NEW INSIGHTS INTO THE RELATION OF MORPHOLOGICAL AWARENESS AND READING COMPREHENSION IN CHILDREN

by

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ABSTRACT

The purpose of reading is to understand the meaning encapsulated in text. Reading comprehension is undoubtedly a complex and multifaceted skill. It has been argued that morphological awareness—the awareness of and ability to manipulate meaningful units in spoken language—might play a vital role in reading comprehension. Despite mounting evidence in support of a relation between morphological awareness and reading comprehension, their relation nevertheless remains underspecified. The question therefore remains: how does children's awareness of morphemes in language relate to the comprehension of written text? Across two studies, the aim of this dissertation was to clarify the relation between morphological awareness and reading comprehension in English-speaking children. It was hypothesized that morphological awareness supports children's ability to decode (morphological decoding) and understand (morphological analysis) morphologically complex words, which, in turn, contributes to reading comprehension. With 224 Grade 3 children, Study 1 used a multiple-mediation design to test the direct and indirect contributions of morphological awareness to reading comprehension via four potential mediators: word reading, vocabulary, morphological decoding, and morphological analysis. The findings of Study 1 showed that morphological awareness contributed indirectly to reading comprehension through a morphological decoding path and a separate morphological analysis path. Interestingly, there was an enduring direct contribution of morphological awareness to reading comprehension beyond all mediators and controls. Using longitudinal autoregressive modeling, Study 2 tested whether morphological awareness predicts gains in reading comprehension beyond morphological analysis from Grade 3 to 4 ($N = 197$). It was found that morphological analysis, but not morphological awareness, contributed to gains in reading comprehension. Morphological awareness, for its part, contributed to gains in morphological analysis. This developmental pattern suggests that morphological awareness contributes to reading comprehension over time by supporting the development of morphological analysis. Altogether, the findings of this dissertation suggest that morphological awareness supports children's ability to read and understand unfamiliar morphologically complex words and, in doing so, contributes to their understating of text. Clarifying the concurrent and longitudinal roles of specific morphological skills informs on the possible mechanisms underlying the relation between morphological awareness and reading comprehension, which has important implications for theory and instruction.

LIST OF ABBREVIATIONS AND SYMBOLS USED

$\Delta\chi^2$	Chi square difference
BC 95% CI	Bias-corrected bootstrapped 95 percent confidence intervals
CFA	Confirmatory factor analysis
CFI	Comparative fit index
d	Cohen's *d* estimate of effect size (values of .2, .5, and .8 reflect small, medium, and large effect sizes, respectively)
df	Degrees of freedom
Gr.	Grade
M	Mean
MLR	Maximum likelihood robust
M_U	Mean word frequency per million words in text
N	Number of participants in the sample
p	*p*-value indicating statistical probability
RMSEA	Root mean square error of approximation
SD	Standard deviation
SEM	Structural equation modeling
SRMR	Standardized root mean square residual
Std. Score	Standardized score
t	Statistical value for comparing means
TLI	Tucker-Lewis index
U	Word frequency estimate per million words in text
VIF	Variance inflation factor
β	Standardized path coefficient
χ^2	Chi square

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CHAPTER 1. INTRODUCTION

The ability to extract meaning efficiently and automatically from written text is the hallmark of literacy (Nation & Angell, 2006; Snow, 2002). This ability to understand text is aptly known as *reading comprehension*. It is an essential skill for success in school and in society because written text is the prime medium of learning (Murnane & Levy, 1996; Verhoeven & Perfetti, 2008). Individuals who struggle with reading comprehension are at greater risk of school dropout and incarceration, poorer employment prospects, and adverse health effects (e.g., DeWalt, Berkman, Sheridan, Lohr, & Pignone, 2004; Mol & Bus, 2011). Thus, there is a great deal at stake in terms of literacy instruction that leads to successful reading comprehension skills. Likewise, substantial research, such as the current work, has been devoted to identifying and understanding the factors that underlie the development of reading comprehension. The current dissertation draws on an immense body of research that conceptualizes reading comprehension as a skill that is intrinsically and deeply rooted in one's oral language ability. As part of the language domain, it has been suggested that *morphological awareness* supports the understanding of meaning in text (e.g., Carlisle, 2003; Deacon & Kirby, 2004; Kuo & Anderson, 2006). Morphological awareness is a metalinguistic construct that reflects one's awareness of the meaningful units in oral language (Carlisle, 1995). Here, I focus specifically on the relation between morphological awareness and reading comprehension given that a child's awareness of meaningful elements in language may play a central role in their ability to extract meaning from text. Indeed, there has been a growing interest in testing this possibility over the last decade—especially considering the mounting evidence of the strong correlation between morphological awareness and reading comprehension in children and adults (e.g., Foorman, Petscher, & Bishop, 2012; Kirby, Deacon, Bowers, Izenberg, Wade-Woolley, & Parrila, 2012; Zhang & Koda, 2012). However, despite this often-observed correlation, the precise nature of their relation remains unclear (Carlisle, 2010). My dissertation seeks to clarify the relation between morphological awareness and reading comprehension in English-speaking children.

To elaborate on the description above, morphological awareness is conceptualized as the knowledge and awareness of the smallest units of meaning in language, which encompasses our ability to reflect on and manipulate these morphemes in spoken language (Carlisle, 1995, 2000, 2003). As the smallest meaningful units, morphemes are the building blocks of language that allow us to construct and understand words (Kuo & Anderson, 2006). For example, the morphologically complex word *unhelpful* is made up of three morphemes, *un* + *help* + *ful*, with each constituent morpheme contributing to the word's overall meaning and function in speech. Many morphemes are words that stand on their own as base morphemes (e.g., *help*; also called root words). Affixes, such as the prefix *un*– and the suffix –*ful*, are morphemes that do not stand on their own and must be bound to a base morpheme. Morphological complexity comes in the form of inflections, derivations, and compound forms. Inflections indicate grammatical function (e.g., verb tense) without changing the meaning or word class of the word (e.g., *help* → *helped* [past tense]). Derivations are morphemes that often change the meaning, word class, or part of speech of the base word (e.g., *help* [verb] → *helpfulness* [noun]). Compounds are formed by combining two or more base words (e.g., *flashlight*).

Morphemes afford a great deal of productivity in language production and comprehension; this productivity occurs across inflected, derived and compound forms (e.g., *helps*, *helper*, *helped*, *helping*, *helpable*, *helpless*, *helpful*, *helpmate*, etc.). It is not surprising, then, that a substantial proportion of words that children encounter, both in spoken language and especially in print, are morphologically complex (Anglin, 1993; Nagy & Anderson, 1984). In fact, in his analysis of elementary school-level texts, Anglin (1993) found that 60 to 80% of the words in texts from Grade 3 and beyond were morphologically complex. This prominence of morphologically complex words in children's texts is one reason to consider the ways in which morphological awareness might contribute to reading comprehension.

1.1. The Relation of Morphological Awareness and Reading Comprehension

Over the last decade, an increasing number of studies have reported a significant relation between morphological awareness and reading comprehension in developing readers (e.g., Carlisle, 2010; Jarmulowicz, Hay, Taran, & Ethington, 2008; Kieffer & Box, 2013; Nagy, Berninger, & Abbott, 2006). The accumulating evidence demonstrates that morphological awareness has a reliable association with reading comprehension in several languages, including English (Carlisle, 2000; Nagy, Berninger, Abbott, Vaughan, & Vermeulen, 2003), French (e.g., Casalis & Louis-Alexandre, 2000), Finnish (e.g., Müller & Brady, 2001), Danish (e.g., Arnbak & Elbro, 2000), and Mandarin (e.g., Ku & Anderson, 2003). This relation is also robust; morphological awareness explains unique variance in reading comprehension beyond factors such as phonological awareness, nonverbal intelligence, vocabulary, and word reading skills (e.g., Cunningham & Carroll, 2015; Deacon & Kirby, 2004; Jeon, 2011; Nagy et al., 2006; Roman, Kirby, Parrila, Wade-Woolley, & Deacon, 2009). The value of these controls should not be understated. Vocabulary knowledge and code-related variables such as phonological awareness and word reading are strong predictors of reading comprehension in their own right, and account for substantial variance in this skill throughout development (e.g., Garcia & Cain, 2014). The fact that morphological awareness contributes to reading comprehension beyond these variables signals the theoretical and empirical importance of this construct in supporting the understanding of text during reading.

From a longitudinal perspective, a small set of studies now show that morphological awareness supports gains in reading comprehension over time (e.g., Deacon, Kieffer, & Laroche, 2014; Foorman et al., 2012; Kruk & Bergman, 2013). Unlike correlational data collected at a single time point, longitudinal data can show the temporal relation between variables. An autoregressive longitudinal design provides a stringent test of a variable's ability to predict change, or gains, over time. It does so by taking account of a child's initial skill level and then examining the amount of change in skill over time relative to that of others. From this measure of change, researchers can then quantify the extent of change, or gains, that is uniquely accounted for by another skill(s). For example, an autoregressive approach can be used to test whether morphological awareness in Grade 3 is related to reading comprehension in Grade 4 *after* controlling for initial reading comprehension ability in Grade 3. Deacon and colleagues (2014) utilized this particular approach in children from Grade 3 to 4. They found that initial morphological awareness predicted Grade 4 reading comprehension after controlling for the autoregressive effect of Grade 3 reading comprehension as well as measures of word reading, vocabulary, phonological awareness, nonverbal ability, and age (see also Deacon & Kirby, 2004; Foorman et al., 2012). Longitudinal findings of this kind inform us as to the directionality of effects, which, in the case of this relation, suggests that morphological awareness contributes to the development of reading comprehension over time. Additional evidence supporting the direction of the relation between morphological awareness and reading comprehension comes from studies of morphological instruction. Namely, instruction in morphological awareness has been linked to improvements in reading comprehension (see Carlisle, 2010; Goodwin & Ahn, 2010). Overall, the evidence reviewed thus far supports an important role for morphological awareness in reading comprehension.

1.2. Theoretical Perspectives

As Carlisle (2010) noted in her integrative review, "the way or ways morphological awareness contributes to different areas of literacy are, in general, underspecified" (p. 480). This is especially true for the relation of morphological awareness to reading comprehension. Overwhelmingly, the role of morphological awareness, and morphology more generally, is not considered in theories of word reading and reading comprehension (Carlisle & Kearns, 2017; Frost, Grainger, & Rastle, 2005; Reichle & Perfetti, 2003). At the surface, the constructs of morphological awareness and reading comprehension appear to be inherently linked. On one side, morphological awareness deals with the awareness of meaningful units in language and, on the other side, reading comprehension is the understanding of meaning in text. Both constructs are patently associated with the processing of meaning, which is the ultimate purpose of oral and written language. And yet, despite the considerable evidence supporting a connection between morphological awareness and reading comprehension, the ways—or mechanisms—through which these constructs are linked remain unclear. This leads to the key question in the dissertation: How does children's awareness of the meaningful units in spoken language contribute to their ability to comprehend text during reading? Considering that "few models of literacy development specify any role for morphological awareness" (Carlisle, 2010, p. 466), theoretical insight relevant to answering this question is limited. I nevertheless consider here how morphology has been contextualized within current theories of word reading and reading comprehension. As will become evident, there is much work to be done in specifying the role(s) of morphological awareness in children's reading development.

1.3. Theories of Word Reading

1.3.1. Phase Theory of Reading Development. The influence of morphology on word reading is considered, to a small extent, in Ehri's Phase Theory of Reading Development (Ehri, 1995, 2005, 2014). Ehri's theory describes the development of word reading through a sequence of four overlapping phases; not considering the first "pre-alphabetic" phase, which describes children's skills prior to their exposure to letters, the last three phases describe the progression of children's word reading skills through practice over time. Across these phases, word reading skills and strategies become increasingly efficient to the point that words can be read effortlessly by sight in the last phase. Each phase is distinguished by the dominant type of connections linking orthography (i.e., letters, letter patterns, whole words) to phonology (i.e., individual sounds, a word's pronunciation). In the second phase, for instance, children learn about and increasingly rely on individual letter-sound correspondences. Referred to as phonological decoding, this more laborious approach to word reading is a necessary stepping stone in reading development (Ehri, 2014; Gough & Tunmer, 1986; Share, 1995). In the latter phases, children read words via increasingly-large orthographic chunks that connect readily to their pronunciations. When orthographic chunks become as large as whole words and are read with automaticity, Ehri (2005) states that children are engaging in sight word reading.

Morphology becomes relevant to word reading in the final phase, the consolidated alphabetic phase. In this phase, Ehri (1995) proposes that children become familiar with letter patterns that occur frequently in written words and that they retain larger patterns in memory. As the name of the phase suggests, these recurring letter patterns become consolidated into distinct orthographic chunks. For example, the letter pattern *–ight* likely becomes consolidated in memory and treated as a single unit given its frequent recurrence in written words (e.g., *night*, *sight*, *light*, *bright*, etc.). As the example suggests, reading words via orthographic chunks allows for faster and more efficient word reading than decoding words by individual letter-sound correspondences. In Ehri's view, letter patterns can include onsets and rimes (*quest*: [onset] *qu* + [rime] *est*), syllables (*question*: *ques* + *tion*), morphemes (*question* + *able*), and even whole words (*questionable*). Thus, morphemes may impact word reading efficiency provided they recur in print and become consolidated as orthographic chunks in memory (Ehri, 1995, 2005). According to the Phase Theory, for instance, the frequently recurring morpheme –*able* likely becomes consolidated in memory and, if so, would increase reading efficiency for words that include this common suffix (e.g., *questionable*, *walkable*, *comfortable*, etc.). The Phase Theory is primarily concerned with decoding written form, not about the extraction of meaning from written words during reading. Because of this, Ehri's Phase

Theory of Reading Development does not distinguish between consolidated patterns that are morphemes (*–able*) from those that are not morphemes (*–ight*). I return to discuss this issue in greater detail below.

1.3.2. Psycholinguistic Grain Size Theory. Like Ehri's (1995) Phase Theory, the consolidation of recurring orthographic chunks as single units in memory is a prominent component of Ziegler and Goswami's (2005) Psycholinguistic Grain Size Theory. Ziegler and Goswami argue that the process by which recurring letters are chunked into increasingly larger grain sizes is key for word reading efficiency. According to the Psycholinguistic Grain Size Theory, children rely on small and large grain size chunks as needed; in contrast to Ehri's phase theory, the size and use of orthographic chunks are not delineated by children's progression through phases of development. Instead, at any point in reading development, word reading is accomplished through multiple grain size decoding strategies that function in parallel to read words as efficiently as possible. The division of labour between small and large grain size chunks is viewed to be a function of the language and the consistency of its orthography. In languages with highly consistent orthographies such as Greek, Spanish, and Italian, children can use decoding strategies based on smaller grain sizes (e.g., single letter-sound correspondences) while still demonstrating efficient word reading. In comparison, English has a highly inconsistent orthography. Consider, for instance, the different pronunciations for the letter pattern *ough* (e.g., *though, thought, through, drought*) and the numerous spellings of the phoneme /*u*/ (e.g., *through, threw, clue, zoo*). Ziegler and Goswami argue that in languages with less consistent orthographies such as English, children need to use larger grain sizes for reading words because smaller grain sizes are less reliable. Like Phase

Theory, the Grain Size Theory makes no explicit distinction between large grain sizes that are meaningful (i.e., morphemes) and those that are non-meaningful orthographic chunks.

1.3.2.1. Morphology and morphological awareness in theories of word reading. Both the Phase Theory of Reading Development and the Psycholinguistic Grain Size Theory argue that readers consolidate recurring letters patterns into orthographic chunks in memory—a process that ultimately increases efficiency in word reading (Ehri, 1995, 2005; Ziegler & Goswami, 2005). Critically, neither theory distinguishes between consolidated chunks that reflect morphemes (–able) from orthographic chunks without associated meaning (–ight). In other words, consolidated letter patterns—be they onset, rime, syllable, morpheme chunks—are treated analogously with respect to their influence on word reading efficiency.

The equivalence of morpheme and non-morpheme orthographic chunks in processing words seems unlikely. This is because word reading via larger morpheme chunks is likely to be more efficient than using smaller grain size chunks (e.g., syllables, rimes, etc.). For example, reading the word *unquestionable* is accomplished more economically when decomposed into its three morphemes (*un+question+able*) than its five syllables (*un-ques-tion-a-ble*), and certainly more efficient than phonologically decoding its 13 individual grapheme-phoneme correspondences (*ʌ-n-k-w-ɛ-s-tʃ-ə-n-ə-b-ə-l*). Beyond processing economy, another possible feature distinguishing morphemes and orthographic chunks lies in the fact that morphemes carry meaning (i.e., semantics). On this note, researchers have speculated that semantic activation likely supports word reading (e.g., Nation & Angell, 2006; Perfetti & Hart, 2002; Taylor, Plunkett, & Nation, 2010). The sublexical morphemes within morphologically complex words are likely to be much more familiar letter patterns than the complex words in which they are embedded. Accordingly, processing morphemes within unfamiliar complex words provide an opportunity for partial semantic activation that would not be possible via meaningless orthographic chunks. Through a top-down process (c.f., Frost, 2012; Perfetti & Stafura, 2014), the semantic activation afforded by morphemes might facilitate faster or more accurate word reading beyond what would be possible without semantic activation (Perfetti, 2007).

Relatedly, many words in English have an irregular spelling associated with their pronunciation, which makes them especially difficult for children to read via their letter–sound correspondences. For instance, the pronunciation of *health* is different than what we might expect based on the pronunciation of its base word *heal*. If children are relying exclusively on phonological decoding, this difference is enough to lead them astray when reading *health* aloud; more critically, this mispronunciation may interfere with word comprehension. On the other hand, children who recognize the morphological relation between *heal* and *health* are more likely to deduce that *health* is related to the meaning of *heal* regardless of their phonological inconsistency. As such, morphemes are likely to be beneficial for words with inconsistent spellings because their consolidation in lexical memory enables expedited access to their pronunciation and meaning (Harm & Seidenberg, 2004; Nation, 2009; Perfetti, 2007). The authors of the Phase Theory (Ehri, 1995) and Grain Size Theory (Ziegler & Goswami, 2005) do not explicitly deliberate on these speculations, yet they are indeed worthy of further study.

Another question arises when contemplating the role of morphological awareness in these theories of word reading. In short, it seems that morphological awareness is not considered in the Phase and Grain Size Theories (Ehri, 2014). It is particularly noteworthy that Ziegler and Goswami (2005) make no reference to morphological awareness. According to their Grain Size Theory, two tenets that are consistent across languages are that learning to read depends on 1) the availability of the phonological unit in spoken language and 2) the consistency in the mappings between pronunciation and print. In my view, morphological awareness is related to both tenets. For the first point, morphemes are, by definition, available phonological units of meaning in oral language. For the second point, combining morphemes to construct words is fairly rule-based and predictable, and the pronunciation and spelling of morphemes is relatively consistent (e.g., *question* is pronounced and spelled similarly in *questions*, *questioning*, *questionable*, etc.). An awareness of morphological structure in language could enable children to become sensitive to the meaningful patterns that recur in spoken and printed words, which is relevant to both tenets of the Grain Size Theory. Therefore, it seems important that theories consider the potential role of morphological awareness in word reading (e.g., Carlisle & Stone, 2005; Kearns, 2015; Nunes & Bryant, 2011).

1.4. Connectionist Models

Whereas word reading theories consider morphemes as consolidated letters chunks, connectionist frameworks conceptualize morphemes as distinct patterns of code activation (see Harm & Seidenberg, 2004; Plaut, McClelland, Seidenberg, & Patterson, 1996; Seidenberg & McClelland, 1989). For instance, Gonnerman and colleagues suggest that “morphemes are not like beads on a string but rather reflect degrees of convergence between form and meaning that vary across words" (Gonnerman, Seidenberg, & Andersen, 2007, p. 338). Each morpheme is associated with a distinct activation pattern distributed across orthographic, phonological, and semantic codes (Plaut, 2005). In this conceptualization, I would argue that morphological awareness, then, would be taken as the awareness of and familiarity with the statistical regularities of these patterns of activation (Deacon, Conrad, & Pacton, 2008). Connectionist computational models evaluate a model's ability to learn patterns of code activation and generalize this learned information to novel situations (e.g., Plaut, 2005; Plaut et al., 1996; Seidenberg & McClelland, 1989). Studies have revealed that computational models can become attuned to morphological regularities in the form of recurring patterns of activation of orthographic, phonological, and semantic codes (Rueckl, 2010). Intriguingly, this has been observed regardless of whether morphological relations were explicitly trained (Rueckl & Raveh, 1999) or not (Harm & Seidenberg, 2004). The limited evidence thus far suggests that morphemes are learned based on distinct patterns of print, sound, and meaning activation over time (i.e., number of learning instances). These learned patterns are said to become 'hidden' morphological representations in the model that can generalize to the processing of novel stimuli (Plaut, 2005; Rueckl, 2010; Rueckl & Raveh, 1999). One implication of this finding is that it suggests that morphological awareness includes an element that is uniquely morphological—one that is related to, but can operate beyond, orthographic, phonological, and semantic processes.

1.4.1. Lexical Quality Hypothesis. The *Lexical Quality Hypothesis* conceptualizes how knowledge of spoken and written language become unified as increasingly high-quality lexical representations in memory (Perfetti, 1999, 2007, Perfetti

& Hart, 2001, 2002). According to this theory, high-quality lexical representations are the foundational elements that enable reading efficiency and masterful word comprehension and, consequently, reading comprehension (Perfetti & Stafura, 2014). In order to achieve a high-quality status, a lexical representation requires substantial knowledge of a word's form and meaning. The main constituents of this knowledge—orthography, phonology, and semantics—are often described as the three pillars of a triangle, which are linked together in a connectionist-inspired network. These constituents must be tightly bonded to the point that they can be redundantly activated. For example, seeing the word *banana* in print activates the orthographic constituent, which automatically activates the phonological and semantic constituents associated with the sound and meaning of *banana*, which then feeds back to orthography, and so on throughout a tightly connected network. Moreover, high-quality representations are both precise and flexible; precision for distinguishing among similar representations (e.g., distinguishing between *precedent* vs. *president*) and flexibility to account for contextual effects (e.g., *record* in the context of *please keep a <u>record</u> of transaction* vs. *please <u>record</u> the conversation*). Improving the quality of any given lexical representation (i.e., increasing constituent knowledge and strengthening the bonds between them) is accomplished through reading practice and language experiences over time. Although not an explicit theory of reading comprehension, the Lexical Quality Hypothesis contends that the ratio of high- to low-quality lexical representations directly impacts reading comprehension (Perfetti, 2007).

1.4.1.1. Morphology and the Lexical Quality Hypothesis. As a connectionist-informed theory, the Lexical Quality Hypothesis includes a morphological constituent beyond orthographic, phonologic, and semantic constituents. Specifically, Perfetti (2007) lists five features of lexical representations; the first three constituents—orthography, phonology, and semantics—are the primary elements that define the identity of word. The fourth feature is the morphological knowledge constituent (labelled 'morpho-syntax' in Perfetti, 2007), which seemingly occupies a more limited, or secondary, role. Finally, the fifth feature is a binding constituent that reflects the extent to which the four knowledge constituents are fused together. Although morphology is described as occupying a secondary role in the theory, the Lexical Quality Hypothesis nevertheless suggests that strong morphological awareness skills contribute positively to the quality of lexical representations. When considering the role of morphology in this theory, it remains unclear how and to what extent morphological awareness shapes lexical representations or strengthens the bonds between orthography, phonology, and semantic constituents. Indeed, it is difficult to identify specific morphological effects from studies to date testing the Lexical Quality Hypothesis.

