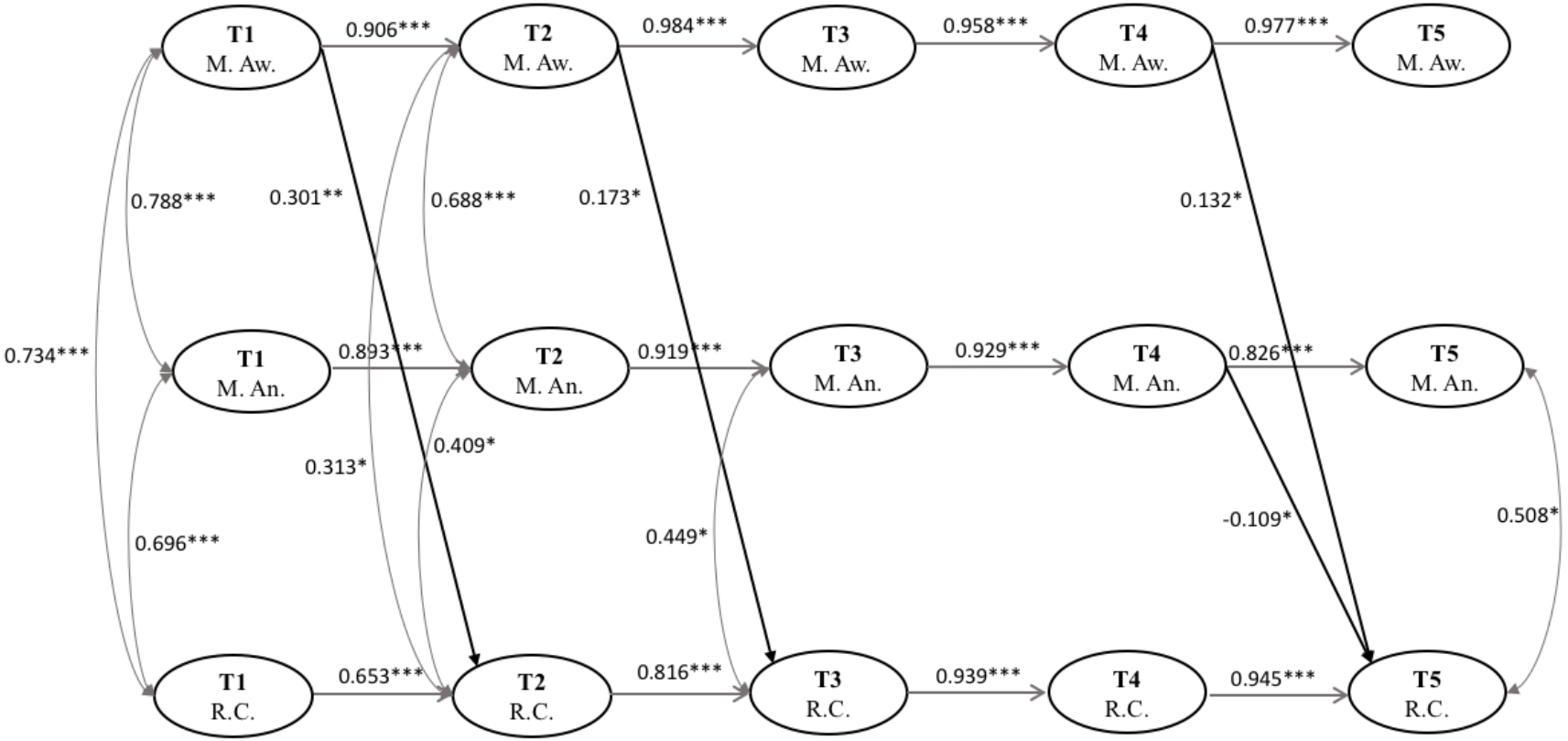
Significant links from this model are shown in Figure 4. All autoregressive links were significant at $p < .001$. Four cross-lagged predictive links were significant: positive pathways were found from awareness at wave 1 to reading comprehension at wave 2, awareness at wave 2 to reading comprehension at wave 3, and awareness at wave 4 to reading comprehension at wave 5, and a negative significant path was found from analysis at wave 4 to reading comprehension at wave 5. Significant concurrent links were found between all three latent variables at wave 1 and 2 and there were significant concurrent links between analysis and reading comprehension at wave 3 and 5. Model fit statistics were as follow: $\chi^2(525) = 788.275$, $p < .001$, RMSEA = .054, CFI = .946, SRMR = .068. This model demonstrated similar fit to the hypothesized model above; however, it had a larger number of significant links specified and it therefore provides more information about the relationships between variables.

Model 3: Final Model with Predictive Link Between Morphological Awareness and Morphological Analysis

Levesque et al. (2019) found that morphological awareness predicted analysis, which in turn predicted reading comprehension from Grade 3 to Grade 4, and in the hypothesized model a significant predictive link was found from morphological awareness at wave 3 to analysis at wave 4. Due to the model not converging when all cross-lagged predictive pathways were entered in Model 2, these pathways were entered one at a time into Model 2. All cross-lagged links from awareness to subsequent waves of analysis and from analysis to subsequent waves of awareness were insignificant except for the significant link from wave 3 awareness to wave 4 analysis that was found in the hypothesized model (Model 1). When this significant link was entered it improved model fit statistics slightly: $\chi^2(524) = 783.722$, $p < .001$, RMSEA = .054, CFI = .946, SRMR = .064. Just like the previous model, most of the fit statistics indicated good

Figure 4

Model 2: Fully Specified Exploratory Model



Note. T = Time, M. Aw. = Morphological Awareness, M. An. = Morphological Analysis, R.C. = Reading Comprehension. Values represent standardized coefficients. *$p \leq .05$ **$p \leq .01$. ***$p \leq 0.001$. For sake of model clarity, latent variable indicators and insignificant links are omitted from the model.

fit and the CFI was very close to the specified threshold. This model has essentially the same number of parameters and fit statistics as the previous model and therefore the two cannot be compared using the $\Delta\chi_2$ test or by examining a change in the CFI. However, because adding this link did not make the fit statistics worse and because it maintains its significance in this model it is kept in the model (see Figure 5). Due to the exploratory nature of the present study, this final model was retained as the best fitting model due to producing the best fit statistics and because it provides the most information on how the variables relate to one another (refer to Table 8 for a summary of the models).

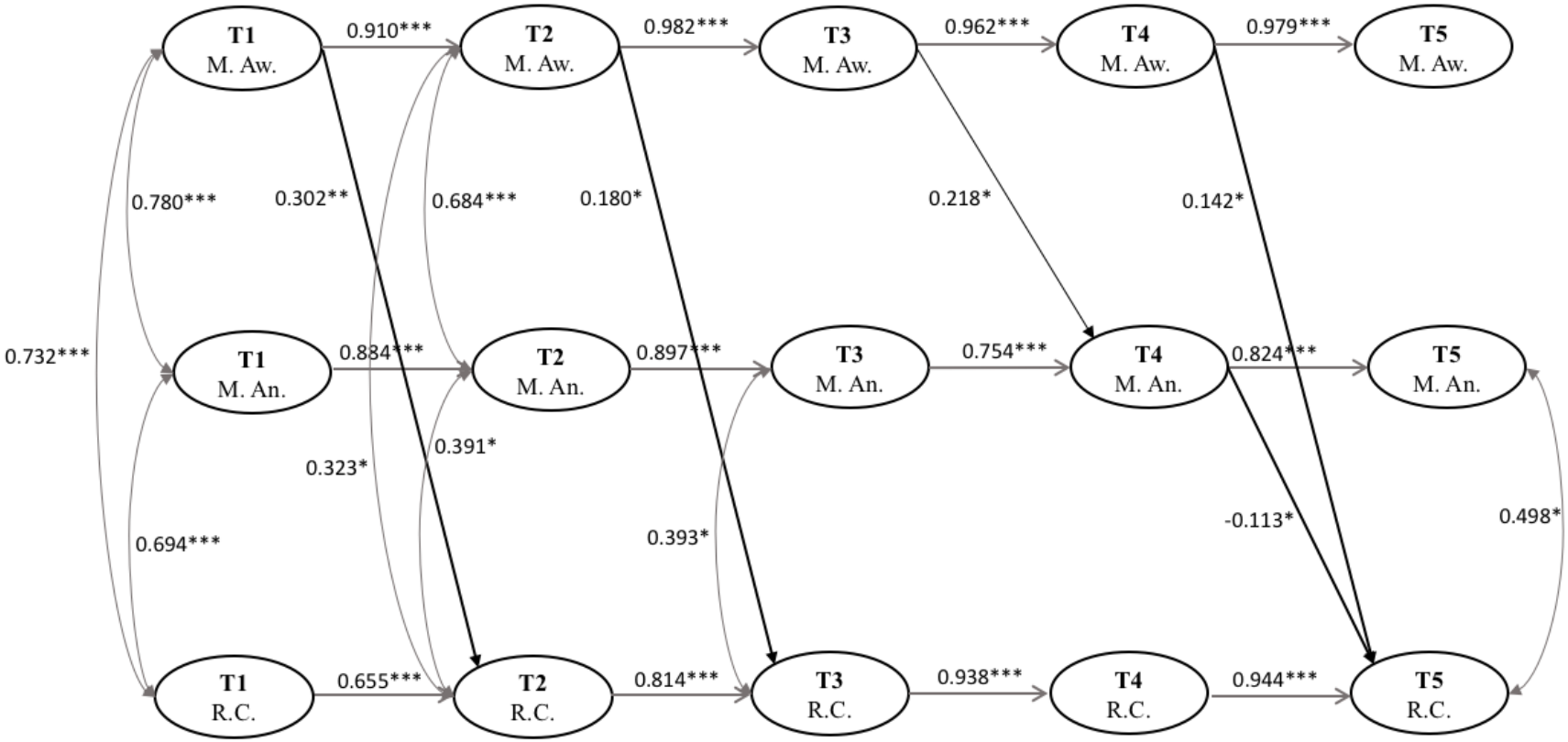
The finding from Levesque et al. (2019) that morphological awareness predicted analysis, which in turn predicted reading comprehension was also explored. A model that specified this relationship, with cross-lagged predictive links throughout subsequent waves from morphological awareness to analysis and analysis to reading comprehension was entered. Autoregressive and concurrent links were included as well. However, no significant links were found from awareness to subsequent waves of analysis in this model, indicating that this finding may not hold true at this early point in development. The reverse relationship was also examined with morphological analysis predicting awareness (Zhang et al., 2020), however none of these cross-lagged predictive paths were significant.