1.5. Theories of Reading Comprehension

Building on these models of word reading, I turn to theories of reading comprehension to explore whether these theories specify a role of morphological awareness on children's ability to comprehend text.

1.5.1. Simple View of Reading. Originally proposed by Gough and Tunmer (1986), the *Simple View of Reading* is one of the most widely-cited theories of reading comprehension. According to the Simple View of Reading, reading comprehension is the product of two independent components: word reading and listening comprehension (Gough & Tunmer, 1986; Hoover & Gough, 1990). The word reading component (originally called 'decoding'; Gough & Tunmer, 1986) reflects the ability to read words quickly and accurately in addition to phonological decoding skills. The listening comprehension component encompasses the linguistic knowledge and skills that support the understanding of spoken language. There is widespread support for the importance and distinctiveness of the two components in predicting reading comprehension (e.g., Catts, Herrera, Nielsen, & Bridges, 2015; Kendeou, van den Broek, White, & Lynch, 2009; Oakhill & Cain, 2012; Protopapas, Simos, Sideridis, & Mouzaki, 2012; Vellutino, Tunmer, Jaccard, & Chen, 2007). The Simple View of Reading further characterizes relative contributions of word reading and listening comprehension to reading comprehension across development (Garcia & Cain, 2014; Hoover & Gough, 1990). For readers of English, word reading contributes more strongly to reading comprehension in the early stages of reading; language comprehension eventually eclipses word reading by explaining increasing variance in reading comprehension as children get older (e.g., Adlof, Catts, & Little, 2006; Florit & Cain, 2011; LARRC 2015). Although it has been critiqued for being overly simplistic (Kirby & Savage, 2008), the Simple View has offered a useful model for the study of reading comprehension.

1.5.1.1. Morphology and the Simple View of Reading. The Simple View of Reading does not specify any particular role for morphological awareness in reading comprehension. Morphological awareness is not mentioned in relation to either the word reading or listening comprehension components of the Simple View (Gough & Tunmer, 1986). This has led to the contention that the Simple View of Reading is perhaps *too* simple to fully account for the complexity of reading comprehension (Kirby & Savage, 2008; also see LARRC, 2015; Salceda, Alonso, & Castilla-Earls, 2013; Silverman, Speece, Harring, & Ritchey, 2013). Even so, the mounting evidence of a relation between morphological awareness and reading comprehension leads us to ask: Where does morphological awareness fit within the Simple View of Reading?

Arguably, the description of morphological awareness included at the outset of this dissertation (i.e., the knowledge and awareness of meaningful units of spoken language) would lead to the assumption that morphological awareness falls within the listening comprehension component of the Simple View model (Tong, Deacon, Kirby, Cain, & Parrila, 2011). Although morphological awareness is likely strongly associated with the listening comprehension component, I build on recent arguments that these two linguistic constructs are not synonymous (Kieffer, Petscher, Proctor, & Silverman, 2016). For instance, the Simple View of Reading as it was originally conceptualized claims that the listening comprehension and word reading component are distinct and independent predictors of reading comprehension (Gough & Tunmer, 1986). Accordingly, if morphological awareness is strictly a subskill of listening comprehension, it too should be independent from the word reading component. And yet there are multiple studies demonstrating contributions of morphological awareness to word reading (e.g., Carlisle, 1995; Kirby et al., 2012; Nunes & Bryant, 2011; Roman et al., 2009).

Morphological awareness does not appear to fit solely within a single component of the Simple View model (Gough & Tunmer, 1986). Taking this into consideration leads me to contemplate two possible ways in which morphological awareness relates to reading comprehension within the Simple View of Reading framework. One possibility is that the construct of morphological awareness is included in both components of the Simple View. With this option, it would contribute to word reading and listening comprehension separately, with both components contributing independently to reading comprehension. A second possibility is that morphological awareness appears once in the model within an entirely separate component from word reading and listening comprehension. This added ‘morphological’ component would contribute to each of the word reading and listening comprehension components, with each in turn contributing to reading comprehension. Moreover, having an additional component leaves open the possibility that the morphological awareness component contributes directly to reading comprehension, as would be predicted based on recent empirical evidence (e.g., Deacon et al., 2014; Kieffer & Lesaux, 2012). These two possibilities are worthy of investigation.

1.5.2. Reading Systems Framework. The *Reading Systems Framework* proposed by Perfetti and colleagues explicitly includes morphology in its model of reading comprehension (Perfetti, 1999; Perfetti, Landi, & Oakhill, 2005; Perfetti & Stafura, 2014). The Reading Systems Framework delineates a broad set of knowledge sources—called *systems*—that impact reading comprehension. Knowledge sources include orthographic knowledge, linguistic knowledge, general world knowledge, etc., with each being distinct systems that interact within a cognitive system that operates with limited resources. As a whole, these systems are meant to capture the complexity of reading comprehension.

1.5.2.1. Morphology and the Reading Systems Framework. The comprehensive Reading Systems Framework places morphology in two separate systems of the model: the linguistic system and the lexicon. Within the linguistic system, morphology is included alongside other linguistic elements such as phonology and syntax. As morphology’s second placement in the framework, the lexicon relates directly to the Lexical Quality Hypothesis discussed previously (Perfetti, 2007). The lexicon is where word-specific knowledge (i.e., lexical representations) is accumulated and stored in memory over time. The quality of lexical representations is reflected by the extent of knowledge in the orthographic, phonological, and semantic constituents, as well as knowledge in a secondary morphological constituent and an overall binding constituent that links them all together.

Through the dual placement of morphology in the linguistic system and in the lexicon, the Reading Systems Framework specifies three pathways in which morphology might play a role in reading comprehension (Perfetti & Stafura, 2014). First, in the most direct pathway, morphology in the linguistic system is depicted as contributing directly to reading comprehension. Second, morphology in the linguistic system is depicted as having an indirect influence on reading comprehension by contributing to the word reading system (i.e., the system that processes visual input for decoding and identifying words in print). Third, morphology in the linguistic system is depicted as having an indirect influence on reading comprehension through its contribution to the lexicon. The indirect lexicon pathway is unique in that it contributes to reading comprehension on one side and to the word reading system on the other side. The latter path to word reading suggests that activation, or partial activation, in the lexicon subsequently facilitates the ongoing word reading process, while simultaneously supporting reading comprehension. Untimely, all pathways lead toward reading comprehension.

Therefore, the Reading Systems Framework stands out from other theories because it overtly implicates a morphological influence on reading comprehension through multiple pathways: a direct pathway, an indirect pathway through the lexicon, and another indirect pathway via word reading (Perfetti et al., 2005). However, without further specification of these pathways, it could be argued that morphology does not have a unique role, but rather is part of an indiscriminate linguistic influence that propagates throughout the framework toward reading comprehension. On the other hand, the multiple pathways of the Reading Systems Framework raise the possibility that morphology plays multiple distinct roles in supporting reading comprehension. At present, the precise role(s) that morphology might occupy through these pathways remains unclear. Moreover, assuming that morphology does indeed play multiple distinct roles, it remains to be determined whether the extent of such potential unique influences on reading comprehension can be distinguished 1) from each other and 2) from other linguistic factors in the framework.

1.6. The Current Work

It has long been suggested that "morphological awareness provides the avenue to comprehension" (Kuo & Anderson, 2006, p. 161). Simply put, my dissertation seeks to clarify this "avenue" by specifying the ways in which morphological awareness relates to reading comprehension in English-speaking children. Despite the accumulated evidence thus far, we have yet to fully explain the nature of their connection. Thus, the present research is motivated by the general lack of understanding of the relation of morphological awareness and reading comprehension in research and in theory.

This research is grounded in current theory and findings in the literature. I extrapolated from across the wide-range of theoretical insight described throughout this introduction to inform the research questions and predictions. My theoretical perspective is especially influenced by the Reading Systems Framework (Perfetti et al., 2005; Perfetti & Stafura, 2014), which provides the clearest footing for generating predictions of how morphological awareness contributes to reading comprehension. For instance, the Reading Systems Framework implicates a morphological contribution to reading comprehension through three distinct pathways. Instigated by this framework, I considered the possibility that morphology may play multiple roles in reading comprehension. Specifically, I reasoned that these roles might reflect the manifestation of separable dimensions of morphological influence on reading comprehension, with morphological awareness reflecting one such dimension. I tested this possibility in two empirical studies in this dissertation.

In both dissertation studies, I put forward the overarching prediction that morphological awareness influences reading comprehension through its contribution to other morphological dimensions. I contend that morphological awareness, as a metalinguistic skill, enables ready access to the morphological structure of complex words encountered in spoken and written language (e.g., Carlisle, 2000; Deacon et al., 2014; Kuo & Anderson, 2006). For this reason, I argue that morphological awareness has a targeted effect on one's ability to read and understand words with a complex morphological structure; this, in turn, influences reading comprehension. This formed the basis for speculating about the role of two additional, related yet distinct, morphological dimensions beyond morphological awareness: *morphological decoding*, a print-centered dimension that is specific to reading complex words and *morphological analysis*, a meaning-centered dimension focused on deriving meaning from morphological structure. The print- and meaning-centered morphological dimensions were expected to contribute uniquely to reading comprehension. To summarize this theoretical perspective, it was predicted that morphological awareness would contribute to reading comprehension through its influence on separable morphological dimensions that govern children's ability to read and understand morphologically complex words.

1.6.1. Study 1 Research Question. *How does morphological awareness contribute to reading comprehension in children?* The goal of the first study was to test potential mediators of the relation of morphological awareness and reading comprehension in third grade students. Multiple possible mediators were considered, including morphological decoding, morphological analysis, word reading, and vocabulary. Using multiple mediation modeling, the influence of the mediators was tested simultaneously to determine which factor(s) account for unique variance in mediating the contribution of morphological awareness to reading comprehension. As Preacher and Hayes (2008) describe, "including several mediators in the same model is one way to pit competing theories against one another within a single model" (p. 881). This statistical approach has substantial value for elucidating the possible mechanisms underlying the relation of morphological awareness and reading comprehension. For this study, I predicted that morphological awareness would have a targeted influence on proximal morphological skills—morphological decoding and morphological analysis—and that these skills would account for the contribution of morphological awareness to reading comprehension in children.

1.6.2. Study 2 Research Question. *How does morphological awareness predict change in reading comprehension over time?* The purpose of the second study was to consider the longitudinal relation between morphological awareness and reading comprehension and specifically evaluate whether morphological awareness contributes to gains in reading comprehension skills over time beyond other language and literacy factors. Using a subset of variables from Study 1, Study 2 follows children from Grade 3 to 4. This investigation contrasts the influence of morphological awareness with that of morphological analysis in predicting gains in reading comprehension over time. Previous studies have attributed gains in reading comprehension to children's morphological awareness (e.g., Casalis & Louis-Alexandre, 2000; Deacon et al., 2014). It was hypothesized that morphological analysis is the underlying mechanism that best accounts for these gains due to its role supporting children's word comprehension. More generally, longitudinal studies are vital for establishing precedence of the causal relations between critical language and literacy variables. In Study 2, longitudinal relations were explored using an autoregressive cross-lag design. This design serves to test the direction of effects depicted in theories and speaks to potential gains in children's skills over time by controlling for their initial abilities.

1.6.3. Expected Contribution of Dissertation. How morphological awareness relates to reading comprehension remains an important empirical question. As explained by Frost and others (e.g., Nagy, 2007; Sandra, 1994),

> How morphological structure interacts with the lexical system is indeed a central issue, since it bears on the representational architecture of the mental lexicon. However, the starting point for any reflection on this central issue is to provide evidence that morphologically defined variables do indeed influence language processing (Frost et al., 2005, p. 2).

Using comprehensive mediation analysis (Study 1) and autoregressive longitudinal analysis (Study 2) in structural equation modeling, this research seeks to inform on the potential variables underlying the relation of morphological awareness and reading comprehension in children. By addressing the questions above, my research will contribute knowledge about the specific nature of the relation of morphological awareness and reading comprehension in developing readers. This work will help clarify the role of morphology in theories of reading development and reading comprehension with likely implications for reading instruction in the classroom.

CHAPTER 2

MORPHOLOGICAL AWARENESS AND READING COMPREHENSION: EXAMINING MEDIATING FACTORS

by

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2.1. Abstract

The relation between morphological awareness—defined as the awareness of and ability to manipulate the smallest units of meaning in language—and reading comprehension remains in need of specification. In this study, we evaluated four potential intervening variables through which morphological awareness may contribute indirectly to reading comprehension. We assess word reading and vocabulary, as well as children's ability to read and analyze the meaning of morphologically complex words (morphological decoding and morphological analysis, respectively). Controls of phonological awareness and nonverbal ability were included in the model. Participants were 221 English-speaking children in Grade 3. Multivariate path analyses revealed evidence of two indirect relations and one direct relation between morphological awareness and reading comprehension. In the first indirect path, morphological awareness contributed to morphological decoding, which then influenced word reading, and finally reading comprehension. In a second indirect path, morphological awareness contributed to morphological analysis, which contributed to reading comprehension. Finally, in a direct path, morphological awareness contributed to reading comprehension beyond all other variables. These findings inform as to the potential mechanisms underlying the relation between morphological awareness and reading comprehension in children.

Keywords: morphological awareness; reading comprehension; path analysis; morphological decoding; morphological analysis; mediation

2.2. Introduction

Reading comprehension is a multifaceted skill deeply rooted in language (e.g., Foorman, Koon, Petscher, Mitchell, & Truckenmiller, 2015). Accordingly, a great deal of research has focused on uncovering the metalinguistic skills predictive of children's reading comprehension. One such skill is morphological awareness—the awareness of and ability to reflect on and manipulate the smallest meaningful units (morphemes) in spoken language (Carlisle, 1995). Substantial evidence suggests an association between morphological awareness and reading comprehension, even after accounting for factors such as phonological awareness, nonverbal skills, vocabulary, and word reading (Foorman, Petscher, & Bishop, 2012; Kirby, Deacon, Bowers, Izenberg, Wade-Woolley, & Parrila, 2012; Nagy, Berninger, & Abbott, 2006). Building on this knowledge base, we ask how morphological awareness contributes to reading comprehension by examining potential mediating factors in this relation for developing readers. This line of inquiry is akin to prior investigations of the relation between phonological awareness and word reading, for which substantial empirical work identified phonological decoding as the key mediating agent (e.g., Tunmer & Chapman, 1998). Here, we focus on morphological awareness and reading comprehension, as the mechanisms underlying this relation remain unclear (Carlisle, 2007).

In a recent theoretical framework of reading comprehension, Perfetti, Landi, and Oakhill (2005) postulated that morphology plays a dual role in text comprehension. First, as part of the lexical system, morphology is said to contribute indirectly to the understanding of text by facilitating word reading. To clarify this model, it remains to be determined empirically whether morphology has a targeted influence on specific aspects of word reading or a general influence on word reading overall. Second, as part of the linguistic systems, it is argued that morphology affects reading comprehension directly by influencing comprehension processes more generally (Perfetti & Stafura, 2014). We build on this broad suggestion to speculate that the linguistic system taps into an overarching semantic network shared between spoken and written language. Within the linguistic system, morphology likely serves as a structural guide for how meaning can be constructed through morphemes, the building blocks of meaning in language. In this sense, morphology may actively facilitate the analysis of meaning derived from words with complex morphological structures, ultimately influencing the understanding of text.

Guided by this theoretical foundation, our work evaluates potential ways in which morphological awareness contributes to reading comprehension. Research to date has tended to examine the contribution of morphological awareness to reading comprehension by focusing on more general indirect effects, such as general word reading skills (Kieffer & Lesaux, 2008; Perfetti et al., 2005) and vocabulary knowledge (Carlisle, 2007). There is wide speculation, however, that strong morphological awareness skills are helpful because they provide children with critical insight into the morphological structure of spoken and written language (Carlisle, 2010; Deacon & Kirby, 2004; Verhoeven & Perfetti, 2011). Accordingly, we argue that morphological awareness has a much more targeted effect on reading comprehension—one that actively facilitates children's ability to process morphologically complex words (i.e., multimorphemic words; e.g., *endangerment = en + danger + ment*) they encounter during reading (Gilbert, Goodwin, Compton, & Kearns, 2013; Nagy, Berninger, Abbott, Vaughan, & Vermeulen, 2003). This insight can lead to two, somewhat related, outcomes. Morphological awareness may contribute indirectly to reading comprehension by specifically influencing children's ability to read morphologically complex words (Carlisle, 2000; Deacon, Tong, & Francis, 2015). It also might do so by influencing children's ability to understand morphologically complex words (Deacon et al., 2015; Nag, Logan, Biangardi-Orpe, 2009). These are two distinct potential mediating influences, one through reading morphologically complex words and another through understanding morphologically complex words. In the current study, we simultaneously compare the contribution of factors that might mediate the relation between morphological awareness and reading comprehension in Grade 3 students.

2.2.1.1. Word reading. As stipulated in the reading comprehension framework (Perfetti et al., 2005), morphological awareness might have beneficial effects on children's general word reading ability, and subsequently on their reading comprehension. This indirect contribution is plausible given the associations between morphological awareness and word reading (e.g., Carlisle & Stone, 2005; Deacon & Kirby, 2004; McCutchen, Green, & Abbott, 2008). In turn, accurate word reading is central to the comprehension of text (Perfetti & Stafura, 2014).

Findings of mediation via word reading are conflicting in the small set of available empirical studies. In a study with children in Grades 3 and 4, Deacon, Kieffer, and Laroche (2014) revealed a partially mediated relation whereby morphological awareness contributed both directly to reading comprehension and indirectly through word reading. In contrast, in a study of third grade children, Jarmulowicz, Hay, Taran, and Ethington (2008) reported that the relation of morphological awareness to reading comprehension was fully mediated by word reading skills (measured by nonword decoding). Together, these findings support a role for word reading in mediating the relation between morphological awareness and reading comprehension, as specified by the reading comprehension framework (Perfetti et al. 2005). However, it is not clear whether this is a fully or partially mediated role and whether there might be other potential mediating factors in the relation between morphological awareness and reading comprehension.

2.2.1.2. Vocabulary. Researchers have speculated that morphological awareness may contribute indirectly to reading comprehension through vocabulary (e.g., Carlisle, 2007; McCutchen & Logan, 2011). Certainly, there are strong associations between children's morphological awareness and vocabulary in the elementary school years (Nagy et al., 2006). Sandra (1994) proposed that understanding the morphological connections between words may shape the organization of the mental lexicon, thereby facilitating word learning (see also Bowers & Kirby, 2010; Nagy & Anderson, 1984). In turn, vocabulary is inherently connected to reading comprehension because knowing the meaning of individual words is key to understanding text as a whole (Perfetti & Stafura, 2014). Essentially, then, children with more advanced morphological awareness may be advantaged in reading comprehension because they have more extensive vocabulary knowledge.

The little empirical evidence to date suggests a potential mediating influence of vocabulary in the relation between morphological awareness and reading comprehension. The most pertinent evidence comes from a study of students in grades 4 to 9. Nagy and colleagues (2006) showed that morphological awareness made a direct contribution to reading comprehension along with an indirect contribution via vocabulary. McCutchen and colleagues' (2008) study of fourth and sixth grade readers suggested full mediation by vocabulary; they demonstrated no unique role of morphological awareness on reading comprehension after vocabulary was included in the regression. Together, these studies point to vocabulary as a potential mediator, either full or partial, in the relation between morphological awareness and reading comprehension

Two recent studies directly contrasted word reading and vocabulary as mediators in the relation between morphological awareness and reading comprehension. In a study of sixth grade students, Kieffer and Box (2013) found that morphological awareness contributed directly to reading comprehension and indirectly through each of silent word reading and vocabulary. In a larger study of linguistically-diverse Grade 6 students, Kieffer and Lesaux (2012) found a direct contribution of morphological awareness to reading comprehension and an indirect effect through vocabulary but, in this case, no indirect effect of silent word reading. These slightly divergent indirect effects need to be interpreted in light of their measurement. In Kieffer and Lesaux (2012), both the vocabulary and word reading measures were written in format and read by students, so they likely both involved participants' reading skills. As such, the reading vocabulary and silent word reading tasks may have tapped the same underlying construct to some extent (i.e., word reading), accounting for the fact that only one *unique* indirect effect was observed. In contrast, in Kieffer and Box (2013), the vocabulary test was written, but read aloud to students to minimize reading demands. These explanations are speculative, though, and further research needs to disentangle the potential mediating roles of word reading and vocabulary.

2.2.1.3. Moving beyond word reading and vocabulary. Several researchers have pointed to the need to extend beyond these general measures of word reading and vocabulary to ones more focused on morphologically complex words to understand the relation between morphological awareness and reading comprehension (Kearns, 2015; Kuo & Anderson, 2006; Nagy, Carlisle, & Goodwin, 2014). Since morphological awareness provides critical insight into the meaning-related structure of language, it seems more plausible that morphological awareness has a targeted effect on words with a complex morphological structure. This distinction is important considering that prior research in this area has focused little on the specific influence of morphologically complex words. Central to the current study, we postulated that the relation between morphological awareness and reading comprehension may be mediated specifically by children's ability to read and understand morphologically complex words, and that these indirect effects would supplant indirect effects of word reading and vocabulary (Deacon et al., 2015; Nagy et al., 2014).

2.2.1.4. Morphological Decoding. Morphological decoding involves parsing a morphologically complex word into its morphemes to produce the correct pronunciation (Carlisle, 2000; Deacon et al., 2015; Verhoeven & Perfetti, 2011). An example of morphological decoding would be a child who decomposes the complex word *misheard* at the correct morphemic boundaries, *mis* + *heard*, rather than reading it as *mish* + *heard*; the latter is a common occurrence in young readers because the letter combination *sh* is a frequently-occurring diagraph and therefore difficult to parse. Importantly, morphologically complex words are inherently longer and less frequent than monomorphemic words and they are increasingly encountered in print throughout the elementary grades (Nagy & Anderson, 1984; Nunes, Bryant, & Barros, 2012). As such, morphological decoding may play a prominent role in facilitating reading comprehension because it represents an on-line process of decoding unfamiliar morphologically complex words encountered during reading. It is also possible that morphological decoding—described by Ehri (2005) as an advanced form of reading—strengthens children's word reading skills more generally (e.g., efficiency and automaticity of word reading) thereby facilitating reading comprehension.

Scarce research has specifically investigated whether morphological decoding mediates the relation between morphological awareness and reading comprehension. Certainly, there is evidence of a relation between morphological decoding and both morphological awareness (e.g., Mann & Singson, 2003; Nagy et al., 2003) and reading comprehension separately (e.g., Nunes et al., 2012). In a study of Grade 5 students, Gilbert and colleagues (2013) found that morphological decoding fully mediated the relation between morphological awareness and reading comprehension. However, the fully-meditated effect was only present for students who scored average and above on the morphological decoding task. The direct effect remained for the students who scored below average on the morphological decoding task. It is unclear whether these differences reflect effects of students' word reading skills more generally as there was no standardized word reading task. Beyond this single study, further research needs to assess whether indirect effects of morphological decoding are distinct from those of word reading skills.

2.2.1.5. Morphological analysis. Originally termed morphological problem-solving (Anglin, 1993), morphological analysis is inferring the meaning of an unfamiliar morphologically complex word based on its morpheme constituents (Baumann et al., 2002; Deacon et al., 2015). Take the infrequent word *unquestionable* as an example. While infrequent, this word has a relatively accessible morphological structure (prefix *un-*, base *question*, suffix *-able*), which provides children with an opportunity to infer its meaning by analyzing its parts. Indeed, morphological analysis is suggested to be central in learning new vocabulary (Zhang, 2014). Yet, in our view, it is distinct from vocabulary because morphological analysis refers to an on-line process of inferring meaning from morphological structure rather than the stored knowledge of the whole word. Morphological analysis is likely to be essential for reading comprehension given that over half of the uncommon words encountered in print by students in grades 3 to 9 have meanings decipherable from their smaller morphemic units (Nagy & Anderson, 1984).

Beyond evidence of relations between morphological analysis and each of morphological awareness (Carlisle & Fleming, 2003) and reading comprehension (McCutchen & Logan, 2011), little research has evaluated morphological analysis as a mediator between these two constructs. In a study with adult English second-language learners, Zhang and Koda (2012) found that morphological awareness contributed to morphological analysis, which contributed to vocabulary, which, in turn, contributed to reading comprehension. This evidence would suggest that morphological analysis plays a mediating role. However, these relations may be different for young readers who are beginning to read for comprehension in their native language.

To our knowledge, only one study has examined the contributions of morphological awareness, morphological decoding, and morphological analysis on reading comprehension. In a study of third and fifth grade students, Deacon and colleagues (2015) found that morphological decoding and morphological analysis—but *not* morphological awareness— each made significant contributions to reading comprehension. These analyses included word reading, phonological awareness, and nonverbal ability as controls (though, notably, not vocabulary). This would suggest that each of morphological decoding and morphological analysis might play a mediating role in the relation of morphological awareness and reading comprehension in developing readers. This possibility needs to be tested in models specifically designed to evaluate multiple intervening factors simultaneously.

2.3. The Present Study

In the present study, we evaluated four potential mediators in the relation between morphological awareness and reading comprehension: morphological decoding, morphological analysis, word reading, and vocabulary. We adopted a multiple-mediation path analysis approach, which evaluates the competing direct and indirect effects in the model simultaneously. This approach tests for unique effects; this is crucial in determining the influence of any particular mediator beyond the contributions of the other mediators in the model (Preacher & Hayes, 2008).

We propose directions of effects in our multiple-mediation models that are theoretically- and empirically-driven. Of course, in analyzing these relations, we remain aware that these are data from a single point in time, which cannot disentangle the directions of effects. Based on the accumulated evidence (e.g., Deacon et al., 2015; Gilbert et al., 2013; Jarmulowicz, et al., 2008), we hypothesized that morphological awareness is principally related to reading comprehension because it facilitates the reading and understanding of morphologically complex words. As such, we predicted unique indirect effects though morphological decoding and morphological analysis. We also predicted no direct effect of morphological awareness to reading comprehension beyond the mediators. In terms of word reading and vocabulary, we predicted that word reading would be influenced by morphological decoding (e.g., Nunes et al., 2012) and that vocabulary would be influenced by morphological analysis (e.g., Zhang & Koda, 2012), with all four factors contributing to reading comprehension. We did not expect word reading and vocabulary to have unique mediating effects after the inclusion of morphological decoding and morphological analysis.

We worked with English-speaking children in Grade 3. This is a point in literacy development at which students transition from learning to read to reading for meaning (Chall, 1983). There are substantial increases in awareness to morphological derivations (Anglin, 1993) with notable links to reading achievement (Nagy et al. 2014) at this age.

We measured morphological awareness with two oral tasks commonly used in prior studies: the Test of Morphological Structure (Carlisle, 2000) and the Word Analogy Task (Kirby et al., 2012). Together, these tasks served to capture the broad linguistic nature of morphological awareness (Deacon, Parrila, & Kirby, 2008). Word reading, vocabulary, and reading comprehension were measured with standardized tests, each recognized as being highly reliable and valid measures of these constructs. As in prior work (Deacon & Kirby, 2004; Kirby et al., 2012), we administered standardized measures of phonological awareness and nonverbal ability to control for any potential influence they may exert on the variables in our model.

We measured morphological analysis by asking children to select the correct definition for infrequent morphologically derived words (e.g., *questionable*; Deacon et al., 2015). The low surface frequency of these complex words reduced the chances that children were readily familiar with the items at the whole-word level. Importantly, the derived words contained either a high- or low-frequency base morphemes (e.g., *questionable* and *disposable*, respectively). This approach experimentally manipulates the accessibility of the morphological structure for derived words matched on frequency, word length, and other factors (e.g., Carlisle & Katz, 2006; Quémart, Casalis, & Colé, 2011). For the purposes of this study, we used participants' performance in selecting the correct meaning for the words with high-frequency bases. These words, while infrequent for children, have accessible morphological constituents that children can leverage in deriving meaning, and thus assessing their morphological analysis skills. The task also necessitated the integration of meaning across both the base and the suffix morphemes to select the correct definition.

We measured morphological decoding through children's accuracy in reading aloud multimorphemic words across three tasks. The first task used the same base frequency approach described above, with a different set of morphologically derived words. Two additional tasks evaluated morphological decoding: one focusing on morphological units in real words (e.g., *misheard*) and the other in nonwords (e.g., *mishope*; Nunes et al., 2012). Both tasks involve parsing the morphologically complex words at the morphemic boundary in order to produce the correct pronunciation (i.e., not reading the /*sh*/ sound in *misheard* or *mishope*).

2.4. Method

2.4.1. Participants. Participants were 221 English-speaking children in Grade 3 (124 girls; M_{age} = 8 years-10 months; SD_{age} = 3.95 months) recruited from elementary schools in eastern North America. Literacy instruction in these schools generally integrates both whole-language and phonics instruction. Students received a small token of appreciation (e.g., pencil, sticker) for their participation in each session of the study.

2.4.2. Materials.

2.4.2.1. Morphological awareness. We measured this construct with two separate orally-presented tasks. We adapted the Test of Morphological Structure (from Carlisle, 2000) to target specifically morphological awareness of derivational morphology. Participants were asked to change the target item to complete a sentence (e.g., *Farm. My uncle is a ___ [farmer]*). There were 28 target items. Half had no phonological change (e.g., *accept–acceptance*) and half had a change (e.g., *revise–revision*). Further, half of the items involved the production of a derived word from a base word (e.g., *farm* to *farmer*) and half the decomposition of a derived form to its base form (e.g., *growth* to *grow*).

The second measure of morphological awareness was the Word Analogy Task (Kirby et al., 2012). In this spoken task, participants heard the first three words and were asked to complete the pattern by providing the missing word (A:B:: C:D; *run: ran:: walk: [walked].*). The 20 test items included an equal number of inflected and derived words, and both types included phonologically transparent (e.g., *walk-walked*) and phonological opaque transformations (e.g., *stood-stand*).

2.4.2.2. Morphological analysis. Following Deacon et al. (2015), we created a morphological analysis task consisting of 20 derived words (presented within a longer list of items). All of the derived words were infrequent, with fewer than three occurrences per million words in text ($U < 3$; $M_U = 1.60$; frequencies from Zeno, Ivens, Millard, &

Duvvuri, 1995). Despite their low surface frequency, the derived words included a high frequency base morpheme (e.g., *respectful*; $M_U = 91.15$; $U > 50$, criteria as per Deacon, Whalen, & Kirby, 2011). All of the derived words ended with one of the 20 most commonly used suffixes in the English language (Blevins, 2001). Moreover, derived words were chosen to be phonologically, orthographically, and semantically transparent with their base morpheme.

This task was presented orally and in print form. Each derived word was presented along with four multiple-choice definitions: one correct and three distractors (Deacon et al., 2015). Participants were asked to choose the definition that best represented the meaning of the derived word. The correct definition included a higher-frequency synonym or a paraphrase of the most common definition of the word (according to the Oxford English Dictionary; OED Online, 2015). For all items, the correct definition reflected the meaning of both the base morpheme and the suffix. For instance, the correct definition for *knowledgeable* was *capable of having a lot of information*, such that 'information' represents the base word *knowledge* and 'capable of' captures the suffix *–able*. The distractor definitions were created based on guidelines adapted from Anglin (1993), such that they were of the same grammatical category and of the same length as the correct definition. Moreover, the distractor definitions were systematically related to either the base morpheme only, the suffix only, or neither. For example, distractor definitions for *knowledgeable* included: 1) *without having a lot of information* ('information' reflects the base morpheme *knowledge*), 2) *capable of having a lot of patience* ('capable of' reflects the suffix *–able*), and 3) *without having a lot of patience* (does not relate to either base or suffix of *knowledgeable*).

2.4.2.3. Morphological decoding. Participants completed three tasks assessing morphological decoding. In the morphologically derived word reading task, children read 40 low frequency morphologically derived words ($U < 5$; $M_U = 1.61$; Zeno et al., 1995), which were administered within a larger set of items not analyzed in this study. These derived words were different from those in the morphological analysis task, although they included the same types of common suffixes. Half of the targets were phonologically transparent derived words (e.g., *reasonless*; $M_U = 1.08$) and half were phonologically opaque (e.g., *publicity*; $M_U = 2.08$); transparent and opaque items did not differ on word length ($M = 9.1$ letters; $t(38) = 0.52$, $p = .60$). Following the same base frequency approach for the morphological analysis task (also see Deacon et al., 2015), all of the derived words used in this study had a high frequency base morpheme ($U > 48$; $M_U = 148.17$). The base frequency across phonological and opaque items did not differ, $t(38) = -1.21$, $p = .24$.

The second and third morphological decoding tasks were adapted from Nunes, Bryant, and Olsson (2003; Nunes et al., 2012). Of these two tasks, morphological units in real word and nonword decoding, one focused exclusively on real words and the other on nonwords (Nunes et al., 2012). For both sets of items, the correct pronunciation is determined in part by the morphological boundaries in the words (e.g., *unishaped* = *uni* + *shaped*). The 19 real words and 15 nonwords were presented in a randomized order.

For all morphological decoding tasks, children read individual target words aloud. Words were displayed in black 40-point Arial font, centered on a computer screen using DirectRT software (Jarvis, 2008). Each trial began with a 1-second central fixation followed by the word, which remained on the screen for 1.5 seconds following the initial pronunciation of the word, or, for a maximum of 5 seconds if no pronunciation attempts were made. The experimenter recorded children's reading accuracy. Each task included three practice trials.

2.4.2.4. Reading comprehension. Participants completed the Reading Comprehension subtest (Level 3) of the Gates-MacGinitie Reading Tests–Fourth Edition (MacGinitie, MacGinitie, Maria, & Dreyer, 2000). In this paper and pencil task, children silently read 11 passages of varying length and completed up to 48 multiple choice questions assessing their understanding of the passages over a 35-minute period.

2.4.2.5. Word reading. Participants' word reading skills were measured with the Test of Word Reading Efficiency (TOWRE; Torgesen, Wagner, & Rashotte, 1999). The Sight Word Efficiency subtest includes a list a real English words (e.g., *cat*, *book*, *people*) and the Phonemic Decoding subtest includes a list of pronounceable nonwords (e.g., *baf*, *dess*, *shlee*). Participants complete each subtest separately by reading through the list of items of increasing difficulty as quickly and as accurately as possible in 45 seconds.

2.4.2.6. Vocabulary. The Peabody Picture Vocabulary Test (Dunn & Dunn, 2007) was administered individually. Participants pointed to one of four pictures that best represented the word spoken by the experimenter.

2.4.2.7. Phonological awareness. Phonological awareness was measured with the Elision subtest of the Comprehensive Test of Phonological Processing (Wagner, Torgesen, & Rashotte, 1999). With up to 20 words, children were asked to repeat each target word and then repeat it without a specific sound (e.g., "Say *stale*. Now say *stale* without /t/").

2.4.2.8. Nonverbal ability. The Matrix Reasoning subtest of the Wechsler Abbreviated Scale of Intelligence (Wechsler, 1999) was used to assess participants' nonverbal abilities. Participants were presented with incomplete patterns and asked to complete the pattern by selecting one of five choices.

2.4.3. Procedure. Testing occurred in a quiet location in the child's school. Children completed individual and group testing sessions on separate days. In the individual sessions, participants completed the morphological awareness and morphological decoding tasks as well as the standardized measures of phonological awareness, nonverbal ability, vocabulary, and word reading. The group testing occurred on the last day of testing and included the morphological analysis and reading comprehension tasks. Standardized tasks were administered per their respective manuals.

2.4.4. Data Analysis Plan. To address the research questions, we used confirmatory factor analysis (CFA) and structural equation modeling (SEM) using Mplus version 7.31 (Muthén & Muthén, 2015). CFA was used to test the hypothesized measurement model and contrast it with theoretically viable alternatives, and SEM was used to test the hypothesized model for the relations of interest and contrast it with alternatives. A multiple-mediation path model is shown in Figure 1 as a reference point for this study. This full (i.e., all paths included) model depicts morphological awareness as having a direct effect on reading comprehension and indirect effects via morphological decoding, morphological analysis, word reading, and vocabulary. Controls for phonological awareness and nonverbal ability are included. We also account for covariances between the mediators and among the predictors.

Paths were estimated using maximum likelihood robust (MLR) parameter estimates in Mplus, which guards against bias due to non-normality and non-independence of observations (Finney & DiStephano, 2013). MLR uses full-information maximum likelihood, which is a recommended estimation method for handling missing data (Enders, 2010; Schafer, & Graham, 2002). The current study included a small amount of missing data across measures ($M = 2.71\%$).

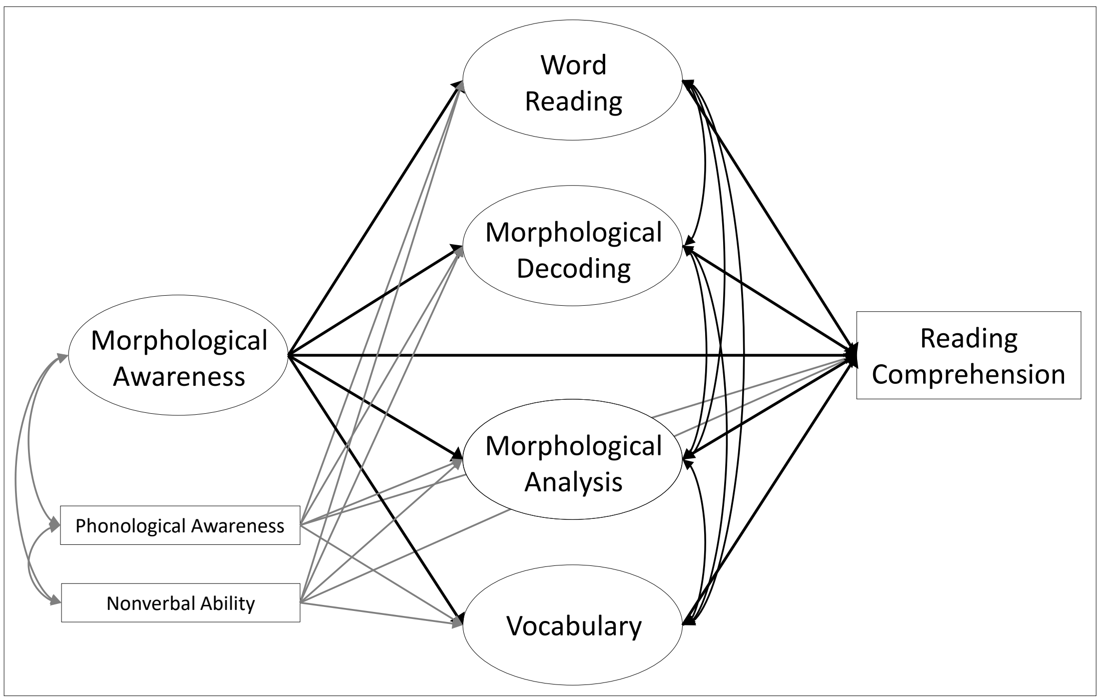

Figure 1. Example of a multiple mediation path model with all variables and paths included.

We evaluated model fit based on goodness of fit indexes recommended in the literature. Comparative Fit Index (CFI) and Tucker-Lewis Index (TLI) values around or greater than .95, Root Mean Square Error of Approximation (RMSEA) values below .08, and Standardized Root Mean Square Residual (SRMR) values below .05 are indicative of excellent model fit (Hu and Bentler, 1999; Kim, 2015; Kline, 2016). We compared the fit of competing theoretical (nested) models using the Satorra-Bentler scaled difference chi-square test (Satorra & Bentler, 2010; Bryant & Satorra, 2012). Finally, we used bias-corrected (BC) bootstrapped 95% confidence intervals to evaluate the statistical significance of the direct and indirect effects of interest, for which other significance tests can be biased (Preacher & Hayes, 2008); these are also robust to potential deviations from multivariate normality.

2.5. Results

Descriptive statistics are presented in Table 1. Standard scores across all standardized tasks show that participants were performing as expected for their age. Table 2 presents the correlations among the variables. VIF and tolerance statistics were well-within acceptable ranges, providing no indication of problems with multicollinearity.

2.5.1. Measurement Model. CFA was used to fit the hypothesized measurement model and compare it with theoretically viable alternative models. As shown in Figure 1, latent variables were created for morphological awareness, morphological decoding, morphological analysis, word reading, and vocabulary. The indictors for the latent variables are displayed in Figure 2; factor loadings are presented in Table 1. Of note, the morphological analysis latent variable was created by dividing the 20-item morphological analysis task into two random subgroupings of 10 items each—Analysis1 and Analysis2. The vocabulary latent variable was created by calculating a disturbance value from its variance and reliability estimate and extracting this disturbance from the variable (Bollen, 1989; Kline, 2016). Essentially, vocabulary became a single-indicator latent variable (Kline, 2016), thus making it more on par with the other latent variables in the model. This was important in guarding against a statistical power imbalance that would have occurred between latent and observed mediator variables.

Table 1

Descriptive Statistics for Study Measures

Measure (maximum score)	*M* score (*SD*)	*M* Std. Score (*SD*)	Skewness	Kurtosis	Reliability	Factor Loadings
Morphological Awareness						
TMS (28)	15.00 (5.27)	–	-.11	-.26	.86[d]	.88
WA (20)	11.20 (3.97)	–	-.33	-.24	.79[d]	.78
Word Reading						
SWE	61.32 (12.22)	107.00 (12.92)[a]	-.98	1.23	.97	.86
PD	27.04 (12.36)	101.84 (14.38)[a]	-.03	-.63	.90	.91
Morphological Decoding						
MDWR (40)	20.36 (8.16)	–	-.46	-.58	.92[e]	.94
MU-RW (19)	9.52 (5.45)	–	-.17	-1.14	.91[e]	.95
MU-NW (15)	4.09 (3.29)	–	.51	-.80	.81[e]	.82
Morphological Analysis						
Analysis1 (10)	5.49 (1.86)	–	-.10	-.44	.44[e]	.68
Analysis2 (10)	6.56 (2.25)	–	-.45	-.53	.67[e]	.82
Vocabulary						
PPVT (228)	145.43 (15.87)	105.92 (12.34)[a]	-.68	2.51	>.97[f]	–
Reading Comprehension (48)	30.20 (10.61)	473.83 (41.15)[b]	-.19	-1.22	.96[f]	–
Phonological Awareness (20)	12.29 (4.80)	9.91 (2.93)[c]	.01	-1.51	.79[f]	–
Nonverbal Ability (32)	16.92 (5.59)	49.79 (9.32)[d]	-.43	-.84	.92[f]	–

Note. TMS = Test of Morphological Structure; WA = Word Analogy; SWE = Sight Word Efficiency; PD = Phonemic Decoding; MDWR = Morphologically Derived Word Reading; MU-RW = Use of Morphological Units in Real Words; MU-NW = Use of Morphological Units in Nonwords; Analysis1 = Morphological Analysis 1; Analysis2 = Morphological Analysis 2; PPVT = Peabody Picture Vocabulary Test.

[a]Standardized score, $M = 100$ ($SD = 15$). [b]Average Extended Scale Score, where the normed 50%ile for Grade 3 (Spring) is 472. [c]Standardized score $M = 10$ ($SD = 3$). [d]Standardized score, $M = 50$ ($SD = 10$). [e]Cronbach's alpha. [f]Reliability from manual.

Table 2

Correlations Among all Study Measures for Children in Grade 3

Measures	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.
Morphological Awareness													
1. TMS	—												
2. WA	.68	—											
Word Reading													
3. SWE	.52	.46	—										
4. PD	.50	.48	.79	—									
Morphological Decoding													
5. MDWR	.56	.53	.81	.84	—								
6. MU-RW	.58	.53	.78	.82	.89	—							
7. MU-NW	.43	.54	.61	.68	.75	.82	—						
Morphological Analysis													
8. Analysis1	.49	.45	.40	.35	.46	.47	.38	—					
9. Analysis2	.50	.52	.44	.48	.58	.55	.48	.56	—				
Vocabulary													
10. PPVT	.70	.59	.37	.38	.47	.50	.42	.44	.54	—			
11. Reading Comprehension	.66	.61	.65	.62	.73	.71	.59	.49	.59	.57	—		
12. Phonological Awareness	.29	.28	.35	.46	.43	.43	.36	.14	.36	.25	.29	—	
13. Nonverbal Ability	.39	.31	.19	.10[a]	.13[a]	.12[a]	.09[a]	.22[a]	.22	.27	.21	.04[a]	—

Note. All correlations are significant at $p < .05$ unless otherwise indicated. [a]$p > .05$. See Table 1 for unabbreviated task labels.

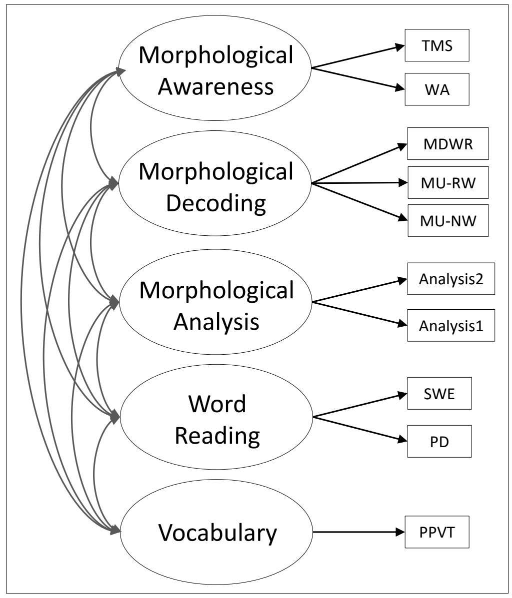

Figure 2. The 5-factor measurement model for the latent variables proposed in this study.