Discussion

Gaining an empirical understanding of how morphological awareness and morphological analysis contribute to young children's reading comprehension over time is important for the theoretical understanding and conceptualization of morphological processes as well as for practical education-based implications and applications. The current study sought to examine and clarify the relationships between morphological awareness, morphological analysis, and reading comprehension from Grade 1 to 3 (age 6 to 9). Morphological awareness, which is conceptualized as the awareness of and ability to manipulate morphemes, contrasts with morphological analysis, which is the ability to use an understanding of morphemes to infer the meaning of unfamiliar or morphologically complex words (Baumann et al., 2002; Carlisle, 2007; Kirby et al., 2012; Levesque et al., 2019). This research extends previous literature by providing a cross-sectional, multiple-wave, longitudinal design that examines the developmental trajectory of distinct morphological processes and reading comprehension and the relationships between them during a period of early reading acquisition.

Figure 5

Model 3: Final Cross-Lagged Model with Predictive Pathway from Awareness (T3) to Analysis (T4)



Note. T = Time, M. Aw. = Morphological Awareness, M. An. = Morphological Analysis, R.C. = Reading Comprehension. Values represent standardized coefficients. *$p \leq .05$ **$p \leq .01$. ***$p \leq 0.001$. For sake of model clarity, latent variable indicators and insignificant links are omitted from the model.

It was hypothesized that there would be a shift in how morphological awareness and analysis contribute to reading comprehension during the developmental period from Grade 1 to Grade 3 as children make the shift from learning to read to reading to learn (Chall, 1983). Specifically, initial hypotheses included that within early waves of testing in Grades 1 and 2, morphological awareness would be an important concurrent predictor of reading comprehension when literacy skills are emerging, and morphological analysis would be an important concurrent predictor of reading comprehension in Grade 3 (waves 4 and 5) when children encounter more morphologically complex words, signifying a shift from morphological awareness to analysis in facilitating reading comprehension as children acquire stronger reading skills (Levesque et al., 2019). Predictive relationships were hypothesized to be significant from morphological awareness to reading comprehension from waves 1 to wave 4 (Grade 1 to beginning of Grade 3), and that analysis would predict growth through to wave 5 (the end of Grade 3). Predictive relationships from awareness to analysis and analysis to awareness were also explored.

To examine these relationships, autoregressive, concurrent, and predictive pathways between morphological awareness, analysis, and reading comprehension were included in cross-lagged panel models. The results partially supported the hypothesized model. As expected, all autoregressive pathways were significant for each of the three outcome variables signifying strong stability in the growth of morphological processes and reading comprehension throughout this time period (Kline, 2016).

As hypothesized, morphological awareness was a significant predictor of subsequent reading comprehension from Grade 1 through to the end of Grade 2; however, no predictive relationships were found from either morphological processing skill from the end of Grade 2 through to the end of Grade 3. This relationship may reflect the important role of morphological awareness early on in the development of reading comprehension skills (Deacon et al., 2018; James et al., 2021). Only one predictive link was found between the two morphological processing constructs. Morphological awareness at the end of Grade 2 predicted morphological analysis at the beginning of Grade 3. In this constrained model, significant concurrent links were found only at the beginning of Grade 1 between morphological awareness and analysis and between morphological awareness and reading comprehension. Overall, the hypothesized model confirmed the unique contribution of morphological awareness on early reading comprehension

skills, however due to the constraints put on this model, this was not considered as the best fitting model.

While the hypothesized model provided adequate fit statistics and significant pathways, the hypothesized results were not fully supported and constraining the data to fit within this model limited the exploration of the relationship between the constructs of morphological awareness, analysis, and reading comprehension throughout the five waves of testing. In order to explore these relationships in more depth, a fully specified model allowing for relationships from morphological awareness and analysis to reading comprehension both concurrently and in a predictive manner throughout all five waves was tested. Due to conflicting past research and the exploratory nature of this study, extending the hypothesized model in this way allowed for a more thorough examination of these relationships at this period of development. This model was retained as the best fitting model as it provided additional significant information delineating relationships between the morphological processes and reading comprehension. Although this model demonstrated similar fit statistics to the hypothesized, it added a number of significant links that were not specified in the hypothesized model, and it therefore provided more information about the relationship between these variables.

Similar to the previous model, strong to very strong autoregressive coefficients were found throughout subsequent waves of morphological awareness, morphological analysis, and reading comprehension indicating stability over time with past skills predicting future skill (Kearney, 2017). Allowing for autoregressive pathways allowed for greater confidence in the additional significant relationships that were found as these relationships maintain their significance even after accounting for prior level of ability (Kearney, 2017).

In both the hypothesized model and the fully specified exploratory model, conceptually important relationships emerge and are sustained. Relationships found in the hypothesized model were maintained in the fully specified model with the addition of new concurrent and predictive pathways. The predictive influence of morphological awareness on reading comprehension was maintained throughout Grade 1 to Grade 2. New predictive relationships were found, including from awareness to reading comprehension from the beginning of Grade 3 to spring of Grade 3, suggesting that this influence may be maintained throughout these early grades. It is clear that morphological awareness plays an important role in reading comprehension from Grade 1 to Grade 2 as an early concurrent predictor, suggesting a bidirectional influence of early

morphological awareness skills and reading comprehension skills, but also as a predictor of subsequent reading comprehension. This supports previous research that has found morphological awareness to be a significant contributor to reading comprehension over time (Deacon et al., 2014; Foorman et al., 2012; Kirby et al., 2012; Kruk & Bergman, 2013, Levesque et al., 2017).

The significant relationship that maintains from morphological awareness to reading comprehension for this age group supports the idea that morphological awareness may be developing first in its direct support of reading comprehension, before morphological analysis skills strengthen and become a more important predictive link. Theoretically, morphological awareness is required especially during early years in the development of reading comprehension at a foundational level when children are concurrently developing both morphological and reading-related skills (Deacon, 2008).

In contrast to the hypothesized results, morphological analysis was found to have important concurrent relationships with reading comprehension throughout all but one wave of testing. It appears that earlier on morphological awareness and analysis contribute concurrently in similar ways, when children are gaining emerging reading skills. Although morphological analysis does not appear to have a significant predictive effect on later reading comprehension during these grades, it is clear that this skill has a unique and important relationship with reading comprehension at concurrent points in time. This may suggest that morphological analysis, while related to reading comprehension ability, has little direct predictive influence on reading comprehension for children in Grades 1 to 3.