Our proposed 5-factor model (Figure 2) demonstrated a good fit to the data, $\chi^2(25) = 45.31$, $p < .05$, CFI = .99, TLI = .98, RMSEA = .06, SRMR = .02. To confirm the appropriateness of this 5-factor measurement model, we contrasted its fit to alternative theoretically plausible measurement models. For instance, we compared our 5-factor model to a 3-factor model where morphological awareness, morphological decoding, and morphological analysis were part of one "morphology" factor, given the theoretically strong relation among these three constructs and the possibility that they are not measurably distinct for children in third grade (CFA 2 in Table 3). Table 3 describes the combinations of 3- and 4-factor measurement models that were compared to our 5-factor model along with the results of the Satorra-Bentler scaled χ^2 difference tests. Across all comparisons, the 5-factor model provided a significantly better fit to the data. This suggests that the measures used in the study are best captured by the five distinct latent variables of morphological awareness, morphological decoding, morphological analysis, word reading, and vocabulary. As shown in Table 3, the 5-factor model was also the best fitting model across a range of indices, providing additional evidence for the appropriateness of the hypothesized dimensionality of these constructs. This conclusion is an important first step in testing the unique predictive relations between these factors and reading comprehension.

2.5.2. Direct and Indirect Effects of Morphological Awareness on Reading Comprehension. In our SEM analyses, we pursued a theoretically-driven model-testing strategy that consisted of adding (or removing) one path at a time and evaluating changes in fit across nested models, consistent with common practice (Kline, 2016). It is not advisable, however, to compare all the conceivable nested models that can be derived from the full model in Figure 1. For the sake of clarity and succinctness, we began by testing a nested model that best depicted our predictions (Model 1A in Figure 3). We then tested theoretically-plausible alternatives with the goal of identifying the most parsimonious and well-fitting model. The models presented in Figure 3 illustrate the sequential process undertaken to evaluate the direct and indirect contributions of morphological awareness to reading comprehension via the four potential mediators.

We began by fitting the data to Model 1A; this model captures our prediction that morphological awareness is indirectly related to reading comprehension via morphological decoding and morphological awareness, with no direct contribution from morphological awareness itself. Additionally, direct paths between morphological decoding and word reading and between morphological analysis and vocabulary were included. This reflects our prediction that word reading and vocabulary are not the primary mediators once morphological decoding and morphological are considered, while, at the same time, acknowledging their potential peripheral role in the relation (Deacon et al., 2014; Zhang & Koda, 2012). Essentially, the inclusion of these paths

Table 3

The 3-, 4-, and 5-Factor Models that were Tested to Determine the Measurement Model and to Demonstrate the Distinctiveness of the Latent Variables in this Study

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	χ^2 test[a]	Model Fit Indices			
						$\Delta\chi^2$ (*df*)	CFI	TLI	RMSEA	SRMR
CFA 1 5-factor model	M-Awareness	M-Decoding	M-Analysis	Word Reading	Vocabulary	—	.99	.98	.06	.02
CFA 2 3-factor model	M-Awareness M-Decoding M-Analysis	Word Reading	Vocabulary	—	—	220.89[b] (7)	.86	.80	.17	.08
CFA 3 4-factor model	M-Awareness M-Decoding	M-Analysis	Word Reading	Vocabulary	—	186.74[b] (4)	.89	.83	.16	.08
CFA 4 4-factor model	M-Awareness M-Analysis	M-Decoding	Word Reading	Vocabulary	—	26.85[b] (4)	.97	.96	.08	.03
CFA 5 4-factor model	M-Awareness Word Reading	M-Decoding	M-Analysis	Vocabulary	—	206.23[b] (4)	.88	.81	.17	.08
CFA 6 4-factor model	M-Awareness Vocabulary	M-Decoding	M-Analysis	Word Reading	—	9.30[c] (3)	.98	.97	.07	.03
CFA 7 4-factor model	M-Awareness	M-Decoding M-Analysis	Word Reading	Vocabulary	—	61.44[b] (4)	.95	.92	.11	.07
CFA 8 3-factor model	M-Awareness	M-Decoding Word Reading	M-Analysis Vocabulary	—	—	48.50[b] (6)	.96	.94	.09	.04

[a]Models compared using Satorra-Bentler scaled χ^2 difference test. [b]$p < .001$. [c]$p < .03$. Significant *p*-value indicates a significant reduction in fit compared to CFA 1.

tested the idea that morphological awareness is related to word reading and vocabulary indirectly through its influence on morphological decoding and morphological analysis, respectively. Although Model 1A provided a good fit to the data, additional theoretically viable models were compared to identify the best fitting model.

Focusing on the top part of the model, Model 1B added a path between morphological awareness and word reading, which tested whether morphological awareness directly contributes to morphological decoding and word reading concurrently. The Satorra-Bentler scaled chi-square difference test indicated that including this additional path did not significantly improve fit (Satorra-Bentler $\Delta\chi^2 = .59$, $\Delta df = 1$, $p = .44$), so the more parsimonious Model 1A was retained. In Model 1C, we removed the path between morphological decoding and reading comprehension—this path also had the highest *p*-value (.58). Model 1C tested the possibility of sequential mediation such that morphological awareness facilitates morphological decoding, which then predicts word reading, which, in turn, contributes to reading comprehension[1]. Model 1C had equally good fit as Model 1A (Satorra-Bentler $\Delta\chi^2 = .33$, $\Delta df = 1$, $p = .56$) and was therefore retained as the more parsimonious model.

Focusing on the bottom part of the model, we added a direct path between morphological awareness and vocabulary (Model 1D). This tested whether morphological awareness contributes to both mediators of morphological analysis and vocabulary concurrently. The inclusion of this path significantly improved model fit compared to Model 1C (Satorra-Bentler $\Delta\chi^2 = 6.48$, $\Delta df = 1$, $p < .05$), indicating that the path between

[1] Though not motivated by our predictions, we also tested for good measure a model where the directionality of the sequential mediation was reversed: morphological awareness → word reading → morphological decoding → reading comprehension. This model significantly reduced fit compared to Model 1A (Satorra-Bentler $\Delta\chi^2 = 4.64$, $\Delta df = 1$, $p < .05$) and thus, was not considered further.

morphological awareness and vocabulary represents an important relation in the model. Model 1E tested the idea that morphological analysis does not predict reading comprehension directly, but instead, predicts it indirectly through vocabulary. However, Model 1E was rejected because removing the path between morphological analysis and reading comprehension significantly reduced model fit compared to Model 1D (Satorra-Bentler $\Delta\chi^2 = 7.57$, $\Delta df = 1$, $p < .01$). As a final step in testing the indirect effects, we removed the path between vocabulary and reading comprehension in Model 1F. This model tested the idea that vocabulary is not implicated in mediating the relation of morphological awareness to reading comprehension beyond the remaining mediators and controls. Model 1F provided an equally good fit to the data as Model 1D (Satorra-Bentler $\Delta\chi^2 = 1.53$, $\Delta df = 1$, $p = .22$) and was retained as the more parsimonious model.

As a final step in our model-building process, we added a direct path between morphological awareness and reading comprehension (see Figure 4[2]). This tested whether morphological awareness contributes directly to reading comprehension beyond the indirect effects and controls. Model 1G provided a significantly better fit than Model 1F (Satorra-Bentler $\Delta\chi^2 = 24.34$, $\Delta df = 1$, $p < .001$). Thus, the model-building process maximized both parsimony and fit, yielding the final Model 1G, which demonstrated excellent fit to the data across a variety of indices ($\chi^2\,(43) = 63.92$, $p = .02$, CFI = .99, TLI = .98, RMSEA = .05, SRMR = .02).

2.5.3. Interpreting the Final Model. Model 1G revealed a partially mediated relation between morphological awareness and reading comprehension. Standardized

[2] The path between morphological analysis and vocabulary, which was nonsignificant in all models, was replaced with a double-headed arrow in Model 1G. This removes the implication of directionality between the variables while accounting for covariance between the mediators. This change does not impact model fit.

coefficients (β) for the paths are shown in Figure 4, with magnitude of effects interpreted using Cohen's (1992) rules of thumb. Morphological awareness had a significantly large effect on morphological decoding (β = .69, p < .001), which in turn showed a large effect on word reading (β = .95, p < .001). Additionally, word reading contributed a moderate-to-large effect on reading comprehension (β = .37, p < .001). The entirety of this indirect path, labelled the *morphological decoding pathway* (morphological awareness → morphological decoding → word reading → reading comprehension), corresponded to a significant moderate indirect effect (β = .24, BC-bootstrap 95% CI [.29, .87]). This indirect effect corresponds to a unique contribution of morphological awareness to reading comprehension that is mediated by morphological decoding and word reading beyond all other direct and indirect effects and controls.

Morphological awareness had a strong effect on morphological analysis (β = .72, p < .001), which, in turn, had a moderate effect on reading comprehension (β = .28, p < .01). The entirety of this indirect effect, labelled the *morphological analysis pathway* (morphological awareness → morphological analysis → reading comprehension), corresponded to a significant, small-to-moderate indirect effect (β = .20, BC-bootstrap 95% CI [.13, 1.50]). This indirect pathway suggests that the contribution of morphological awareness to reading comprehension was partially mediated by morphological analysis.

Morphological awareness showed a large effect on vocabulary (β = .85, p < .001). However, after accounting for morphological awareness, the controls, and the indirect effects, vocabulary did not account for unique variance in reading comprehension. For the sake of model parsimony, the vocabulary-to-reading comprehension path was not included in the final model. More precisely, it suggests that vocabulary does not appear to mediate the relation of morphological awareness and reading comprehension beyond the other mediators in this study.

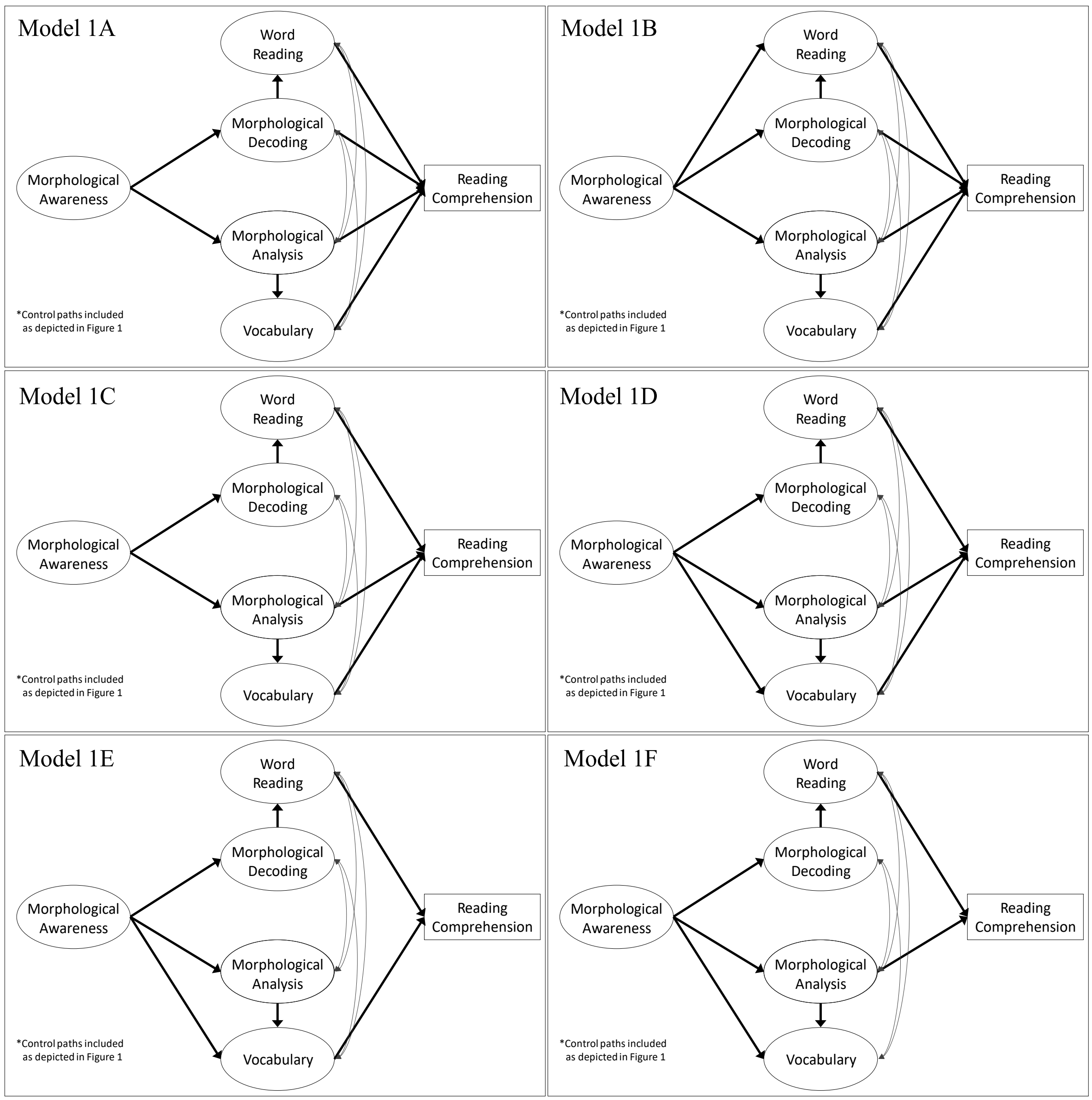

Figure 3. Sequence of nested models tested to evaluate the indirect contributions of morphological awareness on reading comprehension (phonological awareness and nonverbal ability control paths included, as shown in Figure 1).

Recognizing the large coefficients between morphological awareness and vocabulary ($\beta = .85$)[3], and likewise between morphological decoding and word reading ($\beta = .95$)[4], we conducted two follow-up analyses to further evaluate the multidimensionality of these constructs (see Footnotes 3 & 4). These analyses provide additional evidence beyond the CFA analyses presented above because they test alternate specifications of the measurement models in the context of their relations to other variables in the structural model. The findings support our claim that morphological awareness and vocabulary, and likewise morphological decoding and word reading, represent distinct, if strongly related, constructs in the context of their contributions to reading comprehension.

Finally, morphological awareness contributed directly to reading comprehension ($\beta = .36$, $p < .01$), with a moderate-to-large direct effect, representing its unique contribution to reading comprehension after accounting for all other paths in the models. Taken together, our results support a partially-mediated relation where morphological awareness contributed to reading comprehension directly as well as indirectly through two mediation pathways, a morphological decoding pathway and a morphological analysis pathway.

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[3] **Follow-up analysis 1**. We re-tested the final model with morphological awareness and vocabulary specified as a single latent variable; this model fit significantly worse than Model 1G (Satorra-Bentler $\Delta\chi^2 = 12.45$, $\Delta df = 5$, $p < .03$).
[4] **Follow-up analysis 2**. We re-tested the final model with morphological decoding and word reading specified as a single latent variable; this model fit significantly worse than Model 1G (Satorra-Bentler $\Delta\chi^2 = 15.19$, $\Delta df = 5$, $p < .02$).

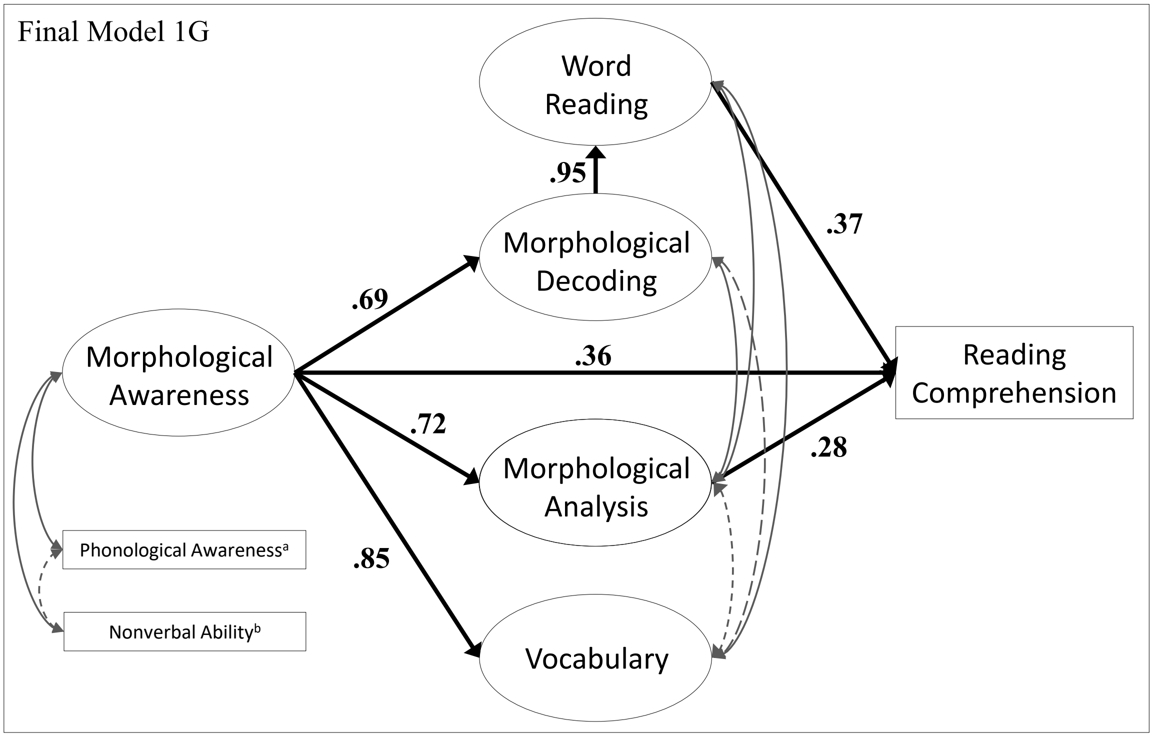

Figure 4. Final model with standardized coefficients included. Solid and dashed lines represent significant and nonsignificant effects, respectively.

[a]Phonological awareness to word reading (β = .03); to morphological decoding (β = .23*); to morphological analysis (β = .13); to vocabulary (β = -.03); to reading comprehension (β = -.10*). [b]Nonverbal ability to word reading (β = -.003); to morphological decoding (β = -.17*); to morphological analysis (β = -.04); to vocabulary (β = -.09); to reading comprehension (β = -.06). *indicates statistical significance.

2.6. DISCUSSION

The goal of the current study was to examine empirically the ways in which morphological awareness contributes to reading comprehension in English-speaking Grade 3 readers. We used path analyses controlling for phonological awareness and nonverbal ability to contrast the contributions of four potential mediators: word reading, vocabulary, morphological decoding, and morphological analysis. Our modeling revealed that the relation between morphological awareness and reading comprehension was partially mediated. Morphological awareness showed a direct contribution to reading comprehension beyond the influence of the four mediators. Moreover, two indirect pathways of similar magnitude emerged—a morphological decoding pathway and morphological analysis pathway.

In the morphological decoding pathway, the relation of morphological awareness on reading comprehension was mediated by morphological decoding and word reading in sequence. Consistent with our prediction, morphological awareness had a targeted effect on children's ability to decode unfamiliar complex words rather than on their word reading skills more generally (Kuo & Anderson, 2006; Nagy et al., 2006). Morphological decoding then contributed to word reading, which, in turn, contributed to reading comprehension. The finding of sequential mediation suggests that morphological decoding, an advanced reading skill (Ehri, 2005), is part of a larger array of reading-related skills that children utilize. As an on-line reading process specific to morphologically complex words, it is likely that morphological decoding plays an important role in the development of increasingly-efficient word reading skills.

In the morphological analysis pathway, morphological awareness contributed to children's ability to analyze the meaning of unfamiliar derived words, which, in turn, supported their reading comprehension. This evidence of a morphological analysis pathway connects two lines of prior research: studies showing links between morphological awareness and morphological analysis (Zhang, Koda, & Leong, 2016) and studies showing relations between morphological analysis and reading comprehension (McCutchen & Logan, 2011). Our work reveals that this is likely a continuous pathway, such that young readers with good morphological awareness will better analyze meaning in morphologically complex words, with cascading benefits to the understanding of text as a whole (Perfetti & Stafura, 2014).

There is one non-significant finding in particular that inspires further consideration; our analyses showed that vocabulary did not uniquely mediate the relation of morphological awareness and reading comprehension in third grade readers beyond the other direct, indirect, and control paths. The non-significant mediating role of vocabulary here resonates with earlier evidence that vocabulary does not uniquely contribute to reading comprehension beyond morphological awareness for students in Grades 4 and 5 (Nagy et al., 2006). That said, our findings contrast with evidence of vocabulary mediating the relation between morphological awareness and reading comprehension in older readers, namely Grade 6 and above (Kieffer & Box, 2013; Nagy et al., 2006; Zhang & Koda, 2012). We speculate that the influence of an indirect vocabulary pathway might manifest over time. In younger readers, it could be that morphological analysis is a more influential mediator than vocabulary, perhaps because of its role in the *acquisition* of vocabulary (Anglin, 1993; Baumann et al., 2002; Nagy & Anderson, 1984; Zhang, 2014). In older readers, the vocabulary pathway might emerge once sufficient vocabulary knowledge has been amassed over time. As we consider this interpretation, we need to point out that there was a clear correlation between vocabulary and reading comprehension ($r = .55$, $p < .001$). The pathway was non-significant only in modeling that incorporated morphological awareness and morphological analysis—factors that, like vocabulary, each draw heavily on meaning-based linguistic processes. As such, these analyses need to be framed within a larger context of morphological factors. They also need to be taken seriously given our findings that morphological awareness and morphological analysis were distinct factors from vocabulary, consistent with Kieffer, Petscher, Proctor, and Silverman, (2016) and Tighe and Schatschneider (2015; but see Spencer et al., 2015). We concede, however, that the second best-fitting measurement model, CFA 6, was a four-factor model in which morphological awareness and vocabulary were represented by a single factor in third grade children. Longitudinal research is greatly needed to determine the developmental connections between these highly-related factors.

Intriguingly, the final model revealed a lasting direct contribution of morphological awareness to reading comprehension beyond the influence of all mediator and controls variables. Similar findings of a unique morphological awareness contribution have been observed in less restrictive path analyses (Deacon et al., 2014; Kieffer & Box, 2013; Kieffer & Lesaux, 2012; Nagy et al., 2006). Our findings diverge from those of Deacon and colleagues (2015) who showed no unique effect of morphological awareness on reading comprehension after accounting for morphological decoding and morphological analysis. We argue that our analyses go beyond those of Deacon et al. (2015) and others (e.g., McCutchen & Logan, 2011) by utilizing latent variables and a multiple mediation model that specifically tests for unique effects. In our view, the emergence of this relation in a model with added tight controls necessitates the serious consideration of this finding. Specifically, the enduring direct path suggests a connection between morphological awareness and reading comprehension that goes beyond the mediators and controls in our model.

2.6.1. Limitations and Future Directions. As with all research, our findings need to be contextualized within the measurement decisions. First, we need to consider the potential influence of measurement on the separability of morphological decoding and word reading that we detected. For instance, the morphological decoding tasks focused exclusively on accuracy whereas the word reading measure of TOWRE included both accuracy and speed. We chose TOWRE because it is a well-established, developmentally-appropriate, and highly reliable measure of word reading. That said, including speed in the measurement of word reading may have increased its unique relation with reading comprehension (see also Kieffer & Box, 2013; Kim, 2015). It is possible that morphological decoding and word reading would have merged as one factor had they shared more similar testing formats (e.g., accuracy only; higher frequency complex words in the morphological decoding task).