The first few years of school may be a time when these skills are concurrently developing, and this relationship may change as children gain a foundational understanding of morphemes and advanced reading skills. Once children develop a strong morphological understanding, they may be able to use strategic morphological analysis skills to support their reading comprehension. This finding is supported by research that has found that while morphological awareness contributes directly and indirectly to reading comprehension, morphological analysis contributes primarily in indirect ways (Goodwin et al., 2020; Levesque et al., 2017; Zhang et al., 2020).

However, morphological analysis may be particularly useful in predicting advanced reading comprehension, as children are exposed to increasingly morphological complex words

and there is a greater demand placed on the reader to infer meaning (Levesque et al., 2021; Nagy & Anderson, 1984; Xie et al., 2019). Morphological analysis in later grades may be of greater benefit as children acquire stronger reading skills (Levesque et al., 2019). Generally, beginning in Grade 3, the majority of words that children encounter in reading are considered morphologically complex (Anglin, 1993; Levesque et al., 2019), which may explain why morphological analysis's contribution to reading comprehension is not predictive at this earlier point in time.

Interestingly, a significant negative predictive relationship was found from morphological analysis to reading comprehension from wave 4 (beginning of Grade 3) to wave 5 (end of grade 3), indicating an inverse relationship with stronger morphological analysis skills predicting poorer reading comprehension skills. This finding is in contrast with the hypothesized predictions; however, the strength of this negative relationship was relatively weak (-.11) and may be the result of subtle changes in the development of these processes. In the previous wave of morphological analysis (waves 3 to 4), the autoregressive coefficient was found to be smaller than its neighbouring waves, 2 to 3, and 4 to 5 which may be contributing to this negative relationship due to non-linear growth. This negative relationship is not consistent with concurrent relations as it was found that just like in previous waves, at wave 5 there was also a positive concurrent relationship between morphological analysis and reading comprehension indicating that these two are relating positively to one another at a similar point in time.

This negative relationship is generally not supported in past literature; however, research by Goodwin et al. (2020) maybe help to shed light on this finding. They examined the differences in how distinct morphological processes support reading comprehension for students in Grade 8 and found that morphological analysis had a negative relationship with reading comprehension for students with limited vocabulary (Goodwin et al., 2020). Students with limited reading vocabulary were unable to effectively apply morphological analysis skills to reading comprehension tasks (Goodwin et al., 2020). Although it would be erroneous to draw conclusions from one unexpected finding, this may help provide insight on why this relationship was found. Perhaps in Grade 3, students' vocabulary knowledge is not yet strong enough to benefit from morphological analysis in a positive way. The ability to figure out word meanings through the process of morphological analysis had been shown to be dependent on vocabulary knowledge and English proficiency (Goodwin et al., 2020; Zhang et al., 2020). In Grade 3, it

could be that these skills are not developed well enough to benefit from morphological analysis in the support of reading comprehension growth and that as students' vocabulary and morphological skills strengthen as they become more aware of the intricacies of morphemes and their meaning, they are better able to incorporate the skill of morphological analysis to support their reading comprehension.

The mechanisms by which these two aspects of morphological processing and reading comprehension relate to one another over time remain unclear. A recent direction taken in research that looked at the relationship between morphological awareness, analysis, and reading comprehension has examined the possibility that in later grades morphological awareness mediates a predictive relationship between morphological analysis and reading comprehension (Levesque et al., 2019) and it was also found that morphological analysis may mediate the relationship between morphological awareness and reading comprehension (Zhang et al., 2020). These potential relationships were briefly explored in the current study by including pathways from awareness to analysis and analysis to awareness in the hypothesized model, one at a time in the fully specified model, and through additional modelling that specified awareness predicting analysis and analysis predicting reading comprehension and vice versa. Results of these specified models suggest that this relationship does not hold true at this earlier point in development or for how these morphological constructs were conceptualized in the present study. This may indicate that morphological awareness may be a broader skill required to obtain more precise morphological analysis skills, and that morphological analysis may have a stronger link to reading comprehension once these foundational skills are developed (Levesque et al., 2021). Participants included in the current study were younger than participants used in research supporting mediation models of morphological processes. Participants of the current study may have been concurrently developing morphological and reading-related skills thereby indicating different relationships in this time period.

Although no concurrent or predictive relationships were found from either morphological awareness or analysis to reading comprehension at wave 4 (beginning of Grade 3), initial evidence of a potential shift to morphological awareness contributing to morphological analysis growth may be indicated in the present study by a single predictive cross-lagged path from morphological awareness to analysis from the end of Grade 2 to the beginning of Grade 3. This finding, while somewhat of an anomaly as it was inconsistent with other waves in the study, may

provide initial support for a shift in how these constructs relate to one another beginning around this point in development. However, additional research is needed to explore this further and provide a greater understanding of how these relationships change with age. The concept that the relationship between morphological analysis and reading comprehension strengthens throughout development may be supported by recent research by Zhang et al. (2020) who found that morphological analysis was a stronger mediator of morphological awareness for students in Grade 4 and 5 with stronger English proficiency than for those with limited English Proficiency and that the ability to utilize morphological analysis may relate to improvements in vocabulary knowledge (Nakamoto et al., 2007). Perhaps as young children develop stronger language and vocabulary skills, they are better equipped to utilize morphological analysis to support their reading comprehension.

Currently, despite literature examining the relationship between these morphological processes and reading comprehension, there is a lack of consistency in conclusions drawn on how they relate at different time points throughout a student's educational career. As readers gain morphological knowledge, skills in morphological processing, and become increasingly familiar with morphological consistencies, morphological awareness and analysis may be useful at different points in their development to support reading and comprehending of novel or complex text. While the present study does not provide definitive conclusions, this research contributes to the literature by providing further evidence of distinct aspects of morphological processing and the importance of examining their separate contributions to reading comprehension. It extends past research by providing longitudinal developmental information of students in Grade 1 to Grade 3. However, in order to make more definite conclusions and to gain a stronger understanding of how these morphological processes relate to one another and to reading comprehension, replication and further research is required to examine the distinct contributions throughout this developmental time frame.

Identifying how anomalies associated with distinct aspects of morphological processing contribute to acquiring reading comprehension skills may help guide the design of educational practices and indicate at what point in time children are likely to benefit from morphological awareness and analysis lessons or intervention to support reading comprehension (Bowers et al., 2010; Nagy at al., 2014). In line with the findings from the present study, interventions and lessons focusing on identifying and manipulating the morphological structure of words,

involving morphological awareness, may be more beneficial in the earlier grades to support later reading comprehension (Good et al., 2015; Wolter et al., 2014; Wolter & Gibson, 2015). Instruction focusing on teaching students to decipher meaning from unfamiliar morphologically complex words by strengthening their understanding of meanings associated with morphemes, in line with morphological analysis, could be more beneficial in the later grades once children develop a larger vocabulary to strengthen reading comprehension (Crosson et al., 2021; Crosson & McKeown, 2016; McCutchen et al., 2014; Zhang et al., 2020). For example, explicit instruction on how to use morphological analysis as a strategy to infer meaning and interpret unfamiliar text may make it more likely that beginning or poor readers may implement this strategy while reading to strengthen reading comprehension (Zhang et al., 2020). The current study and future research may provide support for the effective use of targeted morphological interventions and instruction in ways that are most likely to be effective at precise points throughout development to support comprehension. Future research may consider the difference in the effectiveness of these types of interventions at different ages.

Limitations and Future Directions

While the results of this study further our understanding of the intricacies of the early development of children's morphological processing skills as they relate to reading comprehension, these results may only be generalizable to English speakers. Given that the research was conducted in English, a relatively opaque orthography, the results may not be transferrable to languages with more-transparent spelling conventions and differences in morphological structure (Share & Cooper, 2008). The developmental relationship between morphological awareness and morphological analysis may differ for languages with morphological and orthographic structures that are different from those in English. Related to this, the present study did not exclude participants whose first language was a language other than English which should be considered when interpreting the results.

As the study of distinct aspects of morphological processes is relatively new in terms of reading research, an additional limitation of the current study is the lack of consistency in how these constructs are conceptualized and measured (Zhang et al., 2020). Using different experimental measures may be contributing to the lack of consistency in published literature in this area. It is difficult to draw strong conclusions when there is inconsistency in how morphological awareness, morphological analysis, and reading comprehension are measured.

Different conclusions may be reflecting different conceptualizations and modes of measurement. For example, in the present study, the Absolute Vocabulary Knowledge Test (AVKT) was used as a measure of morphological analysis. It required children to produce definitions and sentences to orally provided morphological complex words, whereas in previous research morphological analysis has also been measured by providing participants with response options or providing morphologically complex words in a sentence context, therefore placing less emphasis on participants' expressive language (Zhang et al., 2020; Goodwin et al., 2020). Participants in the present study did relatively poorly on the AVKT throughout the five waves of testing, which may be indicating that this skill is not adequately developed in Grades 1 to 3, or perhaps indicating that the expressive language demands were too great for these students. Perhaps, if students were provided with response options, the relationship that was found between morphological analysis and reading comprehension may be different. Using consistent measures that are valid indicators of morphological abilities at specific developmental levels would allow for stronger conclusions, a more consistent understanding, and less contradicting or differing results.

Avenues for future research could include replication and extension of the current study by tracking children's morphological awareness, analysis, and reading comprehension beyond Grade 3 to see how these processes relate to one another and change over time. Future research could also specifically explore the potential reciprocal relations between morphological awareness, morphological analysis, and reading comprehension. Past research has found evidence for reciprocal relationships between early morphological processing and later reading skills for this age period (Deacon et al., 2013; Kruk & Bergman, 2013). A specific mediation analysis would also be a beneficial next step when examining these relationships among members of this age range (Deacon et al., 2017; Zhang et al., 2020). These investigations could further our understanding of the relationship between morphological awareness, morphological analysis, and reading comprehension by examining how the two aspects of morphological processing and reading comprehension influence one another and to explore the potential reciprocal or mediating relationship between them as these skills are concurrently developing. Additionally, this approach could be replicated in research that distinguishes between good versus struggling readers to explore whether these relationships change based on skill level and how children with different reading abilities utilize and access different morphological processes

to support reading comprehension.

A second possibility for future research is to explore the relationship between morphological awareness, morphological analysis, and reading comprehension in an older developmental trajectory to examine the role of morphological awareness and morphological analysis in more experienced readers and to examine how these relationships change over time. Perhaps the influence of morphological analysis in reading comprehension increases with age as students encounter increasingly morphologically complex words (i.e. in late elementary or junior high grades). There is also the possibility that perhaps there is a peak in morphological analysis' contribution to reading comprehension and when students reach a certain level of reading comprehension ability the role of morphological analysis begins to decrease as familiarity with morphologically complex words grows. This is beyond the scope of this study but would provide interesting information about the developmental trajectory of the influence of morphological processes on reading comprehension.

Due to the differing results found in previous research in this area, further research is needed to clarify how these two morphological processes support reading comprehension throughout development and to determine directionality, strength, function, and changes in how they relate to one another at different points in time.

Conclusions

The findings of the present study provide evidence for distinct ways by which morphological awareness and morphological analysis contribute to reading comprehension from Grade 1 to Grade 3. Concurrent links to morphological awareness and reading comprehension were found early on, as well as significant predictive links from earlier morphological awareness to subsequent reading comprehension at points in each grade, confirming a strong relationship between morphological awareness and reading comprehension throughout these early grades.

Morphological analysis was found to have important concurrent relationships with reading comprehension at points in each grade without direct positive contributions in a predictive manner. This provides further support for an indirect influence and further information on the development and mechanisms involved in each aspect of morphological processing at this point in development.

The current findings provide initial evidence for a potential shift in how the different aspects of morphological processing predict and contribute to reading comprehension as

comprehension skills are emerging. A predictive link between awareness and subsequent analysis was found from the end of Grade 2 to Grade 3, perhaps indicating the beginning of a shift in how morphological awareness and analysis relate to one another as children begin to develop strong morphological, vocabulary, and reading-related skills.

Results contribute to a wider understanding of how morphological processes and reading comprehension relate which may be used to inform interventions to facilitate and improve morphological skills in order to improve reading comprehension in young children. This research supports the importance of examining distinct aspects of morphological processes in research, examining the contributing factors to reading comprehension. Further research is required to strengthen the understanding of how morphological awareness, morphological analysis, and reading comprehension relate to one another from Grade 1 to Grade 3.

References

Anglin, J. (1993). Vocabulary development: a morphological analysis. *Society for Research in Child Development, 58*(10), i-186. https://doi.org/10.2307/1166112

Aylward, E. H., Richards, T. L., Berninger, V. W., Nagy, W. E., Field, K. M., Grimme, A. C., Richards, A. L., Thomson, J. B., & Cramer, S. C. (2003). Instructional treatment associated with changes in brain activation in children with dyslexia. *Neurology, 61,* 212-219. https://doi.org/10.1212/01.WNL.0000068363.05974.64

Baumann, J. F., Edwards, E. C., Font, G., Tereshinski, C. A., Kame'enui, E. J., & Olejnik, S. F. (2002). Teaching morphemic and contextual analysis to fifth-grade students. *Reading Research Quarterly, 37*(2), 150–176. https://doi.org/10.1598/rrq.37.2.3

Berninger, V.W., Abbott, R. D., Nagy, W., & Carlisle, J. (2009). Growth in phonological, orthographic, and morphological awareness in Grades 1 to 6. *Journal of Psycholinguistic Research, 39*(2), 141–163. https://doi.org/10.1007/s10936-009-9130-6

Beyersmann, E., Castles, A. & Coltheart, M. (2012). Morphological processing during visual word recognition in developing readers: Evidence from masked priming. *The Quarterly Journal of Experimental Psychology, 65*(7), 1306–1326. https://doi.org/10.1080/17470218.2012.656661

Bowers, P. N., Kirby, J. R., & Deacon, S. H. (2010). The effects of morphological instruction on literacy skills: A systematic review of the literature. *Review of Educational Research, 80*(2), 144–179. https://doi.org/10.3102/0034654309359353

Castles, A., Rastle, K. & Nation, K. (2018). Ending the reading wars: Reading acquisition from novice to expert. *Psychological Science in the Public Interest, 19,* 5–51. https://doi.org/10.1177/1529100618772271

Carlisle, J. F. (1995). Morphological awareness and early reading achievement. In L. B. Feldman (Ed.), *Morphological Aspects of Language Processing.* Pages 189 - 209. Erlbaum.

Carlisle, J. F. (2000). Awareness of the structure and meaning of morphologically complex words: Impact on reading. *Reading and Writing, 12*(3), 169–190. https://doi.org/10.1023/A:1008131926604

Carlisle, J. F. (2003). Morphology matters in learning to read: A commentary. *Reading Psychology, 24,* (3-4), 291-322. https://doi.org/10.1080/02702710390227369

Carlisle, J. F. (2007). Fostering morphological processing, vocabulary development, and reading comprehension. In R. K. Wagner, A. E. Muse, & K. R. Tannenbaum (Eds.), *Vocabulary acquisition: Implications for reading comprehension* (pp. 78–103). Guilford.

Carlisle, J. F. (2010). Effects of instruction in morphological awareness on literacy achievement: An integrative review. *Reading Research Quarterly*, *45*(4), 464–487. https://doi.org/10.1598/RRQ.45.4.5

Carlisle, J. F., & Fleming, J. (2003). Lexical processing of morphologically complex words in the elementary years. *Scientific Studies of Reading*, *7*, 239-253. https://doi.org/10.1207/S1532799XSSR0703_3

Carlisle, J. F., & Goodwin, A. (2013). Morphemes matter: How morphological knowledge contributes to reading and writing. In C. A. Stone, E. R. Silliman, B. J. Ehren, & G. P. Wallach (Eds.), *Handbook of language and literacy: Development and disorders* (2nd ed., pp. 265–282). Guilford.

Carlisle, J. F., & Kearns, D. M. (2017). Learning to read morphologically complex words. In K. Cain, D.L. Compton, & R.K. Parrila (Eds.), *Theories of reading development* (pp. 191–214). John Benjamins.

Chall, J. S. (1983). *Stages of reading development*. McGraw–Hill.