Second, although we measured many constructs with multiple measures with differing formats, time constraints led us to include a single measure of each of morphological analysis, vocabulary, and reading comprehension. We worked to address this limitation statistically. For example, we transformed morphological analysis into a latent variable by randomly dividing the task in two subtasks; this helped attenuate any task reliability concerns. We also applied a statistical correction to vocabulary making it a single-indicator latent variable, more on par with the other mediators in the model (Kline, 2016). Nevertheless, future research should include multiple indicators that differ in their formats to maximize construct coverage. A particularly important next step would be to explore multiple dimensions of vocabulary knowledge, beyond PPVT (e.g., expressive vs. receptive), to examine whether unique relations emerge from these conceptual distinctions.

Third, and most importantly, concerted empirical attempts are needed to test the direction of effects uncovered here. As in all correlational research, an overarching limitation lies in that we can only test the covariances between variables, not the direction of the relations between them. At this time, we prudently interpret the theoretical and empirical significance of mediation obtained from data collected at a single point in time (Maxwell & Cole, 2007). It is very likely that many of the constructs included in the path model share a bidirectional relationship (see Deacon et al., 2014; Kruk & Bergman, 2013). As an example, morphological decoding could contribute to word reading development, just as word reading could lead to development in morphological decoding. As such, we urge caution in over-interpreting the direction of the effects uncovered in our modeling. Further longitudinal research is needed to disentangle the reciprocal relations amongst the constructs in our model.

2.6.2. Theoretical Implications. Perfetti and colleagues' (2005) theoretical framework suggested two broad roles for morphology in supporting reading comprehension: directly through a general linguistic system and a indirectly through the lexical (i.e., word reading) system. Supporting this framework, our findings demonstrate that morphology relates to reading comprehension across a number of distinct ways. We think that our work also serves to clarify the dimensions of morphology that manifest in the linguistic and lexical systems. In terms of the lexical system, our work specifies this indirect lexical link by suggesting that morphological awareness influences reading comprehension by facilitating the reading of morphologically complex words in particular. In doing so, our findings point to a role for morphological units beyond that of the orthographic and phonological units described in the reading comprehension framework and other theories of reading (Ehri, 2005). As part of the linguistic system, we view morphological analysis as an automatic process in activating and inferring word meaning. We speculate that this process occurs for words in speech and in print alike, particularly for unfamiliar complex words. This on-line morphological analysis likely integrates individual word meaning within the larger context of meaning at the text-level (Perfetti & Stafura, 2014). Beyond the specific linguistic role of morphological analysis, we speculate that morphological awareness may be part of a broader, more general component of the linguistic system, as reflected in its direct role that remained beyond the influence of all variables included in our model. We venture that, by third grade, children's awareness of meaningful units in spoken language might share a common underlying semantic thread with their developing ability to read for meaning. As a meta-linguistic skill reflecting the synergy of sound and meaning, morphological awareness may be a foundational element of the linguistic system that works alongside other integration processes to build a mental model of the text while reading (Perfetti & Stafura, 2014).

In conclusion, our research specifies the direct and indirect relations between morphological awareness and reading comprehension in English-speaking third grade children. In particular, we demonstrated that the contribution of morphological awareness exerts a unique direct effect on reading comprehension beyond the substantial influence of the mediators and control variables. Moreover, two indirect effects mediated the relation between morphological awareness and reading comprehension: a morphological decoding pathway and a morphological analysis pathway. We speculate that these two pathways point to the mechanisms underlying this relation—mechanisms specific to children’s ability to decode and analyze the meaning of morphologically complex words rather than general to their word reading skills and vocabulary knowledge. Accordingly, our results are consistent with the idea that morphological awareness facilitates children’s ability to read and understand morphologically complex words, which ultimately benefits their comprehension of text. These findings provide empirical confirmation for prior speculations (Carlisle 2000, 2010; Deacon & Kirby, 2004; Kuo & Anderson, 2006; Verhoeven & Perfetti, 2011) and inform the development of more precise models of reading comprehension.

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2.6.4. References. See general reference list on page 120.

CHAPTER 3

DERIVING MEANING FROM MEANINGFUL PARTS:

THE CONTRIBUTIONS OF MORPHOLOGICAL SKILLS TO GAINS IN CHILDREN'S READING COMPREHENSION

by

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In review for *Journal of Educational Psychology* (format adapted for dissertation).

3.1. Abstract

In the present study, we aim to specify how morphological skills contribute to gains in reading comprehension between Grades 3 and 4. We contrast the roles of two skills: morphological awareness, or the awareness of and ability to manipulate the smallest units of meaning in language, and morphological analysis, the use of morphemes to infer the meaning of unfamiliar complex words. Participants were 197 English-speaking children in Grade 3 who were followed to Grade 4. We assessed morphological awareness and morphological analysis, along with children's reading comprehension. We included controls for word reading, vocabulary, phonological awareness, and nonverbal ability in the model. Multivariate autoregressive path analyses revealed that morphological analysis, but not morphological awareness, predicted gains in reading comprehension. Interestingly, morphological awareness predicted gains in morphological analysis, alluding to an indirect developmental influence on reading comprehension through morphological analysis. These findings contribute to theory by clarifying the ways in which morphological skills support the development of children's reading comprehension.

Keywords: morphological awareness; morphological analysis; reading comprehension; path analysis; longitudinal; autoregressive modeling;

3.2. Introduction

There is now convincing evidence of a strong relation between morphological awareness and reading comprehension (e.g., Deacon, Kieffer, & Laroche, 2014). This relation makes sense considering that morphological awareness is the awareness of and ability to manipulate the minimal meaningful units, or morphemes, in oral language (Carlisle, 1995); as such, it is intuitive that this metalinguistic skill should support children's ability to understand the meaning of connected texts (e.g., Kuo & Anderson, 2003). What is less clear is precisely *how* children's morphological awareness influences their ability to understand the meaning of texts. It is possible that children with more advanced morphological awareness are better able to infer the meanings of morphologically complex words by analyzing their morphemic constituents (e.g., *unhelpful* = *un* + *help* + *ful*; Carlisle, 2000, 2010; Zhang & Koda, 2012). This is referred to as morphological analysis. Morphological analysis could be particularly helpful in determining the meaning of unfamiliar morphologically complex words encountered during reading, thereby supporting overall comprehension of text (e.g., Deacon, Tong, & Francis, 2015; McCutchen & Logan, 2011; Pacheco & Goodwin, 2013). These predicted relations have had little empirical testing. In the current study, we evaluate the relations between each of morphological awareness, morphological analysis, and reading comprehension longitudinally across Grades 3 to 4. Our goal was to determine which morphological skill—morphological awareness or morphological analysis, or both—accounts for gains in children's reading comprehension over time.

Each of morphological awareness and morphological analysis could be important skills in reading comprehension because of the prominence of morphologically complex words in children's texts. Like phonemes, morphemes are represented in English orthography. Thus, akin to phonological awareness, morphological awareness is likely to be a key metalinguistic skill in reading development and, hence, text comprehension (e.g., Kuo & Anderson, 2006). Further, over half of the new words that children in Grades 3 to 9 encounter in text are morphologically complex (Nagy & Anderson, 1984). Morphological analysis might be especially important in reading comprehension because of its specific value in determining the meaning of unknown, or otherwise less familiar, morphologically complex words on-to-spot (Carlisle, 2000; Nagy, Berninger, & Abbott, 2006). Individual word comprehension is critical in text comprehension (Perfetti, 2007; Perfetti & Stafura, 2014). It seems plausible, then, that each of these skills could be involved in supporting children's gains in reading comprehension.

At present, theoretical insight into the longitudinal relations between morphological skills and reading comprehension is limited because morphology remains under-represented in theories of reading development (Carlisle & Kearns, *in press*). Perfetti and colleagues' Reading Systems Framework distinguishes itself from other models by articulating multiple roles for morphology in reading comprehension (Perfetti, 1999; Perfetti, Landi, & Oakhill, 2005; Perfetti & Stafura, 2014). First, as part of an overarching linguistic system, morphology is conceptualized as contributing to reading comprehension directly—perhaps reflecting shared processes that handle meaning across spoken and written form. In our view, this would predict a direct role for morphological awareness in reading comprehension. Second, morphology is shown as contributing to reading comprehension indirectly via the lexicon. Presumably, the indirect lexicon pathway suggests that morphology has a role in the processing of lexical representations.

In our view, this indirect pathway could be through morphological analysis. Third, in a final indirect pathway, morphology contributes to reading comprehension indirectly through the word reading system. This pathway implies that morphology facilitates word reading, which translates into improvements in word reading efficiency and, in turn, enhanced reading comprehension. We focus on the first two pathways, as our interest here lies in morphology in oral language. As such, we build on this model to specify the precise roles of morphology in its direct relation with reading comprehension and its indirect relation through the lexicon.

We specify these theoretically speculated contributions by investigating the potential contributions of each of morphological awareness and morphological analysis to gains in reading comprehension. Determining which specific aspects of morphology would most likely lead to improved reading comprehension would allow us to determine the most impactful practices to adopt in the classroom (Bowers, Kirby, & Deacon, 2010). To contrast our two morphological skills under investigation, instruction aimed at developing morphological awareness would focus on the manipulation of morphemes in general, while improving morphological analysis would need instruction in using morphemes to determine the meaning of words. We need to know whether one or both is most likely to improve children's reading comprehension.

3.2.1.1. Distinguishing Morphological Awareness and Morphological Analysis. The conceptual distinction between morphological awareness and morphological analysis is highlighted by the ways in which these skills have been measured thus far. By definition, morphological awareness is the awareness of and ability to manipulate morphemes in oral language (Carlisle, 2003). As such, morphological awareness is typically measured with oral tasks in which participants manipulate morphemes in words presented in isolation or in sentence contexts (e.g., *farm*. *My uncle is a* ____ [*farmer*]). By comparison, morphological analysis refers to the ability to infer the meaning of an unfamiliar morphologically complex word from its component morphemes (e.g., *undeniable* = *un* + *deny* + *able*; Deacon et al., 2015; Levesque, Kieffer, & Deacon, 2017; Nagy, Carlisle, & Goodwin, 2014). As such, in tasks assessing morphological analysis, children are asked to choose or to produce definitions for morphologically complex words. Items are often chosen to have a low surface frequency, so as to be unfamiliar to children, but to contain a high frequency base morpheme, which provides some accessibility to the morphemes within the complex word (Carlisle & Katz, 2006; Deacon et al., 2015; Levesque et al., 2017; McCutchen & Logan, 2011). Reflecting conceptual differences, morphological awareness tasks focus on manipulation of morphemes in oral language, while morphological analysis tasks index the use of morphemes to infer word meaning.

Recent evidence supports the claim that morphological awareness and morphological analysis are related but distinctive skills. In a study of children in Grade 3, confirmatory factor analysis showed that morphological awareness and morphological analysis are empirically separable factors (Levesque et al., 2017). That said, morphological awareness likely supports morphological analysis in the sense that morphological awareness might enable a child to identify and manipulate morphemes in order to use them in constructing meaning. In support of this possibility, a few recent cross-sectional studies show a significant relation between morphological awareness and the ability to infer the meaning of morphologically complex words (e.g., Carlisle, 2000;

Deacon et al., 2015; Zhang, 2014). Together, these studies provide empirical support for the view that these constructs reflect related but distinct dimensions of morphology.

Testing these ideas is best done by evaluating predictions of gains, rather than associations at a single point in time; this is also key to testing theoretical models. At their heart, all models of word reading or reading comprehension are models of development; their predictions are specific to the factors likely to support children's acquisition of reading skill over time. Autoregressive modeling of longitudinal data is useful in assessing these questions (Bollen & Curran, 2004; Selig & Preacher, 2009). This conservative approach considers inter-individual stability of skills over time (Little, Card, Preacher, & McConnell, 2009; Selig & Little, 2012). In terms of our questions, it can assess whether morphological awareness and/or morphological analysis determines change in reading comprehension performance over time. It can also evaluate predicted relations between morphological skills, evaluating whether morphological awareness predicts gains in morphological analysis.

3.2.1.2. Morphological Awareness and Reading Comprehension: Concurrent and Longitudinal Associations. Most empirical studies to date on the relation between morphological awareness and reading comprehension are cross-sectional, with a handful of newer studies testing gains in reading comprehension over time. In the cross-sectional studies, children's morphological awareness has consistently been shown to be related to reading comprehension beyond substantial controls such as phonological awareness and nonverbal ability (e.g., Nagy et al., 2006; Kirby, Deacon, Bowers, Izenberg, Wade-Woolley, & Parrila, 2012). This direct relation remains even when considering the contribution of strong potential mediators, such as word reading and vocabulary (Kieffer

& Box, 2013; Kieffer & Lesaux, 2008, 2012; Levesque et al., 2017). The relation between morphological awareness and reading comprehension also remains even beyond more general language comprehension skills that reflect the variance shared across morphological awareness, syntactic awareness, and vocabulary (Kieffer, Petscher, Proctor, & Silverman, 2016). Together, studies to date strongly suggest a role for morphological awareness in children's reading comprehension.

A few longitudinal studies have now demonstrated that morphological awareness is responsible, at least in part, for development in reading comprehension. Foorman, Petscher, and Bishop (2012) observed that morphological awareness accounted for unique variance in students' reading comprehension assessed 6 months later, beyond prior levels of reading comprehension (i.e., autoregressor), spelling, and word reading efficiency skills. This pattern emerged using a written task assessing morphological awareness and at each grade level from Grade 3 to Grade 10. In a study across a longer timeframe and with an orally presented task, Deacon and Kirby (2004) showed that children's morphological awareness in Grade 2 predicted gains in reading comprehension between Grade 2 and both Grade 4 and Grade 5 beyond controls for vocabulary, nonverbal ability, and phonological awareness. Building on this, Deacon and colleagues (2014; see also Kruk & Bergman, 2013) recently found that children's morphological awareness in Grade 3 predicted reading comprehension in Grade 4, beyond the autoregressor, word reading, vocabulary, phonological awareness, nonverbal ability, and age. The addition of word reading as a control shows that this relation is specific to the construction of meaning during reading. Taken together, the evidence thus far suggests that morphological awareness is a predictor of gains in children's reading comprehension over time.

3.2.1.3. The Role of Morphological Analysis in Reading Comprehension. It remains an open question, though, as to whether morphological analysis might explain gains in reading comprehension. While scarce, research to date has demonstrated a concurrent association between morphological analysis and reading comprehension in studies both of children (e.g., Deacon et al., 2015; Levesque et al., 2017) and adults (e.g., Zhang & Koda, 2012). McCutchen and Logan (2011), for instance, found that Grade 5 students' ability to extract meaning from morphologically complex words (e.g., *horrific*) was related to their reading comprehension. Using a slightly different approach to assess morphological analysis, Deacon and colleages (2015) asked children in Grades 3 and 5 to choose definitions for morphologically complex words with high and low frequency bases (e.g., *purposeful* vs. *resentful*). Children's performance on this task accounted for unique variance in reading comprehension beyond controls of phonological awareness, word reading, age, and nonverbal ability. The results of both studies suggest that children can infer the meaning of complex words from their morphemic constituents and, critically, that this ability is related to their reading comprehension. To the best of our knowledge, there have no empirical assessments of the longitudinal contribution of morphological analysis to reading comprehension over time.

As we consider the potential longitudinal associations between each of morphological awareness, morphological analysis, and reading comprehension, it leads to the question of whether morphological analysis might explain findings that morphological awareness predicts gains in reading comprehension. Several researchers have speculated that morphological analysis is one mechanism underlying the relation of morphological awareness and reading comprehension (e.g., Carlisle, 2007; Nagy, 2007; Zhang & Koda, 2012). A recent study of children in Grades 3 and 5 showed that morphological analysis, but not morphological awareness, accounted for unique variance in reading comprehension beyond controls of phonological awareness, word reading, age, and nonverbal ability (Deacon et al., 2015). This finding from linear regression analyses suggests that morphological analysis may play a more dominant, or more proximal role in predicting children's reading comprehension. In contrast, a recent study of Grade 3 children uncovered a unique role for each of morphological awareness and morphological analysis in reading comprehension. Levesque and colleagues (2017) demonstrated that morphological awareness had a direct role in reading comprehension and an indirect role through morphological analysis; these direct and indirect relations emerged beyond multiple controls (word reading, vocabulary, morphological decoding, phonological awareness, and nonverbal ability). Results of the two studies conflict as to whether morphological awareness has a unique role in reading comprehension once morphological analysis is taken into account. We build on the studies of concurrent relations to determine which of these morphological skills determine gains in reading comprehension over time.

In testing these longitudinal relations, we consider how morphological awareness and morphological analysis might relate over time. It is plausible that morphological awareness plays a role in the development of morphological analysis, a more proximal skill in reading comprehension. We were able to identify a single published test of this possibility. Zhang, Koda, and Leong (2016) recently demonstrated that morphological awareness in Grade 3 predicted gains in morphological analysis in Grade 4; this pattern emerged both in the children's native language of Malay and in their second language of English. Additional research is needed to better understand the longitudinal relation between morphological awareness and morphological analysis while considering their contributions to reading comprehension over time.

3.3. The Current Study

In the current longitudinal study, we examine both morphological awareness and morphological analysis as predictors of children's reading comprehension skills over time. We extend prior studies by including all three variables, along with key controls of word reading, vocabulary, phonological awareness, age, and nonverbal ability. Using an autoregressive modeling approach, our study follows children from Grade 3 to 4—grades in which students increasingly encounter morphologically complex words during reading (Anglin, 1993; Nagy & Anderson, 1984). The mid-elementary grades are also a fruitful period for development both in morphological awareness and in reading comprehension (Chall, 1983; Foorman et al., 2012). Derivational morphemes in particular are a key point in their acquisition (Carlisle, 2003; Tyler, & Nagy, 1989). As such, we focus on derived words in this study, which are morphologically complex words that typically bring changes in meaning or grammatical category to the base morpheme.

To measure morphological awareness, we use measures based on two widely used oral tasks: the Word Analogy Task (Kirby et al., 2012) and the Test of Morphological Structure (Carlisle, 2000). Reading comprehension and controls for vocabulary, word reading, phonological awareness, and nonverbal ability are assessed with reliable standardized tests. We choose these controls because of their known associations with either word reading or reading comprehension (e.g., Garcia & Cain, 2014; Kirby et al., 2012; Nation & Snowling, 2004). Word reading and vocabulary are particularly important given speculations that they could mediate the relation between morphological awareness and reading comprehension (e.g., Deacon et al., 2014; Kieffer & Lesaux, 2012). We remove their contributions here by controlling for these variables so that we can focus on the relations of interest: namely, the relations between each of morphological awareness, morphological analysis, and reading comprehension.

Following on work by Deacon et al. (2015), our morphological analysis task includes low frequency morphologically complex derived words with more or less accessible morphemic structures brought about by their high or low frequency base morpheme (e.g., *questionable*; high-frequency base *question* versus *disposable*; low-frequency base *dispose*; Carlisle & Katz, 2006; Colé, Segui, & Taft, 1997; Deacon, Whalen, & Kirby, 2011; Quémart, Casalis, & Colé, 2011). Children's morphological analysis skills are assessed based on their ability to choose the correct meaning for the complex words with high frequency bases, as their morphological structure is more accessible for deriving meaning.

Our first research question is whether morphological awareness and/or morphological analysis uniquely predicts gains in reading comprehension. The findings of Deacon et al. (2015) lead us to predict that, in competing to explain variance in reading comprehension, only morphological analysis will contribute uniquely to gains in reading comprehension over time. Following on this prediction and Zhang et al. (2016), our secondary research goal lies on evaluating the longitudinal associations between morphological awareness and gains in morphological analysis.

3.4. Method

3.4.1. Participants. Participants in this study were a part of a longitudinal study that began in Grade 3 (Levesque et al., 2017). At the outset, 221 children in Grade 3 were tested across 14 rural and urban elementary schools in Eastern Canada. By Grade 4, 197 participants remained in the sample, with the 10.86% attrition due to students relocating or being otherwise unavailable for participation. The final sample included 91 boys and 106 girls who were on average 8 years 10 months old (SD = 3.95 months) in Grade 3. All participants spoke English as a first language. The participants demonstrated average mean levels and variation of performance for their age, as indicated by their means and standard deviations on standardized assessments of phonological awareness, nonverbal ability, word reading, and vocabulary (Table 1)[5].

3.4.2. Procedure. This study adheres to tri-council policies for ethical research and was approved by the institution and school board ethics committees. Written consent was obtained from school principals, teachers, and parents prior to the study; assent was obtained from each child at every encounter. In each of Grades 3 and 4, testing took place in February to May with approximately 12 months separating each testing period. Individual and group testing sessions were conducted by trained research assistants in a quiet location in the child's school. The measures described below were administered within a larger battery of tasks. Individual testing occurred across one or more sessions, based on the child's interest and the school's schedule. Individual sessions included the

[5] Participation in Grade 3 and Grade 4 were separated by approximately 12 months. Thus, in Grade 4, participants were on average 9 years 10 months old (SD = 3.8 months). The students who remained in the study did not differ statistically from those who left on most of the Grade 3 measures (ps > .05). On a single measure, that of morphological analysis scores, participants who remained in the study outperformed those who left, $t(203) = 3.64$, $p < .001$.

two morphological awareness tasks as well as the standardized tests of phonological awareness, nonverbal ability, word reading, and vocabulary. Group testing always occurred as a single final session; it included the morphological analysis task and the standardized test of reading comprehension. Grade 3 measures included all of those described below. Grade 4 measures included a second administration of the same morphological analysis task and the grade-appropriate reading comprehension test[6]. All standardized tasks were administered and scored per their respective manual's instructions.

3.4.3. Measures.

3.4.3.1. Morphological awareness. Two measures of morphological awareness were used. The Test of Morphological Structure (from Carlisle, 2000) assessed children's morphological awareness of derivational morphology. For this spoken task, participants were asked to change the target item to complete a sentence (e.g., *Farm. My uncle is a ___ [farmer]*). The task was adapted to include a total of 28 target items; half of these were phonologically transparent (e.g., *accept–acceptance*) and the other half were phonologically opaque (e.g., *revise–revision*). Further, half of the items involved the production of a derived word from a base word (e.g., *farm* to *farmer*) and half involve the decomposition of a derived form to its base form (e.g., *growth* to *grow*). Corrective feedback was provided for the three practice items.

The second measure, the Word Analogy Task (Kirby et al., 2012), assessed participants' awareness of the morphological change occurring between a set of words

[6] It was originally planned to have a Grade 4 measure of morphological awareness as well. However, we were not able to equate this measure on difficulty to the Grade 3 measure. As such, we do not include analyses with this measure, as the different versions of the task may not be equated. Hence, participants' morphological awareness in Grade 4 was not included in the current study.

that followed an analogy (A:B::C:D). Participants heard the first pair of words (A:B), followed by the first word of the second pair (C). They were then asked to complete the pattern by providing the missing word of the second pair (D) (e.g., *run: ran:: walk: [walked]*.). There were 20 test items, which included an equal number of inflected and derived words, both of which included phonologically transparent (e.g., *walk-walked*) and phonological opaque transformations (e.g., *stood-stand*). Participants' raw score is the total number of correct responses after administering all the items. Corrective feedback was provided for five practice items.