Cheung, G. W., & Rensvold, R. B. (2002). Evaluating goodness-of-fit indexes for testing measurement invariance. *Structural Equation Modeling: A Multidisciplinary Journal*, *9*, 233–255. doi: 10.1207/S15328007SEM0902_5

Collins, L. M., Schafer, J. L., & Kam, C., Appelbaum, M. I. (2001). A comparison of inclusive and restrictive strategies in modern missing data procedures. *Psychological Methods* *6*(4): 330-351. https://doi.org/10.1037/1082-989X.6.4.330

Crosson, A. C., & McKeown, M. G. (2016). Middle school learners' use of Latin roots to infer the meaning of unfamiliar words. *Cognition and Instruction*, *34*(2), 148–171. https://doi.org/10.1080/07370008.2016.1145121

Crosson, A. C., McKeown, M. G., Lei, P., Zhao, H., Li, X., Patrick, K., Brown, K., & Shen, Y. (2021). Morphological analysis skill and academic vocabulary knowledge are malleable through intervention and may contribute to reading comprehension for multilingual adolescents. *Journal of Research in Reading*, *44*(1), 154–174. https://doi.org/10.1111/1467-9817.12323

Dawson, N., Rastle, K. & Ricketts, J., Greene, R. L., Benjamin, A. S. (2018). Morphological effects in visual word recognition: Children, adolescents, and adults. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *44*(4), 645–654.https://doi.org/10.1037/xlm0000485

Deacon, S. H., Holliman, A. J., Dobson, G. J., Harrison, E. C. J. (2018). Assessing Direct Contributions of Morphological Awareness and Prosodic Sensitivity to Children's Word Reading and Reading Comprehension. *Scientific Studies of Reading*, *22*(6), 527–534. https://doi.org/10.1080/10888438.2018.1483376

Deacon, S. H. (2008). The metric matters: determining the extent of children's knowledge of morphological spelling regularities. *Developmental Science*, *11*(3), 396–406. https://doi.org/10.1111/j.1467-7687.2008.00684.x

Deacon, S. H. & Bryant, P. (2006). This turnip's not for turning: Children's morphological awareness and their use of root morphemes in spelling. *British Journal of Developmental Psychology*, *24*(3), 567–575. https://doi.org/10.1348/026151005x50834

Deacon, S. H., Kieffer, M. J., & Laroche, A. (2014). The relation between morphological awareness and reading comprehension: Evidence from mediation and longitudinal models. *Scientific Studies of Reading*, *18*(6), 432–451. https://doi.org/10.1080/10888438.2014.926907

Deacon, S. H., Benere, J., & Pasquarella, A. (2013). Reciprocal Relationship: Children's Morphological Awareness and Their Reading Accuracy across Grades 2 to 3. *Developmental Psychology*, *49*(6), 1113–1126. https://doi.org/10.1037/a0029474

Deacon, S. H., & Kirby, J. R. (2004). Morphological awareness: Just "more phonological"? The roles of morphological and phonological awareness in reading development. *Applied Psycholinguistics*, *25*(2), 223–238. https://doi.org/10.1017/S0142716404001110

Deacon, S. H., Tong, X., & Francis, K. (2017). The relationship of morphological analysis and morphological decoding to reading comprehension. *Journal of Research in Reading*, *40*(1), 1–16. https://doi.org/10.1111/1467-9817.12056

Duncan, L. G. (2018). Language and reading: The role of morpheme and phoneme awareness. *Current Developmental Disorders Reports*, *5*(4), 226–234. https://doi.org/10.1007/s40474-018-0153-2

Ehri, L. C. (2020). The science of learning to read words: A case for systematic phonics instruction. *Reading Research Quarterly*, *55*(S1), S45–S60. https://doi.org/10.1002/rrq.334

Elbro, C., & Arnbak, E. (1996). The role of morpheme recognition and morphological awareness in dyslexia. *Annals of Dyslexia*, *46*(1), 209-240. https://doi.org/10.1007/BF02648177

Enders, C. K. (2010). *Applied missing data analysis*. Guilford Press.

Foorman, B., Herrera, S., Petscher, Y., Mitchell, A., & Truckenmiller, A. (2015). The structure of oral language and reading and their relation to comprehension in kindergarten through grade 2. *Reading & Writing*, *28*(5), 655–681. https://doi.org/10.1007/s11145-015-9544-5

Foorman, B.R., Petscher, Y., & Bishop, M.D. (2012). The incremental variance of morphological knowledge to reading comprehension in grades 3–10 beyond prior reading comprehension, spelling, and text reading efficiency. *Learning and Individual Differences*, *22*(6), 792–798. https://doi.org/10.1016/j.lindif.2012.07.009

Good, J.E., Lance, D.M., & Rainey, J. (2015). The effects of morphological awareness training on reading, spelling, and vocabulary skills. *Communication Disorders Quarterly, 36*(3), 142–151. https://doi.org/10.1177/1525740114548917

Goodwin, A.P., & Ahn, S. (2013). A meta-analysis of morphological interventions in English: Effects on literacy outcomes for school-age children. *Scientific Studies of Reading, 17*(4), 257–285. https:// doi.org/10.1080/10888438.2012.689791

Goodwin, A.P., Petscher, Y., Carlisle, J.F., & Mitchell, A.M. (2017). Exploring the dimensionality of morphological knowledge for adolescent readers. *Journal of Research in Reading, 40*(1), 91–117. https://doi.org/10.1111/1467-9817.12064

Goodwin, A. P., Petcher, Y., Tock, J. (2020). Morphological supports: Investigating differences in how morphological knowledge supports reading comprehension for middle school students with limited reading vocabulary. *Language, Speech & Hearing Services in Schools, 51*(3), 589–602. https://doi.org/10.1044/2020_LSHSS-19-00031

Gough, P. B. & Tunmer, W. E. (1986). Decoding, reading, and reading disability. *Remedial and Special Education, 7*(1), 6–10. https://doi.org/10.1177/074193258600700104

Gustavson, K., von Soest, T., Karevold, E., & Røysamb, E. (2012). Attrition and generalizability in longitudinal studies: findings from a 15-year population-based study and a Monte

Carlo simulation study. *BMC Public Health*, *12*(1), 918–918. https://doi.org/10.1186/1471-2458-12-918

Hiebert, E. H., Goodwin, A. P. & Cervetti, G. N. (2018). Core vocabulary: Its morphological content and presence in exemplar texts. *Reading Research Quarterly*, (53), 29–49. https://doi.org/10.1002/rrq.183

Hogan, T. P., Catts, H. W., & Little, T. D. (2005). The relationship between phonological awareness and reading: Implications for the assessment of phonological awareness. *Language, Speech & Hearing Services in Schools*, *36*(4), 285–293. https://doi.org/10.1044/0161-1461(2005/029)

James, E., Currie, N. K., Tong, S. X., Cain, K. (2021). The relations between morphological awareness and reading comprehension in beginner readers to young adolescents. *Journal of Research in Reading*, *44*(1), 110–130. https://doi.org/10.1111/1467-9817.12316

Kearney, M. (2017). Cross lagged panel analysis. In *Encyclopedia of Communication Research Methods* (pp. 312–314). Sage Publications Inc.

Kieffer, M. J., & Lesaux, N. K. (2012). Direct and indirect roles of morphological awareness in the English reading comprehension of native English, Spanish, Filipino, and Vietnamese speakers. *Language Learning*, *62*(4), 1170–1204. https://doi.org/10.1111/j.1467-9922.2012.00722.x

Kieffer, M. J., Petscher, Y., Proctor, C. P., & Silverman, R. D. (2016). Is the whole greater than the sum of its parts? Modeling the contributions of language comprehension skills to reading comprehension in the upper elementary grades. *Scientific Studies of Reading*, *20*(6), 436–454. https://doi.org/10.1080/10888438.2016.1214591

Kirby, J. R. (2007). Reading comprehension: Its nature and development. *Encyclopedia of language and literacy development*, (pp. 1-8).

Kirby, J. R. & Bowers, P. N. (2017). Morphological instruction and literacy: Binding phonological, orthographic, and semantic features of words. In K. Cain, D.L. Compton & R.K. Parrila (Eds.), *Theories of reading development*, (pp. 437–462). John Benjamins. https://doi.org/10.1075/swll.15

Kirby, J. R., Deacon, S. H., Bowers, P. N., Izenberg, L., Wade-Woolley, L., & Parrila, R. (2012). Children's morphological awareness and reading ability. *Reading & Writing*, *25*(2), 389–410. https://doi.org/10.1007/s11145-010-9276-5

Kline, R. B. (2016). *Principles and practice of structural equation modeling* (4th ed.). Guilford.

Kruk, R. S., & Bergman, K. (2013). The reciprocal relations between morphological processes and reading. *Journal of Experimental Child Psychology*, *114*(1), 10–34. https://doi.org/10.1016/j.jecp.2012.09.014

Kuo, L., & Anderson, R. C. (2006). Morphological Awareness and Learning to Read: A Cross-Language Perspective. *Educational Psychologist*, *41*(3), 161–180. https://doi.org/10.1207/s15326985ep4103_3

Levesque, K. C., Kieffer, M. J., & Deacon, S. H. (2017). Morphological awareness and reading comprehension: Examining mediating factors. *Journal of Experimental Child Psychology*, 160, 1–20. https://doi.org/10.1016/j.jecp.2017.02.015

Levesque, K. C., Kieffer, M. J., Deacon, S. H. (2019). Inferring Meaning from Meaningful Parts: The Contributions of Morphological Skills to the Development of Children's Reading Comprehension. *Reading Research Quarterly*, *54*(1), 63–80. https://doi.org/10.1002/rrq.219

Levesque, K. C., Breadmore, H. L., Deacon, S. H. (2021). How morphology impacts reading and spelling: Advancing the role of morphology in models of literacy development. *Journal of Research in Reading*. https://doi.org/10.1111/1467-9817.12313

Little, T. D., (2013). *Longitudinal Structural Equation Modeling.* The Guilford Press.

Marsh, H. W., Byrne, B. M., Yeung, A. S. (1999). Causal ordering of academic self-concept and achievement: Reanalysis of a pioneering study and revised recommendations. *Educational Psychologist*, *34*(3), 155–167. https://doi.org/10.1207/s15326985ep3403_2

McCutchen, D., & Logan, B. (2011). Inside incidental word learning: Children's strategic use of morphological information to infer word meanings. *Reading Research Quarterly*, 46(4), 334–349. https://doi.org/10.1002/RRQ.003

McCutchen, D., Stull, S., Herrera, B. L., Lotas, S., & Evans, S., Carlisle, J. F., Nagy, W. E., Goodwin, A. P. (2014). Putting words to work: Effects of morphological instruction on children's writing. *Journal of Learning Disabilities*, 47(1), 86–97. https://doi.org/10.1177/0022219413509969

Nagy, W. E. & Anderson, R. C. (1984). How many words are there in printed school English? *Reading Research Quarterly*, *19*(3), 304–330. https://doi.org/10.2307/747823

Nagy, W. E., Berninger, V. W., & Abbott, R. D. (2006). Contributions of morphology beyond phonology to literacy outcomes of upper elementary and middle-school students. *Journal of Educational Psychology*, 98(1), 134–147. https://doi.org/10.1037/0022-0663.98.1.134

Nagy, W., Berninger, V., Abbott, R., Vaughan, K., Vermeulen, K. (2003). Relationship of morphology and other language skills to literacy skills in at-risk second-grade readers and at-risk fourth-grade writers. *Journal of Educational. Psychology. 95*(4), 730–742. https://doi.org/10.1037/0022-0663.95.4.730

Nagy, W. E., Carlisle, J. F., & Goodwin, A. P., Carlisle, J. F., Nagy, W. E., Goodwin, Amanda, P. (2014). Morphological knowledge and literacy acquisition. *Journal of Learning Disabilities*, 47(1), 3–12. https://doi.org/10.1177/0022219413509967

Nakamoto, J., Lindsey, K. A., & Manis, F. R. (2007). A longitudinal analysis of English language learners' word decoding and reading comprehension. *Reading and Writing*, *20*(7), 691–719. https://doi.org/10.1007/s11145-006-9045-7

Nation, K., Snowling, M. J., & Clarke, P. (2007). Dissecting the relationship between language skills and learning to read: Semantic and phonological contributions to new vocabulary learning in children with poor reading comprehension. *Advances in Speech-Language Pathology*, *9*(2), 131–139. https://doi.org/10.1080/14417040601145166

Pacheco, M. B., & Goodwin, A. P. (2013). Putting two and two together: Middle school students' morphological problem-solving strategies for unknown words. *Journal of Adolescent & Adult Literacy*, 56(7), 541–553. https://doi.org/10.1002/JAAL.181

Ramirez, G., Walton, P., Roberts, W., Carlisle, J., Nagy, W. E., Goodwin, A. P. (2014). Morphological awareness and vocabulary development among kindergarteners with different ability levels. *Journal of Learning Disabilities, 47*(1), 54–64. https://doi.org/10.1177/0022219413509970

Share, D. L. & Cooper, H. (2008). On the Anglocentricities of current reading research and practice: the perils of overreliance on an "outlier" orthography. *Psychological Bulletin, 134*(4), 584-615. https://doi.org/10.1037/0033-2909.134.4.584

Silva, M., Cain, K., & Graham, S. (2015). The relations between lower and higher-level comprehension skills and their role in prediction of early reading comprehension. *Journal of Educational Psychology*, *107*(2), 321–331. https://doi.org/10.1037/a0037769

Tighe, E. L., & Schatschneider, C. (2015). Exploring the dimensionality of morphological awareness and its relations to vocabulary knowledge in adult basic education students. *Reading Research Quarterly*, 50(3), 293–311. https://doi.org/10.1002/rrq.102

Treiman, R. & Cassar, M. (1996). Effects of morphology on children's spelling of final consonant clusters. *Journal of Experimental Child Psychology*, 63, 141–170. https://doi.org/10.1006/jecp.1996.0045

Wagner, R. K., Torgesen, J. K., & Rashotte, C. A. (1999). CTOPP—Comprehensive Test of Phonological Processing. Austin, TX: Pro-Ed.

Wechsler, D. (1999). WASI—Wechsler Abbreviated Scale of Intelligence. San Antonio, TX: Psychological Corporation.

Wolter, J.A., & Dilworth, V., Carlisle, J. F., Nagy, W. E., Goodwin, A. P. (2014). The effects of a multilinguistic morphological awareness approach for improving language and literacy. *Journal of Learning Disabilities*, 47(1), 76–85. https://doi.org/10.1177/0022219413509972

Wolter, J.A., & Gibson, F.E. (2015). Morphological awareness assessment and intervention to improve language and literacy. *Seminars in Speech and Language*, 36(1), 31–41. https://doi.org/10.1055/s-0034-1396444

Woodcock, R. W. (1998). Woodcock Reading mastery Tests-Revised. Circle Pines, MN: American Guidance Service.

Xie, R., Zhang, J., Wu, X., & Nguyen, T. P. (2019). The relationship between morphological awareness and reading comprehension among Chinese children. *Frontiers in Psychology*, *10*, 54–54. https://doi.org/10.3389/fpsyg.2019.0005

Zhang, D., Koda, K., Leong, C. K. & Pang, E. (2019). Cross-lagged panel analysis of reciprocal effects of morphological processing and reading in Chinese in a multilingual context: Morphology and Chinese Reading. *Journal of Research in Reading, 42*, 58-79. doi:10.1111/1467-9817.12135

Zhang, J., Lin, T., Liu, Y., Nagy, W. (2020). Morphological awareness and reading comprehension: Differential mediation mechanisms in native English speakers, fluent English learners, and limited English learners. *Journal of Experimental Child Psychology*, *199*, 104915–104915. https://doi.org/10.1016/j.jecp.2020.104915

Appendix A

Additional Tables

Table 1

Participant Demographics at Wave 1

Demographics		Frequency (Percent)
N		171 (100)
Sex	Male	94 (54.7)
	Female	77 (44.8)
SES	High	59 (34.3)
	Middle	82 (47.7)
	Low-Middle	13 (7.6)
	Low	17 (9.9)
Primary Language	English	154 (90.0)
	Other	17 (10.5)

Note. SES = Socio-Economic Status based off neighbourhood income levels.

Table 3

Correlations Among Indicators of Latent Variables and Auxiliary Variables at Wave 1

	Vocab	Elr	WC	PC	AVKT_1	AVKT_2	AVKT_3	MKTco	MKTdc
Vocab	-								
Elr	.375**	-							
WC	.329**	.738**	-						
PC	.349**	.733**	.909**	-					
AVKT_1	.431**	.554**	.517**	.490**	-				
AVKT_2	.356**	.420**	.374**	.370**	.428**	-			
AVKT_3	.411**	.441**	.399**	.424**	.448**	.450**	-		
MKTco	.432**	.532**	.583**	.583**	.506**	.358**	.438**	-	
MKTdc	.435**	.507**	.532**	.543**	.440**	.322**	.355**	.649**	-

Note. Vocab = vocabulary, Elr = phonological awareness (elision), WC = word comprehension, PC = passage comprehension, AVKT = Absolute Vocabulary Knowledge test (indicator 1, 2, and 3), MKTco = Morphological Knowledge Test composed items raw score, MKTdr = Morphological Knowledge Test decomposed items raw score. *$p < .05$; ** = $p < .01$.