3.4.3.2. Morphological analysis. Our task was designed as per Deacon et al. (2015) and Levesque et al. (2017). The task consisted of 40 morphologically derived words, each ending with one of the 20 most commonly used suffixes in the English language (Blevins, 2001; Carroll, Davies, & Richman, 1971). These suffixes included: -*able*, -*al*, -*ly*, -*ment*, -*ful*, -*less*, -*ness*, and -*ous*. Moreover, all derived words were phonologically, orthographically, and semantically transparent with their base morpheme. All derived words had low surface frequencies, with fewer than four occurrences per million words in text ($U < 4$; $M_U = 1.53$; based on Zeno, Ivens, Millard, & Duvvuri, 1995). This reduced the possibility that children were familiar with the meaning of these items at the whole-word level. Half of the derived words had a high frequency base morpheme (e.g., *<u>respect</u>ful*; $U > 50$; $M_U = 91.15$) and half had a low frequency base morpheme (e.g., *<u>hazard</u>ous*, $U < 5$; $M_U = 2.38$; criteria as per Deacon et al., 2011). The derived words with high- and low-base frequencies were matched on overall surface frequency, number of syllables, letters, and phonemes (all $p > .46$).

Participants' performance on the derived words with high-frequency bases was used to evidence their morphological analysis skills (as per Deacon et al., 2015; Levesque et al., 2017). To confirm this decision, we used *t*-tests to compare children's scores in selecting the correct meaning for the derived words with high versus low frequency bases. Children were better at selecting the correct meaning for complex words with high than low frequency base morphemes in Grade 3, 60% (SD = 18%) vs. 43% (SD = 18%), t (204) = 15.47, $p < .001$, $d = .94$, and in Grade 4, 68% (SD = 16%) vs. 47% (SD = 19%), $t(191) = 18.27$, $p < .001$, $d = 1.09$. Given that the lists were matched on key dimensions (e.g., surface frequency, word length), children's superior performance on the items with high- frequency bases suggests that morphological analysis occurred to a greater extent for the infrequent complex words with accessible morphological structures.

The morphological analysis task was presented in print form with all items also presented orally by the experimenter. This presentation format reduced the influence of reading on performance, while also reducing memory load. Each morphologically complex word was presented with four multiple-choice definitions: one correct definition and three distractors. Participants were asked to choose the definition that best represented the meaning of the complex word. The correct definition included a higher-frequency synonym or a paraphrase of the most common definition of the word based on the Oxford English Dictionary (OED Online, 2015). The correct definition for any given item was designed to reflect the joint meaning of the base morpheme and the suffix. For instance, the correct definition for *knowledgeable* was *capable of having a lot of information*, such that *information* represents the base word *knowledge* and *capable of* captures the suffix *–able*.

The distractor definitions were created based on guidelines adapted from Anglin (1993). To summarize these, the distractor definitions were chosen to be syntactically similar to and roughly the same length as the correct definition. Moreover, the distractor definitions were systematically related to either the base morpheme only, the suffix only, or neither. For example, distractor definitions for *knowledgeable* were: 1) *without having a lot of information* (i.e., *information* reflects the meaning of the base *knowledge*), 2) *capable of having a lot of patience* (i.e., *capable of* reflects the meaning of the suffix –*able*), and 3) *without having a lot of patience* (i.e., all elements are unrelated to base and suffix of *knowledgeable*). The small, systematic differences across the distractor definitions ensured that children had to analyze the meaning of both component morphemes to select the correct definition among the alternatives. The same morphological analysis task was administered in Grades 3 and 4.

3.4.3.3. Reading comprehension. Participants completed the Reading Comprehension subtest of the Gates-MacGinitie Reading Tests–Fourth Edition (MacGinitie, MacGinitie, Maria, & Dreyer, 2000). Over a 35-minute period, children silently read a series of passages and answered multiple choice questions assessing their understanding of each passage. Participants completed Level 3 and Level 4 of the Reading Comprehension subtest in Grade 3 and Grade 4, respectively. Vertically equated extended scaled scores were used to account for differences in difficulty in the two levels and thus appropriately capture gains over time, consistent with the manual's instructions.

3.4.3.4. Phonological awareness. Phonological awareness was measured with the Elision subtest of the Comprehensive Test of Phonological Processing (Wagner, Torgesen, & Rashotte, 1999). Participants heard up to 20 words presented one at time by the experimenter. Children were asked to repeat each target word; they were then asked to repeat the word without a specific sound (e.g., “Say *stale*. Now say *stale* without saying /t/”; answer: *sale*).

3.4.3.5. Nonverbal ability. The Matrix Reasoning subtest of the Wechsler Abbreviated Scale of Intelligence (Wechsler, 1999) was used to assess participants' nonverbal abilities. Participants are presented with incomplete patterns and asked to complete the pattern by selecting one of five choices.

3.4.3.6. Word reading. Word reading skills were measured with the Test of Word Reading Efficiency (Torgesen, Wagner, & Rashotte, 1999). The Sight Word Efficiency subtest includes a list a real English words (e.g., *cat*, *book*, *people*) whereas the Phonemic Decoding subtest includes a list of pronounceable nonwords (e.g., *baf*, *dess*, *shlee*). Participants complete each subtest separately by reading through the list of increasingly-difficult items as quickly and as accurately as possible in 45 seconds.

3.4.3.7. Vocabulary. Vocabulary was measured with the Peabody Picture Vocabulary Test–Fourth Edition (Dunn & Dunn, 2007). Participants were asked to point the one of four pictures that best represented the word spoken by the experimenter.

3.4.4. Data Analysis Plan. We used Mplus version 7.31 (Muthén & Muthén, 2015) to fit our autoregressive structural equation models. A latent factor was created for morphological awareness using its two indicators: the test of morphological structure and the word analogy task (factor loadings were .88 and .78, respectively). We used full-information maximum likelihood robust (MLR) to account for a small amount of missing data (< 3.60% across measures; Enders 2010). MLR also guards against bias due to non-normality and non-independence of observations (Finney & DiStephano, 2013).

Model fit was evaluated based on the chi-square statistical test, comparative fit index (CFI), Tucker-Lewis index (TLI), root mean square error of approximation (RMSEA), and standardized root mean residual (SRMR). A nonsignificant chi-square reflects a good model fit, although this statistical test is often biased to be significant with large sample sizes (Kline, 2016). CFI and TLI values greater than or equal to .95 and RMSEA and SRMR estimates less than .06 are indicative of good model fit (Browne & Cudeck, 1992; Hu & Bentler, 1999; Kline, 2016). We compared the goodness-of-fit across competing theoretical (nested) models using the Satorra-Bentler scaled chi-square difference test (Bryant & Satorra, 2012; Satorra & Bentler, 2010). Bias-corrected bootstrapping was used to generate the 95% confidence intervals required to evaluate the statistical significance of the paths in the model. Unlike other tests of effects, bootstrapped confidence intervals are robust to potential deviations from multivariate normality (Preacher & Hayes, 2008).

3.5. Results

3.5.1. Preliminary Analyses. Descriptive information and correlations between measures are presented in Tables 1 and 2, respectively. Raw scores were used for data analysis with the exceptions of word reading and reading comprehension. For word reading, the total word reading efficiency standard score was used as the most appropriate composite score for performance on both the sight word and phonemic decoding subtests, as detailed in the manual (Torgesen et al., 1999). For reading comprehension, the extended scaled score was used. This vertically scaled score is recommended for longitudinal analyses across different levels of the Gates-MacGinitie. Inspection of the data for univariate and multivariate outliers, skewness, and multicollinearity (as per Field 2009) showed no indication of data non-normality or other concerns.

Table 1

Descriptive Statistics for Grade 3 and Grade 4 Measures

Measures (maximum score)	*M* Raw Score (*SD*)	*M* Std. Score (*SD*)	Skew	Kurtosis	Reliability
Grade 3 Measures					
Morphological Awareness – TMS (28)	15.24 (5.24)	–	-.32	-.43	.86[e]
Morphological Awareness – WA (20)	11.29 (3.97)	–	-.42	-.06	.79[e]
Word Reading (167)	88.23 (23.12)	105.32 (15.18)[a]	-.20	-.33	>.93[f]
Vocabulary (228)	146.09 (15.83)	106.47 (12.33)[a]	-.09	.72	>.97[f]
Phonological Awareness (20)	12.21 (4.82)	9.88 (2.95)[b]	.19	-.89	.79[f]
Nonverbal Ability (32)	17.07 (5.67)	50.06 (9.56)[c]	-.43	-.84	.92[f]
Morphological Analysis (20)	12.29 (3.49)	–	-.27	-.49	.72[e]
Reading Comprehension (48)	30.71 (10.29)	474.90 (40.09)[d]	.40	-.25	.96[f]
Grade 4 Measures					
Morphological Analysis (20)	13.48 (3.18)	–	-.40	-.23	.68[e]
Reading Comprehension (48)	28.95 (10.25)	492.04 (35.93)	-.03	-.67	.96[f]

Note. TMS = Test of Morphological Structure. WA = Word Analogy.

[a]Standardized score with a mean of 100 (*SD* = 15). [b]Standardized score with a mean of 10 (*SD* = 3). [c]Standardized score with a mean of 50 (*SD* = 10). [d]Extended Scale Score, where the normed 50%ile for Grade 3 (spring) is 472 and Grade 4 (spring) is 492. [e]Chronbach's alpha reliability. [f]Reliability from manual.

Table 2

Correlations Among All Study Measures Included in the Study

Measures	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
1. Morphological Awareness TMS	—										
2. Morphological Awareness WA	.69[a]	—									
3. Gr. 3 Morphological Analysis	.53[a]	.54[a]	—								
4. Gr. 4 Morphological Analysis	.57[a]	.57[a]	.79[a]	—							
5. Gr. 3 Reading Comprehension	.63[a]	.59[a]	.58[a]	.61[a]	—						
6. Gr. 4 Reading Comprehension	.62[a]	.53[a]	.56[a]	.57[a]	.81[a]	—					
7. Age	.13	.02	-.03	-.02	.12	.14	—				
8. Phonological Awareness	.31[a]	.32[a]	.32[a]	.30[a]	.25[a]	.30[a]	.02	—			
9. Nonverbal Ability	.38[a]	.31[a]	.22[a]	.22[a]	.24[a]	.20[a]	.05	.05	—		
10. Vocabulary	.72[a]	.58[a]	.52[a]	.58[a]	.56[a]	.54[a]	.20[a]	.26[a]	.25[a]	—	
11. Word Reading	.48[a]	.45[a]	.53[a]	.48[a]	.57[a]	.56[a]	-.18[b]	.41[a]	.08	.38[a]	—

Note. Grade 3 measures unless otherwise noted. TMS = Test of Morphological Structure. WA = Word Analogy Test.

[a]p < . 01. [b]p < . 05.

3.5.2. Autoregressive Modeling: Building a Control Model. As with traditional linear regression, our first step in creating our autoregressive path model involved building a theoretically-justified and non-redundant control model (see Agresti & Finlay, 2009). The control models are presented in Figure 1. Included in Control Model C1 are the autoregressive paths of Grade 3 morphological analysis on Grade 4 morphological analysis as well as Grade 3 reading comprehension on Grade 4 reading comprehension. Grade 3 measures of age, phonological awareness, nonverbal ability, word reading, and vocabulary were included as controls for Grade 4 variables of morphological analysis and reading comprehension. As is customary, all Grade 3 variables were allowed to covary with each other (Kline, 2016). Control Model C1 shows the results of this initial model, with solid lines indicating significant effects and dashed lines signaling nonsignificant effects.

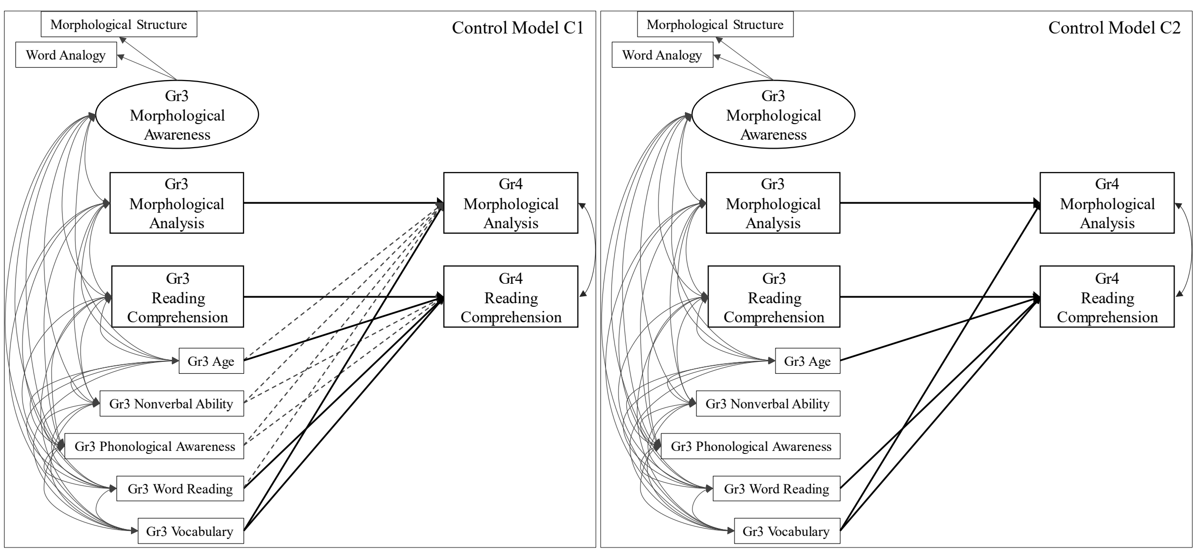


Figure 1. Building a control model.

The second step in building a parsimonious control model involved removing nonsignificant paths from Control Model C1. Taking a conservative approach, we removed nonsignificant paths with a *p*-value greater than .10. Model fit was reassessed after the removal of each single path. Control Model C2 emerged following this sequential removal process. The Satorra-Bentler scaled chi-square difference test revealed that the nested Control Model C2 fit the data just as well as Control Model C1, Satorra-Bentler $\Delta\chi^2 = 7.27$, $\Delta df = 9$, $p = .61$. In other words, the nonsignificant dashed lines shown in Control Model C1 are paths that do not contribute, individually or collectively, toward improving model fit. We were justified in removing these nonsignificant paths for sake of model parsimony. In our view, the statistical non-significance of these paths is largely attributable to the sizeable autoregressive effects that are specific to this longitudinal model. Thus, removing these paths does not speak to the conceptual significance of these variables in reading development

As would be expected, Control Model C2 demonstrated large autoregressive effects associated with Grade 3 morphological analysis (standardized coefficient, $\beta = .68$, $p < .001$) and Grade 3 reading comprehension ($\beta = .65$, $p < .001$) on their respective Grade 4 outcomes. The control paths that remained were as follows: Grade 4 morphological analysis was regressed on vocabulary only ($\beta = .23$, $p < .001$), Grade 4 reading comprehension was regressed on age ($\beta = .07$, $p < .075$), vocabulary ($\beta = .11$, $p < .05$), and word reading ($\beta = .17$, $p < .01$). Control Model C2 was carried forward for all future analyses.

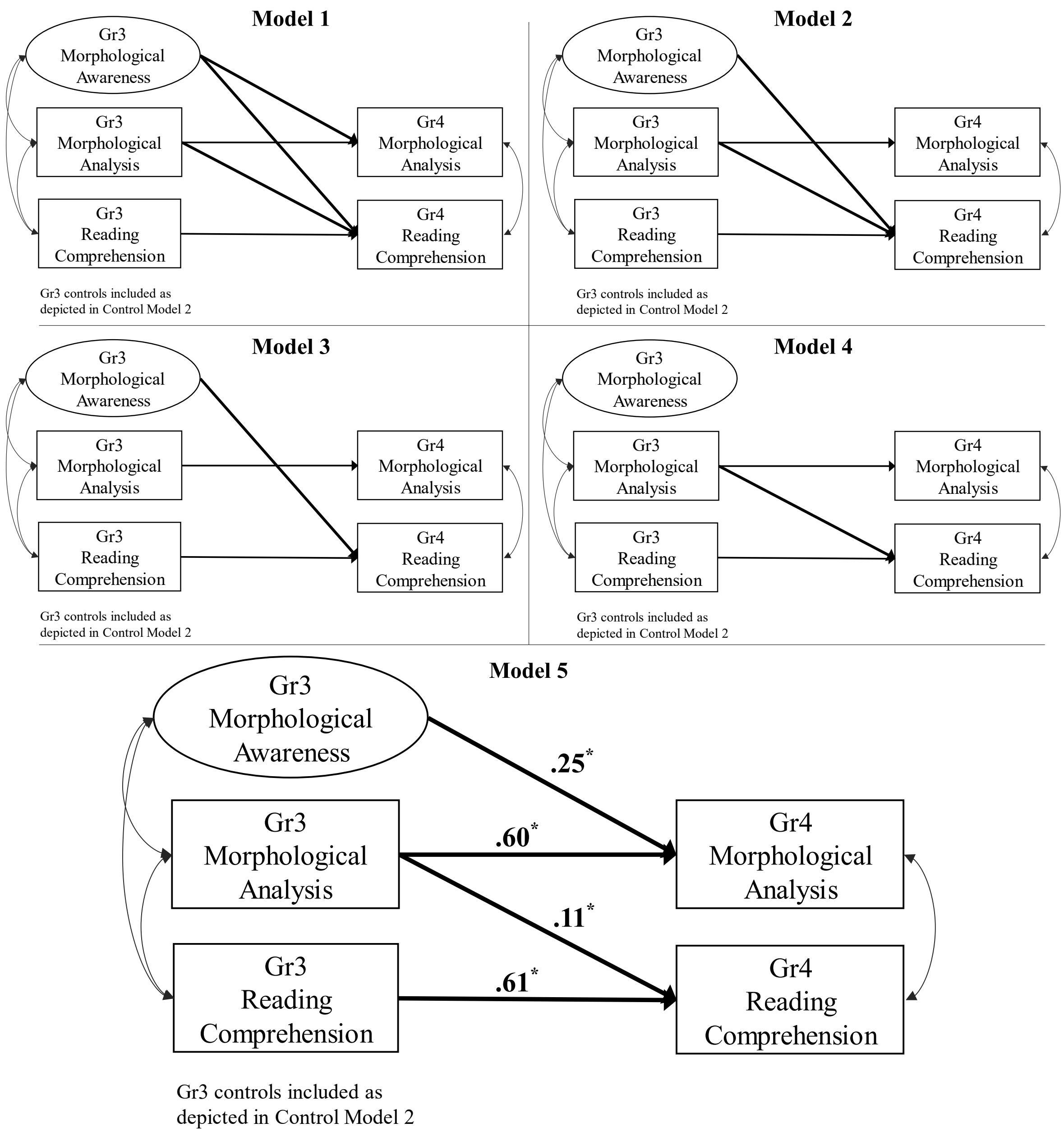


Figure 2. Models tested and compared. Final model (Model 5) with standardized coefficients (β).

*Significant effect determined from bias-corrected bootstrapped 95% confidence intervals (BC 95% CI) that do not cross zero. *Control paths in Model 5* (BC 95% CI in brackets): Grade 4 Reading Comprehension regressed on Grade 3 measures of Age (β = .08, [.47, .65]), Word Reading (β = .15, [.08, .61]), Vocabulary (β = .08, [-.07, .42]). Grade 4 Morphological Analysis regressed on Grade 3 Vocabulary (β = .08, [-.02, .05]).

3.5.3. Comparison of Nested Autoregressive Models. We tested a series of theoretically-driven nested models that evaluated the longitudinal contributions of morphological awareness and morphological analysis on reading comprehension. For the sake of completeness, we begin with the full model, Model 1 in Figure 2. Table 3 presents the fit indices for all models depicted in Figure 2 as well as the results of the chi-square difference tests comparing each nested model to the full Model 1. The full model, Model 1, depicts morphological awareness and morphological analysis in Grade 3 as both contributing to reading comprehension in Grade 4. This model further shows Grade 3 morphological awareness predicting morphological analysis in Grade 4. Across multiple indicators shown in Table 3, Model 1 provided an excellent fit to the data. We compared Model 1 to Models 2–5; each nested model represented a specific alternative prediction. Model 2 represents the prediction that both morphological awareness and morphological analysis in Grade 3 uniquely predict reading comprehension in Grade 4 beyond the autoregressor and controls. On the other hand, Model 3 depicts the prediction that only morphological awareness predicts later reading comprehension. Model 4 depicts the alternative prediction that only morphological analysis predicts later reading comprehension. Finally, Model 5 reflects the primary and secondary predictions of this study; Grade 3 morphological awareness predicts Grade 4 morphological analysis (beyond autoregressor and vocabulary control) and Grade 3 morphological analysis, rather than morphological awareness, predicts Grade 3 reading comprehension (beyond autoregressor and age, word reading, and vocabulary controls).

Table 3

Model Fit Indices and Model Comparisons

Model	χ^2	*df*	*p*	CFI	TLI	RMSEA	SRMR	χ^2 Difference Test	
								$\Delta\chi^2$	p^a
Model 1	19.05	15	.21	.995	.985	.037	.017	—	—
Model 2	26.14	16	.05	.988	.965	.057	.024	5.33	.02
Model 3	28.80	17	.04	.986	.962	.059	.026	8.50	.01
Model 4	27.39	17	.05	.987	.966	.056	.024	6.94	.03
Model 5	20.37	16	.20	.995	.985	.037	.017	1.32	.25

Note. Models depicted in Figure 2. χ^2 difference test using Satorra-Bentler scaled correction.

[a]*p*-value < .05 indicates a significant reduction in model fit compared to Model 1.

In comparison to the full Model 1, the Satorra-Bentler scaled chi-square difference tests revealed significant reductions in model fit for Model 2, Model 3, and Model 4 (*ps* < .05; see Table 3). This indicates that the specific paths removed in each of these nested models represent important effects. As such, Model 2, Model 3, and Model 4 were not considered further. In contrast, our predicted Model 5 provided an equally good fit to the data compared to the full model (*p* = .25), indicating that the path between Grade 3 morphological awareness and Grade 4 reading comprehension was not necessary. Therefore, Model 5 was retained as the best fitting, more parsimonious model.

3.5.4. Interpreting the Final Model. The fit indices listed in Table 3 show that Model 5 had an excellent fit to the data (CFI & TLI > .98, RMSEA & SRMR < .04). Figure 2 includes the standardized path coefficients for Model 5; the magnitude of effects are judged based on Cohen's (1992) guidelines: ~.10 is small, ~.30 is moderate, >.50 is large. Large autoregressive effects confirmed that morphological analysis in Grade 3 was highly predictive of morphological analysis in Grade 4 (β = .60, BC 95% CI [.42, .67]) and likewise for Grade 3 to Grade 4 reading comprehension (β = .61, BC 95% CI [.47, .65]). For the diagonal paths, Grade 3 morphological awareness had a significant moderate effect on Grade 4 morphological analysis (β = .25, BC 95% CI [.04, .35]), controlling for the autoregressive effect and vocabulary. This finding suggests that children's morphological awareness skills in Grade 3 predicted gains in their morphological analysis from Grade 3 to 4. Finally, Grade 3 morphological analysis had a small yet significant effect (β = .11, BC 95% CI [.04, 2.31]) on Grade 4 reading comprehension beyond the autoregressive effect and controls for age, word reading, and vocabulary. This finding suggests that children's morphological analysis in Grade 3 predicted unique gains in their reading comprehension from Grade 3 to 4. Finally, there is no significant path between Grade 3 morphological awareness and Grade 4 reading comprehension, suggesting that morphological awareness was not a unique predictor of later reading comprehension when morphological analysis is included in a longitudinal model.