Table 4

Correlations Among Indicators of Latent Variables at Wave 2

	WC	PC	AVKT_1	AVKT_2	AVKT_3	MKTco	MKTdc
WC	-						
PC	.919**	-					
AVKT_1	.530**	.439**	-				
AVKT_2	.391**	.349**	.556**	-			
AVKT_3	.381**	.357**	.422**	.476**	-		
MKTco	.595**	.603**	.401**	.418**	.433**	-	
MKTdc	.506**	.542**	.332**	.242**	.310**	.590**	-

Note. WC = word comprehension, PC = passage comprehension, AVKT = Absolute Vocabulary Knowledge test (indicator 1, 2, and 3), MKTco= Morphological Knowledge Test composed items raw score, MKTdr = Morphological Knowledge Test decomposed items raw score. *$p < .05$; ** = $p < .01$.

Table 5

Correlations Among Indicators of Latent Variables at Wave 3

	WC	PC	AVKT_1	AVKT_2	AVKT_3	MKTco	MKTdc
WC	-						
PC	.889**	-					
AVKT_1	.643**	.535**	-				
AVKT_2	.569**	.521**	.707**	-			
AVKT_3	.539**	.454**	.615**	.647**	-		
MKTco	.739**	.683**	.570**	.539**	.485**	-	
MKTdc	.618**	.597**	.421**	.406**	.400**	.660**	-

Note. WC = word comprehension, PC = passage comprehension, AVKT = Absolute Vocabulary Knowledge test (indicator 1, 2, and 3), MKTdr = Morphological Knowledge Test composed items raw score, MKTdr = Morphological Knowledge Test decomposed items raw score. *$p < .05$; ** = $p < .01$.

Table 6

Correlations Among Indicators of Latent Variables at Wave 4

	WC	PC	AVKT_1	AVKT_2	AVKT_3	MKTco	MKTdc
WC	-						
PC	.868**	-					
AVKT_1	.536**	.497**	-				
AVKT_2	.473**	.408**	.521**	-			
AVKT_3	.535**	.428**	.541**	.616**	-		
MKTco	.700**	.613**	.541**	.440**	.414**	-	
MKTdc	.554**	.477**	.425**	.330**	.386**	.616**	-

Note. WC = word comprehension, PC = passage comprehension, AVKT = Absolute Vocabulary Knowledge test (indicator 1, 2, and 3), MKTdr = Morphological Knowledge Test composed items raw score, MKTdr = Morphological Knowledge Test decomposed items raw score. *$p < .05$; ** = $p < .01$.

Table 7

Correlations Among Indicators of Latent Variables at Wave 5

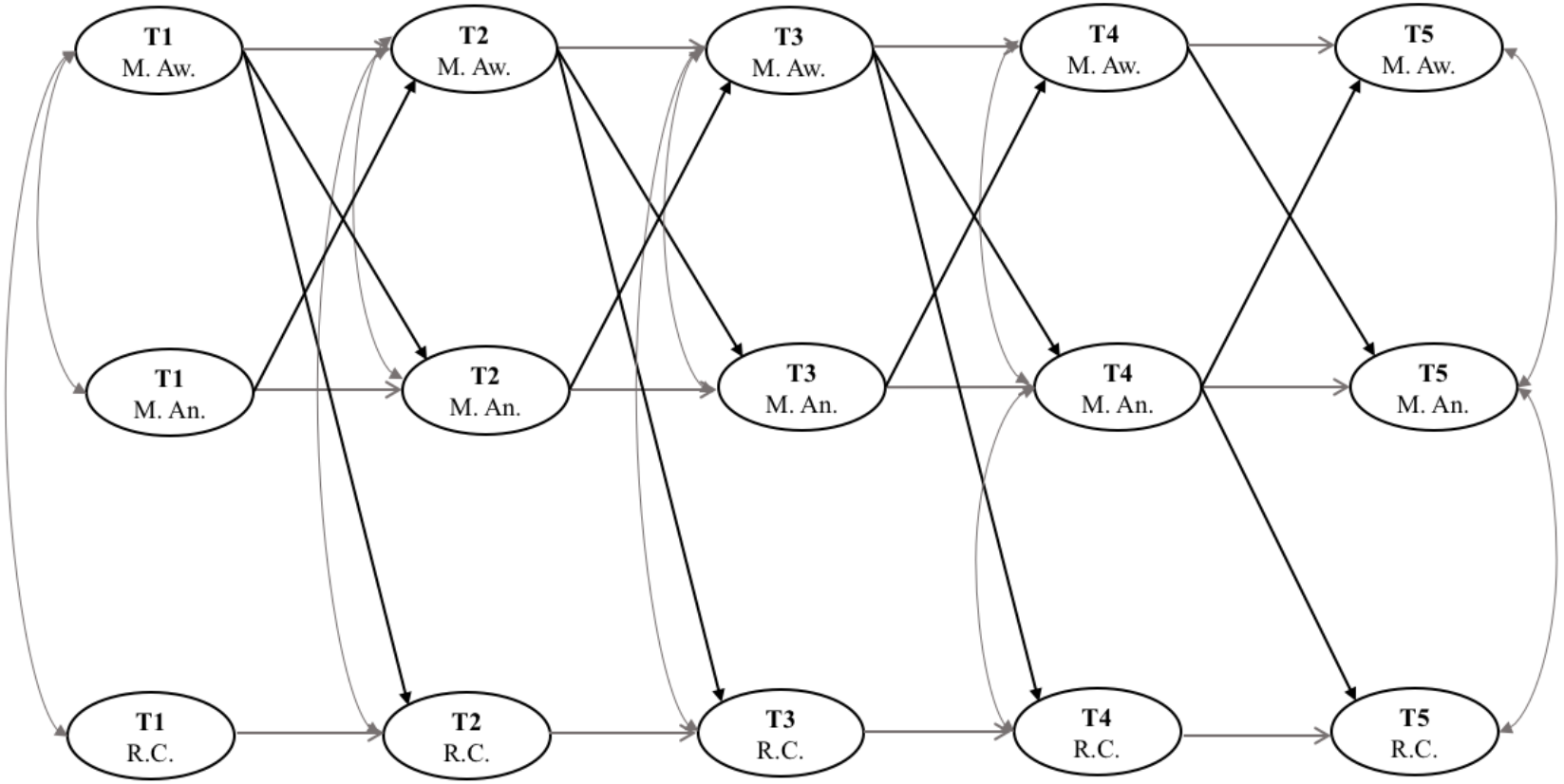
	WC	PC	AVKT_1	AVKT_2	AVKT_3	MKTco	MKTdc
WC	-						
PC	.877**	-					
AVKT_1	.497**	.426**	-				
AVKT_2	.422**	.359**	.611**	-			
AVKT_3	.498**	.409**	.543**	.697**	-		
MKTco	.629**	.552**	.452**	.381**	.438**	-	
MKTdc	.373**	.298**	.273**	.300**	.174*	.412**	-

Note. WC = word comprehension, PC = passage comprehension, AVKT = Absolute Vocabulary Knowledge test (indicator 1, 2, and 3), MKTdr = Morphological Knowledge Test composed items raw score, MKTdr = Morphological Knowledge Test decomposed items raw score. *$p < .05$; ** = $p < .01$.