3.5.5. Post Hoc Mediation Analysis. The pattern of results obtained in this study supports the suggestion that morphological analysis acts as a mediator in the relation of morphological awareness and reading comprehension (Carlisle, 2007; Levesque et al., 2017). In the truest sense, mediation is meant to denote causal change over time (Maxwell & Cole, 2007). However, this description is incongruent with the mediation studies reviewed earlier (and mediation research more generally), which have tested for mediation using single-time-point data. Thus, we performed a post hoc mediation test using our two-wave longitudinal data because this longitudinal analysis may provide a more rigorous test of mediation via morphological analysis than single-time-point studies

(Cole & Maxwell, 2003). We generated an estimate of mediation under the assumption of stationarity—assuming the relations of morphological analysis to reading comprehension from Grade 3 to 4 and from Grade 4 to 5 are of similar magnitudes. We generated this estimate by multiplying the parameters of the two diagonal paths shown in Model 5 (as described in Cole & Maxwell, 2003). The estimated mediation via morphological analysis yielded a small, yet significant effect (β = .03, BC 95% CI [.01, .59]). Though small, this effect suggests that morphological analysis might mediate the contribution of morphological awareness to gains in reading comprehension over time.

3.6. Discussion

In this study, we tested the contributions of morphological awareness and morphological analysis to gains in children's reading comprehension from Grade 3 to 4. Our goal was to determine which skill—morphological awareness, morphological analysis, or both—predicts unique gains in reading comprehension over time. Given our prediction that gains in reading comprehension would be predicted by children's morphological analysis skills, we also examined whether their morphological awareness explained gains in morphological analysis from Grade 3 to 4. To summarize the findings, morphological analysis contributed to gains in reading comprehension between Grades 3 and 4, and morphological awareness contributed to gains in morphological analysis between Grades 3 and 4.

We demonstrated that morphological analysis—but *not* morphological awareness—in Grade 3 predicted gains in their reading comprehension between Grades 3 and 4, beyond age, word reading, and vocabulary. This finding specifies the precise morphological skills that contribute to the development of reading comprehension at this point in children's reading development. This finding extends prior evidence of a relation between morphological analysis and reading comprehension at a single point in time (Levesque et al., 2017; Zhang & Koda, 2012); specifically, we show the value of children's morphological analysis skills in contributing to gains in their reading comprehension over time.

The absence of a unique contribution of morphological awareness to gains in reading comprehension in the current study does not fit neatly with earlier studies showing morphological awareness as a predictor of gains in reading comprehension (e.g., Deacon et al., 2014; Foorman et al., 2012). Prior studies have reported concurrent and longitudinal relations between morphological awareness and reading comprehension (e.g., Kieffer & Box, 2013; Nagy et al., 2006). We think that there is a key difference to keep in mind; prior longitudinal studies did not include morphological analysis (e.g., Foorman et al., 2012; Kruk & Bergman, 2013), thus effects of morphological awareness might have reflected its shared variance with morphological analysis. To our knowledge, only a single cross-sectional study has shown an enduring direct relation between morphological awareness and reading comprehension beyond the indirect effect of morphological analysis and controls of word reading, vocabulary, phonological awareness, and nonverbal ability (Levesque et al., 2017). Taking these results together with our own, it seems that that the relation between morphological awareness and reading comprehension behaves differently over time than when these constructs are measured concurrently (see also Zhang & Koda, 2012). The role of morphological analysis, rather than morphological awareness, may become more influential in the development of reading comprehension over time as children increasingly encounter morphologically complex words in their reading.

In terms of our second research question, children's morphological awareness in Grade 3 predicted gains in their morphological analysis between Grades 3 and 4. These results are in line with those of Zhang et al. (2016) who demonstrated that Grade 3 morphological awareness predicted gains in morphological analysis one year later in children's first (Malay) and second (English) languages. These findings also help to point to a role for morphological awareness in the development of reading comprehension (e.g., Kirby et al., 2012; Kuo & Anderson, 2006); we speculate that morphological awareness contributes to building reading comprehension skill through its contribution to the development of morphological analysis. This speculation is supported by our post-hoc mediation analysis, and needs to be confirmed in a three-wave longitudinal design. Further, our finding that morphological awareness predicts later morphological analysis beyond its autoregressive effect supports these skills as distinct morphological constructs (e.g., Deacon et al., 2015; Levesque et al., 2017); their distinctiveness is also consistent with speculations that skill in morphology is multidimensional (e.g., Kieffer et al., 2016; Tighe & Schatschneider, 2015).

We interpret our results specifically within the language and time period of focus here: English-speaking children in Grades 3 to 4. As a phonologically opaque alphabetic language, English relies on morphological regularities to convey meaning in both spoken and written language (Carlisle & Stone, 2005; Seymour, 1997). It is plausible that the longitudinal relations observed in this study might differ for languages that are highly phonologically transparent or for languages that have different types of scripts (e.g., syllabic, logographic). Additionally, it is highly plausible that these relations might differ earlier in reading development. For example, morphological awareness might have a direct relation to gains in reading comprehension for younger children. Further, such relations might emerge with assessments of inflectional forms, given that these are the first mastered in children's oral language (Carlisle, 2003; Kuo & Anderson, 2006). Our findings are limited to change across two measurement points separated by a single grade level. As such, we can speak to factors that affect gains, but not growth over time. Future studies could use growth curve models with three or more time points as this approach is deemed more appropriate for evaluating growth in skills over time (Rogosa, 1987; Schlueter, Davidov, & Schmidt, 2007). Mediation analyses with data from three or more time points will also be able to disentangle the mediated relations on which we speculate. Taken together, further research is needed to better understand how the relations in question play out over longer periods of time.

3.6.1. Theoretical Implications. Our findings have implications for theory. Namely, our results help to further specify the role of morphology in the Reading Systems Framework (Perfetti et al., 2005). We view morphological awareness as a metalinguistic skill operating within the linguistic system. From the linguistic system, the framework shows a direct pathway between morphological awareness and reading comprehension and an indirect pathway through the lexicon—this depiction is consistent with studies that have measured these skills concurrently (Deacon et al., 2014; Kieffer & Box, 2013; Levesque et al., 2017). We speculate that morphological analysis plays a role in the lexicon. Recall that the lexicon deals with access to meaning; it is the hub for word comprehension (Perfetti, 2007; Perfetti & Stafura, 2014). As such, morphological analysis might be a critical element in the indirect lexicon pathway because it contributes to word comprehension by inferring meaning from morphemic parts. Based on the framework, morphological analysis, as part of the lexicon pathway, would receive input from morphological awareness and support reading comprehension in its own right. Indeed, our findings would support this assertion. Furthermore, we speculate that the influence of the indirect lexicon pathway becomes more prominent over time. We suggest that morphological awareness in the linguistic system provides foundational support for other skills to develop, like morphological analysis. Then, as morphological analysis develops over time, it is likely to exert a growing influence on reading comprehension. Likewise, it is plausible that a greater role of morphological analysis is needed to support reading comprehension because of the increasing presence of morphologically complex words in students' texts throughout the elementary grades (Anglin, 1993; Nagy & Anderson, 1984; Seymour, 1997). As a consequence, the role of morphological awareness may become less critical for successful reading comprehension over time as its contribution becomes eclipsed by that of morphological analysis. Our results are consistent with this interpretation. Certainly, more research is needed to better understand how specific morphological skills develop and subsequently contribute to the development of children's reading comprehension. At this time, our findings allow us to recommend that future models of reading comprehension should consider the influence of distinct morphological skills in their theoretical frameworks.

3.6.2. Educational Implications. In addition to specifying the role of morphology in theories of reading comprehension, the findings of this study may inform instruction in the classroom. Systematic reviews have revealed that instruction in morphology can be beneficial to a broad range of literacy skills, including reading comprehension (Bowers et al., 2010; Carlisle, 2010; but see Goodwin & Ahn, 2013). These reviews have pointed out that instructional programs that include morphology are often vaguely described (Carlisle, 2010). Our findings point to morphological analysis as a morphological skill most likely to support development in children's reading comprehension. Explicit instruction could focus on teaching children how to analyze the structure of morphologically complex words for meaning. For instance, teachers might introduce morphological analysis as a problem-solving strategy that children can turn to in order to figure out the meaning of unknown words they encounter. Teachers may scaffold the process of searching within large unfamiliar words for familiar meaningful chunks and guide children in leveraging these smaller morphemes to support their understanding of unfamiliar words. Given our empirical findings of a role of morphological awareness in supporting the development of morphological analysis, we suspect that morphological analysis instruction has its greatest impact on reading comprehension when it builds on a strong foundation of morphological awareness. Together we argue that targeted instruction in morphological analysis alongside other evidence-based literacy instruction will provide children with powerful tools for understanding texts.

In the current study, we demonstrated that morphological analysis and not morphological awareness supports the development of reading comprehension between Grades 3 and 4. This supports morphological analysis an essential element in children's reading comprehension. This role is likely attributable in part to the large number of morphological complex words in children's texts in the elementary grades (Nagy &

Anderson, 1984). Further, we demonstrated that development in morphological analysis is grounded in morphological awareness. Ultimately, our findings allude to the possibility that morphological analysis serves as an intermediate skill between morphological awareness and reading comprehension. These findings help to clarify the mechanisms underlying the relation between morphological skills and reading comprehension development. Speculatively, the contribution of morphological awareness to gains in reading comprehension may in fact be largely, or fully, mediated by morphological analysis. We think that these findings provide an empirical basis for the role of morphological skills in models of reading comprehension.

3.6.3. References. See general reference list on page 120.

CHAPTER 4. DISCUSSION

4.1. REVIEW OF DISSERTATION GOALS AND FINDINGS

The overarching aim of this dissertation was to clarify the relation of morphological awareness and reading comprehension. Across two empirical studies, I attempted to clarify the relation by considering additional language and literacy constructs that might act as intermediate skills in the relation of morphological awareness and reading comprehension. Study 1 contrasted four potential mediators and examined whether they contributed meaningfully in mediating the concurrent relation between morphological awareness and reading comprehension in Grade 3 children. Study 2 considered the longitudinal relation between morphological awareness and reading comprehension by specifically testing whether morphological awareness contributes to gains in reading comprehension from Grade 3 to 4 beyond the influence of morphological analysis. Together, these studies were designed to address the aim of my dissertation by clarifying both the concurrent and longitudinal connection between morphological awareness and reading comprehension in developing readers. In doing so, it was my intention that this work would elucidate some of the likely mechanisms underlying the relation between morphological awareness and reading comprehension.

4.1.1. Study 1. In the first study, I considered the possibility that morphological awareness may not contribute directly to reading comprehension but may instead contribute indirectly to reading comprehension via one or more intermediate factors. Guided by prior findings and theoretical speculations, four potential mediators were considered simultaneously in a single multi-mediator path analysis model in structural equation modeling: morphological decoding, morphological analysis, word reading, and vocabulary. The general prediction centered on the idea that morphological awareness contributes to reading comprehension because it specifically influences children's ability to read and understand morphologically complex words. Accordingly, I predicted that morphological decoding and morphological analysis, rather than word reading or vocabulary, would mediated the relation of morphological awareness and reading comprehension.

Multi-mediation path analyses in Study 1 revealed that morphological awareness contributed directly as well as indirectly to the reading comprehension skills of children in Grade 3. In one indirect pathway, the effect of morphological awareness on reading comprehension was sequentially mediated by morphological decoding followed by word reading skills (i.e., the morphological decoding pathway). In a second indirect pathway, the effect of morphological awareness on reading comprehension was uniquely mediated by morphological analysis (i.e., the morphological analysis pathway). The significant direct path indicated that morphological awareness continued to explain unique variance in reading comprehension beyond all four mediators in the model as well as controls for phonological awareness and nonverbal ability.

The prediction that morphological awareness relates primarily to reading comprehension through its contributions to morphological decoding and morphological analysis was partially supported. Indeed, children's morphological awareness in Grade 3 played a role in facilitating the reading and understanding of morphologically complex words, and both elements contribute to reading comprehension separately. Relatedly, it is equally noteworthy that the relation of morphological awareness to reading comprehension was not mediated by word reading and vocabulary, as suggested in prior research (e.g., Deacon, Tong, & Francis, 2015; Kieffer & Box, 2013; Nagy et al., 2006). This evidence supports the idea that morphological awareness has a more targeted influence on words that have a complex morphological structure rather than on more general measures of word reading and vocabulary skills. Nevertheless, the initial prediction was only partially supported because morphological awareness remained a significant predictor of children's reading comprehension in its own right—a finding that converges with a growing body of research (e.g., Deacon et al., 2014; Kieffer & Lesaux, 2012). These findings contribute to the literature given that this study offers one of strictest test of how morphological awareness relates to reading comprehension in children. Altogether, the results suggest that morphological awareness is a deeply influential metalinguistic ability, with specific demonstrable contributions to reading and understanding complex words alongside a far-reaching effect on children's ability to comprehend text.

4.1.2. Study 2. The second study of the dissertation focused on the longitudinal relation between morphological awareness and reading comprehension from Grade 3 to 4. Given previous findings suggesting that morphological awareness predicts reading comprehension over time (e.g., Deacon et al., 2014; Foorman et al., 2012), Study 2 investigated how morphological awareness contributes to gains in children's reading comprehension. I specifically tested the prediction that morphological analysis (an important mediator in Study 1), rather than morphological awareness, is the active element that contributes to gains in reading comprehension and in doing so, accounts for the longitudinal relation between morphological awareness to reading comprehension. An autoregressive modeling approach with two-wave longitudinal data was used to test this prediction. The longitudinal design tested the direction of effects depicted in theories. The autoregressive analysis speaks to gains in children's skills over time by controlling for their initial abilities; as such, this analytic approach provided a stringent test of the morphological skills that contribute to the development of reading comprehension over time.

The results of Study 2 revealed that morphological analysis, but notably *not* morphological awareness, in Grade 3 accounted for unique gains in reading comprehension from Grade 3 to 4, beyond controls for age, word reading, and vocabulary. Thus, as predicted, children's morphological awareness was not the primary contributor to gains in reading comprehension over time once their morphological analysis skills were included in the model. Nevertheless, morphological awareness was influential in the longitudinal model. The findings demonstrated that children's morphological awareness in Grade 3 contributed to gains in their morphological analysis skills from Grade 3 to 4 after controlling for vocabulary. Thus, it appears that children's awareness of meaningful units in spoken language plays a role in the development of morphological analysis. Taken together, the results of the second study suggest an important role of morphological analysis in the relation of morphological awareness and to gains in reading comprehension.

4.2. Contributions to Theory

The current research informs theories of reading comprehension, specifying the role of morphological awareness in its development. I believe this to be critical because, as it became apparent in the Introduction, developmental theories have largely overlooked the role of morphological awareness in reading comprehension. Indeed, many researchers have argued that "the placement of morphology in models of reading comprehension clearly needs reevaluation" (Tong et al., 2011, p. 530; see also Carlisle & Kearns, 2017). I contend that my research may clarify the role and placement of morphological awareness in theories of word reading and reading comprehension. Thus, in the ensuing paragraphs, the findings of the dissertation are considered from the perspective of current theoretical frameworks of reading. I then conclude this discussion by providing an overarching view of the dissertation research and offering additional theoretical and empirical insight into the relation of morphological awareness and reading comprehension.

4.2.1. Theories of Word Reading. The Phase Theory of Reading Development (Ehri, 1995, 2005, 2014) and the Psycholinguistic Grain Size Theory (Ziegler & Goswami, 2005) continue to be the staple theories of word reading development given their comprehensiveness and broad applicability for research. Still, one downside is that the influences of morphology on word reading are not distinguished from those of orthography in either the Phase Theory or the Grain Size Theory. Both theories describe a process whereby recurring letter patterns, such as syllables and morphemes, become consolidated into multi-letter chunks over time and exposure. The consolidation of chunks is viewed as key in increasing word reading efficiency because children recognize them as single units, allowing children to use larger chunks to read words. The Phase and Grain Size theories provide a limited perspective on the role of morphology in that they do not consider the possibility that morphemes may influence word reading efficiency to a different extent than non-morpheme units. It will be useful to consider this possibility in future studies by distinguishing morphological and orthographic decoding (see Nunes, Bryant, & Barros, 2012). The current findings suggest that this is a worthwhile distinction. Specifically, in Study 1, the results demonstrated the separability of morphological decoding from more general word reading skills. I speculate that the separability of these constructs suggests that reading words via morpheme units is not analogous to reading words via other grain size units. This interpretation gives credence to the prediction that written morpheme and non-morpheme units differentially impact children's word reading efficiency—an interpretation which has started to receive empirical support (Nunes et al., 2012). Nevertheless, this remains an interesting avenue for further research.

Aside from morphemes, the contribution of morphological awareness to word reading is also overlooked in the Phase Theory and Grain Size Theory (Ehri, 2014; Ziegler & Goswami, 2005). These theories consider children's awareness of the sound structure in language, or phonological awareness (Wagner & Torgesen, 1987), as the key to successful developments in word reading (e.g., Adams, 1990; Bus & van IJzendoorn, 1999; Catts et al., 2015). Certainly, I concur with this suggestion and extend it to suggest that, as demonstrated in the 'morphological decoding pathway' in Study 1, morphological awareness has an important role in the word reading process beyond the influence of phonological awareness. At this point, the Phase and Grain Size theories do not include morphological awareness. Likewise, these theories do not extend beyond word reading efficiency to include reading comprehension. Therefore, it is difficult to fully interpret my finding without extending far beyond their current theoretical frameworks. As such, I return to this topic of morphological awareness and word reading in a subsequent discussion.

4.2.2. Lexical Quality Hypothesis. The Lexical Quality Hypothesis conceptualizes the three knowledge constituents—orthography, phonology, and semantics—that form the basis for lexical representations in memory (Perfetti, 1999; Perfetti & Hart, 2001, 2002). In its latest form, the Lexical Quality Hypothesis also includes a morphologically-focused constituent; it seemingly occupies a more limited role but one that is nevertheless distinct from the orthography, phonology, and semantic constituents (Perfetti, 2007). To briefly review this theory, high-quality lexical representation for any given word is characterized by substantial knowledge across each constituent along with tightly bonded bidirectional connections between them in a triangle network. Having increasingly high-quality lexical representations in memory is the knowledge foundation that enables efficiency and automaticity in word reading and comprehension, which are central elements of reading comprehension. Put differently, the Lexical Quality Hypothesis asserts that the overall ratio of high- to low-quality representations is directly reflected in one's reading comprehension ability.

Several of the findings of this dissertation provide empirical support for claims in the Lexical Quality Hypothesis (Perfetti, 1999; Perfetti & Hart, 2002). The current studies showed that morphological awareness, morphological decoding, and morphological analysis were positively correlated with reading comprehension, both concurrently and longitudinally, indicating that higher levels of morphological skills were associated with greater reading comprehension in children. This pattern mirrors the Lexical Quality's claim that having greater knowledge of morphology improves the quality of representations, and having higher quality representations enable greater reading comprehension. Moreover, the skills associated with morphological awareness, morphological decoding, and morphological analysis were consistently separate from other language and literacy skills tested in Studies 1 and 2. This relates to the suggestion that there is a distinct role of morphology in lexical representations that is separable from the influence of orthographic, phonological, and semantic constituents. The Lexical Quality Hypothesis puts forward that the influence of morphology is captured by an altogether separate morphological constituent ('morpho-syntax'; Perfetti, 2007), which, if visualized, would transform the infamous triangle model in to a square-shaped connectionist model. However, another possibility is that the influence of morphology helps to fuse and strengthen the bonds between the orthographic, phonological, and semantic constituents in the triangle framework (Taft, 1994). Improving the bidirectional connections between these main constituents would lead to accelerated activation of codes throughout the model, which would ultimately enhance language and reading skills.

I postulate that the placement of morphology in the Lexical Quality Hypothesis is best captured as a unifying influence on the constituents of orthography, phonology, and semantics rather than an external influence from a separate morphological constituent. Consider that when morphemes are accessed in the lexical system, it signals that the semantic and phonological codes (for spoken language) or the semantic and orthographic codes (for written language) are firing in unison and jointly propagating patterns of activation throughout the system. Over time and experience, recurring patterns of activation become engrained in the lexicon, which benefits processing speed and economy. Accordingly, the development of morphological awareness may indicate the strengthening of connections between the constituents of form (i.e., orthography &

phonology) and meaning (i.e., semantics). Support for this comes from computation modeling showing that cognizance of morphological regularities in the to-be-learned stimuli helped shape the way in which the orthographic, phonological, and semantic pathways operated in a connectionist network (Harm & Seidenberg, 2004). In my view, morphological decoding and morphological analysis reflect skills that also utilize and support the connections between orthography, phonology, and semantics. In fact, because these skills specialized in processing unfamiliar complex words, morphological decoding and morphological analysis may help form and/or strengthen new connections. Moreover, the important role of morphological analysis observed in Study 2 suggests that, by the mid-elementary grades, processing unfamiliar complex words for meaning might be a key opportunity for establishing new lexical representations and enhancing the quality of partial representations. It is argued, then, that all of these morphological skills influence the quality of lexical representations by strengthening constituent bindings rather than existing as stored knowledge in a separate (i.e., fourth) constituent.

The Lexical Quality Hypothesis, which mainly describes quality from the perspective of individual representations, is less informative about whether lexical quality can be shared between items (Perfetti, 2007). It is likely that morphology—perhaps morphological awareness especially—plays a role in the Lexical Quality Hypothesis that extends beyond individual lexical representations in the lexicon. Recall that connectionist models view morphological awareness as a learned sensitivity to the recurring patterns of convergence of orthographic, phonological, and semantic codes (Deacon et al., 2008; Plaut et al., 1996; Seidenberg & McClelland, 1989). Becoming sensitive to recurring patterns of code is not simply achieved through frequent and repeated exposure to the same word. Rather, a major source of recurring patterns comes from exposure to words that are morphologically related to each other. Indeed, there would be substantial and increasing overlap in the patterns of convergence of orthographic, phonological, and semantic codes as a function of morphological relatedness. Accordingly, morphological awareness is a learned sensitivity to the patterns that recur within and across words. From this description, I posit that morphological awareness not only influences the quality of individual lexical presentations, it also influences the quality of lexical representations throughout the lexicon (e.g., Rueckle, 2010). In this way, individual lexical representations need not be constructed from scratch for every word. A child who has developed a high quality lexical representation for the word *help* would experience a transfer of this knowledge that would benefit the quality of other lexical representations that are morphologically related (e.g., *helping*, *helpless*, *unhelpfulness*, etc.).