Appendix B: Additional Figures

Figure 1

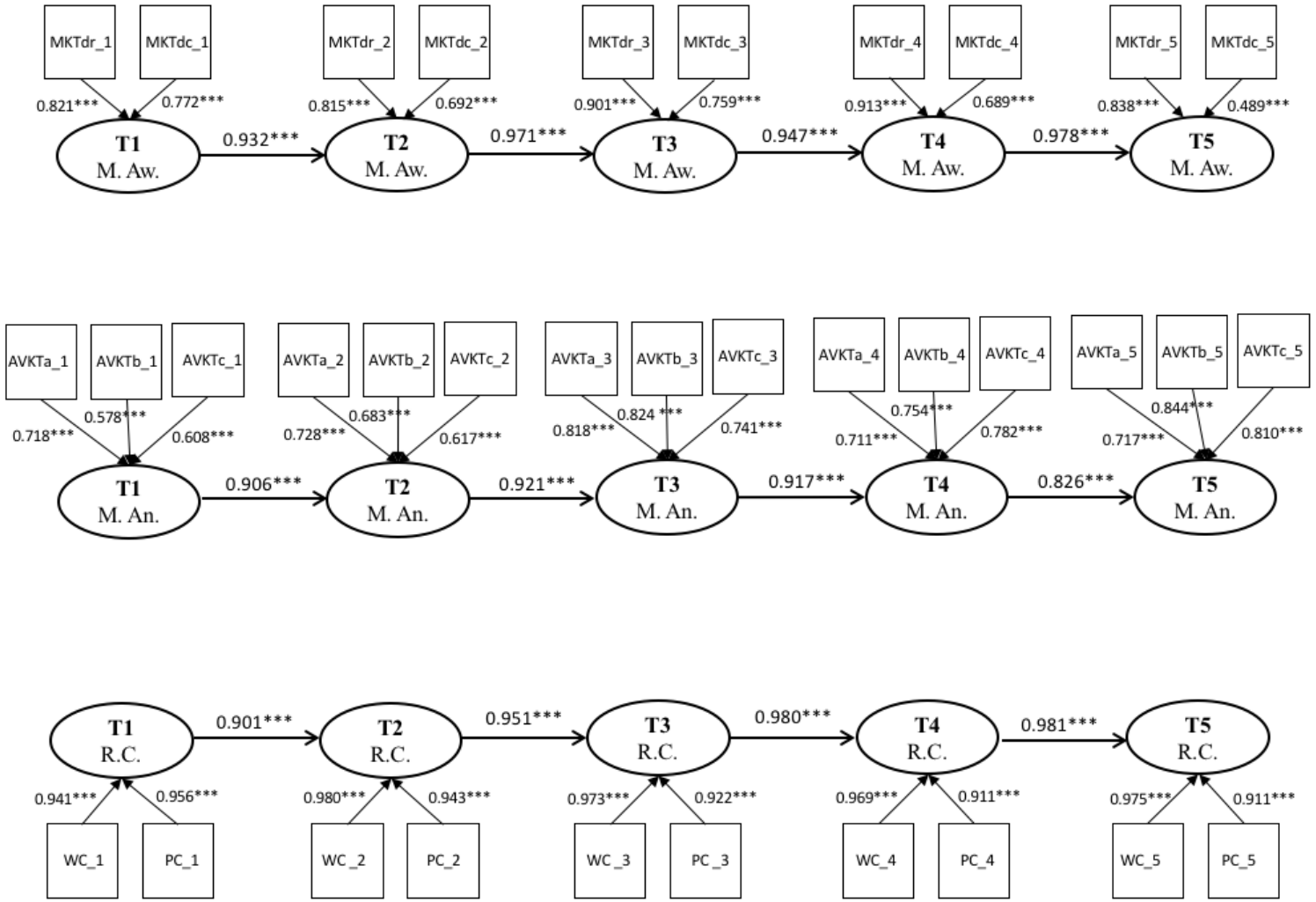
Hypothesized Model of Relationships Among Variables Across Waves



Note: M. Aw. = Morphological Awareness, M. An. = Morphological Analysis, R.C. = Reading Comprehension. T = time: T1= spring of Grade 1, T2 = fall of Grade 2, T3 = spring of Grade 2, T4 = fall of Grade 3, and T5 = spring of Grade 3. Model shows concurrent and predictive pathways between the latent variables of morphological awareness, morphological analysis, and reading comprehension throughout the 5 waves as indicated in the hypothesis section.

Figure 2

Initial Model: Autoregressive Paths and Latent Variable Indicators



Note. T = Time, M. Aw. = Morphological Awareness, M. An. = Morphological Analysis, R.C. = Reading Comprehension. Values represent standardized coefficients. *$p \leq .05$ **$p \leq .01$ ***$p \leq 0.001$.

Appendix C

The Morphological Knowledge Test

Compose

Practice Words

1. Say *enter*. He greeted me when I _____ (entered)
2. Say *sing*. He is my favorite _____ (singer)
3. Say *try.* I couldn't do it, but at least I _____ (tried)

Test Words

1. Say *tree*. In my garden I planted five _____
2. Say *stop*. We ran and then we _____
3. Say *help.* My sister wants to be _____
4. Say *perform*. Tonight is the last _____
5. Say *sun.* I ride my bike when it is _____
6. Say *remark.* The speed of the car was _____
7. Say *ask.* She told me her name when I _____
8. Say *warm.* He chose the jacket for its _____
9. Say *fish.* My friend and I plan to go _____
10. Say *wish.* I have four _____
11. Say *come*. Mary is not here yet. When is she _____
12. Say *assist.* The parent will give you _____
13. Say *human.* The kind man was known for his _____
14. Say *teach.* He is a very good _____
15. Say *profit.* Selling lemonade in the summer is _____
16. Say *appear*. He cared about his _____
17. Say *body.* Can one man have two _____
18. Say *deep*. The lake was well known for its _____
19. Say *life*. How long would you like to _____
20. Say *dead.* I didn't know about his _____
21. Say *permit.* Father refused to give _____
22. Say *shelf*. My uncle made us three _____
23. Say *protect.* She wore glasses for _____
24. Say *active*. He tired after so much _____

Transparent		Shift	
#1-16		#17-24	

Decompose

Practice Words

1. Say *needed*. What do you _____ (need)
2. Say *owner*. This is a house that my parents _____ (own)
3. Say *decision*. The boy found it hard to _____ (decide)

Test Words

1. Say *flowers.* A rose is my favorite _____
2. Say *cutting*. I got my hair _____
3. Say *dangerous.* Are the children in any _____
4. Say *walked*. They went for a long _____
5. Say *continuous.* How long will the storm _____
6. Say *wanted*. Is there anything you _____
7. Say *glasses*. She poured water into a _____
8. Say *popularity*. The girl wants to be _____
9. Say *dirty*. The shelves are full of dust and _____
10. Say *reader*. What books do you like to _____
11. Say *babies.* My aunt has a _____
12. Say *books*. This is a very interesting _____
13. Say *acceptance.* Is that an offer you can _____
14. Say *growth.* She wanted her plant to _____
15. Say *dryer*. Put the wash out to _____
16. Say *density.* The smoke in the room was very _____
17. Say *agreement.* Although I wanted to, I could not _____
18. Say *believe*. What is your most important _____
19. Say *carried*. What do you have to _____
20. Say *strength*. The boy is very _____
21. Say *fifth*. The girl counted from one to _____
22. Say *leaves*. Look at this colorful _____
23. Say *discussion*. The friends have a lot to _____
24. Say *description*. The picture is hard to _____

Transparent	Shift

Appendix D

The Word Analysis Test

Practice Word	No	Yes	Word Supplied
1. Kissed	_____	_____	_____
2. Sound	_____	_____	_____
3. Tend	_____	_____	_____
4. Better	_____	_____	_____
5. Swimmer	_____	_____	_____
6. Very	_____	_____	_____

Test Word	No	Yes	Word Supplied
1. Need	_____	_____	_____
2. Hunter	_____	_____	_____
3. Called	_____	_____	_____
4. Navy	_____	_____	_____
5. Jammed	_____	_____	_____
6. Penny	_____	_____	_____
7. Under	_____	_____	_____
8. Teacher	_____	_____	_____
9. Reed	_____	_____	_____
10. Seed	_____	_____	_____
11. Sunny	_____	_____	_____
12. Wind	_____	_____	_____
13. Hilly	_____	_____	_____
14. Over	_____	_____	_____
15. Fairy	_____	_____	_____
16. Letter	_____	_____	_____
17. Hurry	_____	_____	_____
18. Corner	_____	_____	_____

Comments: _____

_____

_____

1nasal		1nonnasal		2nasal		2nonnasal		3nasal		3nonnasal		Ending Type	
hunter		called		need		reed		penny		seed		er	
jammed		teacher		navy		over		wind		fairy		d	
sunny		hilly		under		hurry		corner		letter		y	
Total													

Appendix E

The Absolute Vocabulary Knowledge Test

Practice Words

1. Hills (Definition) _____
Hills (Query) _____
Hills (Sentence) _____
2. Leader (Definition)
Leader (Query) _____
Leader (Sentence)

Test Words

1. Soaking (D, Q, S)
2. Changed (D, Q, S)
3. Reports (D, Q, S)
4. Forgotten (D, Q, S)
5. Enjoyable (D, Q, S)
6. Mucky (D, Q, S)
7. Stillness (D, Q, S)
8. Sourer (D, Q, S)
9. Knotless (D, Q, S)
10. Treelet (D, Q, S)

Inflected		**Derived**	
Soaking		Enjoyable	
Changed		Mucky	
Reports		Stillness	
Forgotten		Knotless	
Sourer		Treelet	
Total			