Although this dissertation was not driven to specifically test the Lexical Quality Hypothesis, the findings have nevertheless allowed me to speculate on several claims put forward in this theory. These speculations need further study given that the precise role of morphology in relation to reading remains undetermined. Though highly conceptual, the Lexical Quality Hypothesis continues to be a useful theoretical framework for reading research.

4.2.3. Simple View of Reading. The Simple View of Reading characterizes reading comprehension as the product of word reading and listening comprehension, with no explicit mention of morphological awareness (Gough & Tunmer, 1986; Hoover & Gough, 1990). According to its originators, the Simple View does not suggest that reading is a simple process; instead, it implies that the complexities of reading can be divided into the two main components of word reading and listening comprehension (Hoover & Gough, 1990). Many researchers acknowledge that these components were defined rather imprecisely and provide little information regarding the possible subskills and mechanism that support the word reading and listening comprehension components (e.g., Kirby & Savage, 2008). Work following on this theory generally conceptualizes the components of listening comprehension and word reading as placeholders for a broad set of language- and reading-related skills, respectively (e.g., Adlof, Perfetti, & Catts, 2011; Braze, Tabor, Shankweiler, & Mencl, 2007; Foorman, Herrera, Petscher, Mitchell, & Truckenmiller, 2015; Protopapas et al., 2012). Yet, only a few studies to date have explicitly considered the placement of morphological awareness in relation to Simple View components (e.g., Kirby & Savage, 2008). The present research suggests that the role of morphological awareness in reading comprehension is not sufficiently captured by either component alone. The findings of Study 1, for instance, demonstrate that morphological awareness has separable influences on skills related to listening comprehension (i.e., morphological analysis) and word reading (i.e., morphological decoding). This suggests that morphological awareness exists within, or contributes to, both components of the Simple View.

Moreover, the Simple View of Reading (Gough & Tunmer, 1986) as originally conceptualized cannot explain the findings of Study 1 showing a direct contribution of morphological awareness to reading comprehension that remained beyond multiple mediators and control measures in Grade 3. In this case, the Simple View framework provides little footing on which to explain how morphological awareness contributes to reading comprehension through a direct path that seemingly falls beyond listening comprehension and word reading. This finding supports the contention that the Simple View of Reading is too simple to fully account for the complexity of reading comprehension (e.g., Kirby & Savage, 2008; LARRC, 2015; Salceda et al., 2013). The current research suggests a modification to the Simple View of Reading is needed to provide more explicitness of the mechanisms that support the existing components as well as reading comprehension. In a revised version of the Simple View, I envision adding an additional component to the model that would integrate morphological awareness as well as other linguistic and cognitive processes that support the language and reading skills across components more generally (see also Goodwin, Huggins, Carlo, August, & Calderon, 2013). Within this overarching component, morphological awareness would be able to influence reading comprehension directly, as observed in Study 1. Morphological awareness could also contribute indirectly to reading comprehension by facilitating other subskills that fall within the separate word reading and listening comprehension components; the latter suggestion fits with our findings of the mediation effects via morphological decoding and morphological analysis pathways in Study 1.

Finally, in describing the predictors of reading comprehension across development, the Simple View of Reading implies the direction of effects concurrently and longitudinally. The findings of Study 1 and Study 2 support the directionality of the original Simple View model and help clarify the direction of the relations in the newly-proposed revised model of the Simple View. Moreover, the Simple View described the increasing contribution of the listening comprehension component relative to the word reading component over time (Hoover & Gough, 1990)—a statement that has since been supported empirically (e.g., Florit & Cain, 2011; Garcia & Cain, 2014). The longitudinal findings of Study 2 may provide some insight into this shift over time. In this study, morphological awareness predicted gains in children's morphological analysis, a linguistic construct that I consider to be a skill within the listening comprehension component. It is possible that morphological awareness contributes to the increasing contribution of listening comprehension relative to word reading over time by supporting the development of morphological analysis. Indeed, there is considerable speculation in this argument because the current dissertation did not explore predictions of gains in word reading. Future studies may consider testing whether morphological awareness contributes to greater development of morphological analysis than morphological decoding over time. It would also be important to examine whether the increasing contribution of listening comprehension to reading comprehension over time proceeds in a lockstep fashion with growth in morphological analysis.

4.2.4. Reading Systems Framework. Morphology is explicitly included in the Reading Systems Framework—a fact that makes this theory of reading comprehension particularly relevant to the current work (Perfetti, 1999; Perfetti et al., 2005). Specifically, morphology is listed twice, once in the linguistic system and again in the lexicon. More importantly, the dual placement of morphology in the framework corresponds to three possible pathways through which morphology is connected to reading comprehension (Perfetti & Stafura, 2014). First, the framework depicts a direct unobstructed pathway to reading comprehension originating from the linguistic system. Second, it depicts an indirect pathway beginning in the linguistic systems and moving through the word reading system toward reading comprehension. Third, it shows an additional indirect pathway beginning in the linguistic systems going to the lexicon, where lexical representations are stored as per the Lexical Quality Hypothesis previously discussed (Perfetti, 2007). At this point, the indirect lexicon path diverges, leading toward reading comprehension on one side and to the word reading system on the other side. As suggested in the Introduction, the multiple pathways of the Reading Systems Framework open the possibly that morphology supports reading comprehension through multiple distinct roles. However, the Reading Systems Framework does not specify the different roles that morphology might play in these pathways (Perfetti et al., 2005).

Quite clearly, the framework's depiction that morphology connects to reading comprehension through multiple pathways is reflected in Study 1, which demonstrated direct and indirect contributions of morphological awareness to reading comprehension in Grade 3. This dissertation also supports the interpretation that morphology may play different roles through these pathways. Based from the findings, I argue that morphological awareness represents the specific role of morphology that is depicted in the linguistic system of the framework. According to the Reading Systems Framework, the placement of morphological awareness in the linguistic system would indicate that it has a direct influence on reading comprehension and is the starting point for the indirect pathways (Perfetti & Stafura, 2014). The findings of Study 1 are consistent with this interpretation.

The findings of this dissertation also help to specify the indirect pathways that are associated with morphology in the Reading Systems Framework. Namely, I postulate the morphological decoding and morphological analysis—active processes that facilitate the reading and understanding of morphologically complex words—represent the indirect word reading and indirect lexicon pathways, respectively. In terms of the indirect word reading pathway, Perfetti suggests that morphology plays an unspecified role that facilitates the processing of the orthographic input from text within the word reading system, which, in turn, leads to reading comprehension (Perfetti, 1999; Perfetti et al., 2005). I suggest that morphological decoding is reflected in this indirect pathway. This interpretation is derived from the morphological decoding pathway observed in Study 1, which showed morphological awareness supported children's ability to decode words with a complex morphological structure. Morphological decoding then related to children's more general word reading skills, which, in turn, contributed to their reading comprehension.

In terms of the indirect lexicon pathway, the Readings Systems Framework depicts morphology as playing an unspecified role in the lexicon, which, then contributes separately to reading comprehension and the word reading system (Perfetti et al., 2005; Perfetti & Stafura, 2014). It is suggested here that the morphological analysis pathway of Study 1 reflects the indirect lexicon pathway depicted in the framework. As previously discussed in the Lexical Quality Hypothesis (Perfetti, 2007), the lexicon is where word knowledge (orthographic, phonological, and semantic) is accumulated and stored as lexical representations; the goal of activating orthographic, phonological, and semantic codes in the lexicon is ultimately to access the meaning of words. Likewise, the goal of morphological analysis is also to gain access to meaning, in this case by deriving it from morphemes in morphologically complex words. It is plausible, then, that morphological analysis plays an role that facilitates the activation of meaningful units in the lexicon. In addition, morphological analysis likely supports the understanding of new and unfamiliar complex words that would otherwise not be understood on account of their low quality lexical representations in the lexicon. In Study 1, the morphological analysis pathway was reflected by the contribution of morphological awareness to morphological analysis, which, in turn, supported children's reading comprehension. I propose that the morphological analysis pathway observed in Study 1 helps specify the role of morphology in the indirect lexicon pathway of the Reading Systems Framework.

The longitudinal design of Study 2 provides strong support for the direction of effects proposed in the Reading Systems Framework (Perfetti et al., 2005; Perfetti & Stafura, 2014). In comparison to a cross-sectional design, a longitudinal design provides a much more stringent test of directionality and serve to evaluate the temporal relations between skills such as morphological awareness and reading comprehension (Maxwell & Cole, 2007). The directionally depicted in the Framework insinuates that morphology in the linguistic and lexical systems are causal influences on reading comprehension. The findings of Study 2 help clarify this proposed directionality. Namely, Study 2 suggests that gains in reading comprehension are supported by the indirect lexicon pathway where morphological analysis operates, rather than directly supported by morphological awareness in the linguistic system. At the same time, gains in morphological analysis—and thus greater influence stemming from the lexicon—are likely attributable, in part, to morphological awareness in the linguistic system. Speculatively, it is possible that the indirect lexicon pathway where morphological analysis operates becomes more prominent over time to accommodate the increasing presence of unfamiliar morphologically complex words in students' texts (Anglin, 1993; Nagy & Anderson, 1984). On a broader level, the results of Study 2, in comparison to those of Study 1, indicate that the relation between morphological awareness and reading comprehension presents itself differently depending on whether the relation is examined concurrently or longitudinally. Indeed, the Reading Systems Framework provides a comprehensive overview of the systems and pathways that lead to reading comprehension, but it is less clear about the relative and changing contributions to gains in reading comprehension across development.

4.2.5. Summarizing the Contributions of my Research to Theory. At its most basic level, this research contributes to theory by demonstrating the importance of including morphological skills in future theories of word reading and reading comprehension. In more detail, this dissertation supports the view that skills in each of morphological awareness, morphological decoding, and morphological analysis play essential and distinguishable roles in reading comprehension. I summarize the key contributions of the research below.

4.2.5.1. Theories of word reading. Prominent theories of word reading, such as the Phase Theory of Reading Development and the Psycholinguistic Grain Size Theory, obscure potential differences between the effects of morphemes and non-morphemes on word reading (Ehri, 2005; Ziegler & Goswami, 2005). My research suggests that morphemes, as larger grain size meaningful chunks, may influence word reading skills differently than other grain size reading strategies. Critically, Study 1 supports the role of morphological awareness in word reading—this role appears to be especially targeted to facilitating children's ability to read words with a complex morphological structure (i.e., morphological decoding).

4.2.5.2. Lexical Quality Hypothesis. Across both studies, this work supports and further strengthens the claim that morphology plays a role in reading comprehension that is distinct and empirically separable from other language and literacy skills. The present work suggests that morphological awareness supports the development of high quality lexical representations, which are essential to reading comprehension (Perfetti, 2007). Critically, I argue that this role is not item-specific; morphological awareness, which involves sensitivity to morphemic patterns across words, is likely to have a wide-spread influence throughout the lexicon, thus supporting lexical quality across representations that are morphologically related. As active on-line processes, morphological decoding and morphological analysis may support the connections that bind orthography, phonology, and semantic constituents, thus enabling faster on-line activation in the network. More generally, the findings of this dissertation support the idea that morphological skills play a key role in the organization and functioning of the mental lexicon (Nagy, 2007; Sandra, 1994).

4.2.5.3. Simple View of Reading. In relation to the Simple View of Reading (Gough & Tunmer, 1986), the findings of this dissertation suggest that the influence of morphological awareness to reading comprehension is not adequately captured by the existing components of listening comprehension and word reading. Accordingly, a revision to the Simple View may be in order. I suggested the addition of an extra component, one that would consist of overarching skills—like morphological awareness—that influence the components of word reading, listening comprehension, and reading comprehension. The addition of a single component would allow the Simple View of Reading to retain is simple ‘skeletal’ framework while ultimately providing a more accurate and comprehensive theoretical anchor for studying the underlying complexities of reading comprehension.

4.2.5.4. Reading Systems Framework. In many ways, the results of Study 1 of this dissertation mirror the claims proposed in Perfetti's Reading Systems Framework (Perfetti et al., 2005). Namely, the framework depicts multiple pathways through which morphology contributed to reading comprehension. The current findings contribute to this theory by specifying the precise roles of morphology in these pathways and informs on how these contribute to reading comprehension concurrently and longitudinally. It is argued that the evidence supporting a role for morphological decoding and morphological analysis is especially relevant in explaining the indirect pathways of morphology depicted in the framework as these factors are largely understudied

4.3. New Insights from Theory and Research

Building on the theories discussed above, I review and interpret the findings of this dissertation in the following paragraphs through a more holistic viewpoint. By bridging theoretical and empirical perspectives, the goal here is to provide additional insight into the original research question: How does children's awareness of meaningful units in spoken language contribute to their comprehension of text during reading? This discussion will hopefully serve to clarify the relation between morphological awareness and reading comprehension and highlight avenues for future research on this topic.

4.3.1. Morphological Awareness: A Reflexive Filter of Meaning in Spoken and Written Language. Like many researchers, I view morphological awareness as a metalinguistic skill that has wide-spread influence on language and literacy development (e.g., Carlisle, 2010; Kuo & Anderson, 2006). A rudimentary awareness of morphemes emerges early as part of children's language acquisition; morphological awareness continues to develop throughout the childhood years and beyond (Carlisle, 2003). During the elementary school years in particular, there is a steep slope in the development of morphological awareness—especially for knowledge of derivations—that occurs between Grades 1 to 5 (Anglin, 1993; Tyler & Nagy, 1989). It is no coincidence that this rapid improvement in morphological awareness occurs during a critical time in children's reading development. Namely, across Grades 1 to 5, the morphological complexity of spoken and written language increases dramatically (Nagy & Anderson, 1984). Moreover, the entire focus of children's reading transitions from 'learning to read' to 'reading to learn' during this relatively short period (Adams, 1990; Chall, 1983). It would appear, then, that morphological awareness develops to meet the demands of increasing morphological complexity in children's spoken and written environment.

This developmental progression illustrates the point that morphological awareness is shaped by the morphophonemic nature of the language. English, like many languages, is morphophonemic; both phonemes and morphemes function as essential units across spoken and written language (Carlisle & Stone, 2005; Seymour, 1997). However, as children develop their reading skills and become more knowledgeable about orthography, they quickly learn that morphemes preserve and reveal the semantic connections between spoken and written language more consistently than phonemes (Chomsky, 1970; Chomsky & Halle, 1968). Thus, development of morphological awareness goes hand-in-hand with the understanding that morphemes are the prime medium in which meaning is conveyed in speech and print. I postulate that this revelation leads to a permanent and subconscious shift in how meaning is processed in the lexicon. In other words, over time, morphological awareness fundamentally shapes the way in which the mind becomes attuned to morphological patterns for the purpose of filtering the meaningful units in spoken and written language.

Beyond the tests that measure children's explicit awareness of morphology (like those used in this research), I would argue that there is an inherent component of morphological awareness that enables and supports ready-access processing of morphological structure in spoken and written language alike; this underlying morphological processing functions indefinitely in the background by processing phonological and orthographic input automatically and without conscious effort. For this reason, I suggest that morphological awareness is perhaps an even more deeply-rooted metalinguistic skill than previously conceptualized. In Study 1 of the dissertation, the enduring direct contribution of morphological awareness to reading comprehension beyond numerous language and literacy factors could be interpreted as evidence of the deeply-rooted nature of this metalinguistic skill (see also Kieffer et al., 2016). Other researchers have also suggested that morphological awareness is a unique metalinguistic ability that integrates fundamental semantic, phonological, and syntactic processes—once again, speaking to its importance as a metalinguistic skill and its robustness as a predictor of reading comprehension (Carlisle, 2010; Kuo & Anderson, 2006; Perfetti et al., 2005)

Priming studies have provided supporting evidence of an underlying morphological processing filter specifically attuned to morphological structure (e.g., Quémart & Casalis, 2015). In priming studies, morphologically related prime–target pairs (e.g., *weaken* → *weak*) facilitate task performance compared to unrelated pairs. These morphological priming effects are reportedly independent from orthographic, phonological, and semantic priming effects (e.g., Beyersmann, Iakimova, Ziegler, & Colé, 2014; Marslen-Wilson, Bozic, Randall, 2008; McCormick, Rastle, & Davis, 2008; Rastle, Davis, & New, 2004). The latter resonates with a gestalt interpretation of these findings, such that the influence of morphology is more than the combination of orthographic, phonological, and semantic effects. Especially relevant to this discussion are reports of equivalent morphological priming effects resulting from true morphologically complex pairs (e.g., *cheerful* → *cheer*) and pseudo-morphologically complex words (i.e., words that look complex but are not; e.g., *grateful* → *grate*; e.g., Casalis, Quémart, & Duncan, 2015). These effects are seen at the earliest moments of lexical access, during a period in which orthographic, phonological, and semantic effects are absent (Beyersmann, Ziegler, Castles, Coltheart, Kezilas, & Grainger, 2015; Rastle, Davis, Marslen-Wilson, & Tyler, 2000; Taft & Forster, 1975). Researcher have described this as 'blind morphological decomposition', where words are reflexively segmented at the earliest stage according to their morphological structure based on the mere appearance of morphological complexity (Beyersmann et al., 2014). The evidence of blind morphological decomposition supports the idea that the lexicon becomes hyper-sensitive to morphological patterns to the point that we automatically and instantaneously process spoken and written language based on morphological structure.

In children, Kearns (2015) examined which grain size units are preferred by Grade 3 and 4 when reading polysyllabic–polymorphemic words. Using a comprehensive modeling approach, Kearns demonstrated that children relied more strongly on morphological boundaries to read unknown polysyllabic–polymorphemic words than syllabic boundaries. It is noteworthy that children with very weak morphological awareness had difficulty identifying the morphological boundaries within even the most transparent polysyllabic–polymorphemic words. This difficulty was observed beyond phonological awareness and vocabulary, and was not a result of an overall reading problem (Kearns, 2015). The latter echoes work by Quémart and Casalis (2015) showing the separability of morphological processing and dyslexia in children. Thus, children's difficulty in recognizing and processing morphological structure appears to derive specifically from their poor morphological awareness. These findings support the suggestion that, throughout the elementary grades, morphological awareness shapes our subconscious sensitivity to the meaningful units in spoken and written language. In doing so, developing morphological awareness instills an underlying reflexive habit to process language for meaning by way of its morphological structure.

4.3.2. Morphological Decoding and Morphological Analysis: The On-Line Agents of Morphology. Conceptualizing morphological awareness as being a more distal overarching influence on language and literacy skills opened the door to the possibility of multiple dimensions of morphological skill. From this perspective, I considered that there may be morphological dimensions that have a more proximal influence on reading comprehension. A considerable barrier to children's reading comprehension comes from the increasing presence of morphologically complex words in their texts. Building on previous work (e.g., Deacon et al., 2015), I postulated that one morphological dimensions might focus on supporting the reading of morphologically complex words by decomposing their complex structure. Another separate dimension was considered as supporting the understanding of morphologically complex words by deriving meaning from the sublexical morphemes within complex words. From here, morphological decoding and morphological analysis were considered as occupying the proximal, specific contributions of morphological awareness to reading comprehension.

As dimensions of morphological awareness, I view morphological decoding and morphological analysis as grounded within one's general awareness of the morphophonemic nature of spoken and written language. In this sense, morphological decoding and morphological analysis are manifestations of morphological awareness; these skills are the active agents of morphology that assist the reading and understanding of morphologically complex words on-the-spot, which, in turn, supports reading comprehension. The extent to which morphological decoding and morphological analysis can facilitate the reading and understanding of complex words in service of reading comprehension is limited by a child's awareness of morphemes and general sensitivity to the morphological structure of language.

The results of my dissertation research support this viewpoint. Findings from both studies suggest that morphological awareness provided the foundational knowledge that contributed to children's morphological decoding and morphological analysis skills. Critically, each of these proximal skills were associated with unique indirect pathways to reading comprehension in Study 1. While morphological awareness may indeed have wide-spread influence, it appears that its strongest influence is targeted toward supporting the processing of words with a complex morphological structure. The results of Study 1 are particularly important for specifying the precise morphological skills, or dimensions, that play a role in explaining the contribution of morphological awareness to reading comprehension. Study 2 provides strong support for the predicted direction of the relation between morphological awareness and morphological analysis and, ultimately, reading comprehension. The findings of the longitudinal study suggest that developments in morphological analysis are attributable in large part to morphological awareness. I predict the same is true for the development of morphological decoding; this prediction remains to be tested.

The developmental progression observed in Study 2 inspires me to contemplate the point in development at which these morphological dimensions emerge and how their influence on reading comprehension play out over time. Like development in morphological awareness, it is likely that morphological decoding and morphological analysis emerge and develop to tackle the increasing morphological demands in children's language environments. As such, the roles of morphological decoding and morphological analysis might become amplified across the elementary grades as children encounter an increasing number of unknown and unfamiliar complex words during reading (Nagy & Anderson, 1984). In Study 2, it was demonstrated that only morphological analysis contributed to gains in reading comprehension over time. This finding suggests the possibility that the role of morphological analysis becomes more important in later elementary grades to the point of eclipsing the influence of morphological awareness. I speculate that the finding of this disseration support the idea that the contribution of morphological analysis to reading comprehension increases over time as a function of the growing morphological complexity in children's spoken and written language. Likewise, the same may be true of the contribution of morphological decoding to reading comprehension over time. These speculations provide avenues deserving of future research.

4.4. Educational Implications

This research revealed distinct morphological dimensions contributing to reading comprehension, which has clear educational implications for teaching and supporting children's understanding of text. Extant research suggests that teaching children about morphology can be an effective way of improving their word reading and reading comprehension (e.g., Bar-Kochva, 2016; Goodwin & Ahn, 2010; Nagy et al., 2014; Nunes & Bryant, 2006; 2011). However, beyond asserting the general benefits of such instruction, the specific types of morphological instructions that are most effective remain to be determined (Bowers, Kirby, & Deacon, 2010; Carlisle, 2010). The results of this dissertation suggest that have a broad awareness of morphological structure likely has cascading benefits to lexical quality and language and reading-related skills; thus, this work supports reading instruction that explicitly emphasizes the productivity of morphemes and the role of morphological structure in language. The results also provide an empirical perspective of the specific morphological skills that might be most impactful on reading instruction—namely, morphological decoding and morphological analysis. This research suggests that these on-line mechanistic skills are valuable to students' understanding of text in the elementary grades. Additionally, I argue that these are instructionally malleable skills. Therefore, explicit and purposeful instruction of skills that focus on decoding and understanding unfamiliar morphologically complex words might be especially impactful features to include in classroom reading pedagogy.

Beyond general classroom curriculum, explicit instruction across different morphological dimensions should be included within intensive intervention programs that focus on reading remediation. Though unfortunate, it is a reality that too many children experience significant difficulties in learning to read and many endure long-lasting difficulties in reading comprehension into adulthood (Deacon, Cook, & Parrila, 2012). Specific weaknesses in morphological skills have been linked to students who exhibit poor reading comprehension unexplained by their word reading and nonverbal abilities (MacKay, Levesque, & Deacon, 2017; Tong et al., 2011). Relatedly, Foorman and colleagues (2012) observed that substantial differences in reading comprehension across same-grade classrooms were strongly predicted by differences in morphological skills. Speculatively, then, early delays in morphological skills may be at the root of students' reading comprehension difficulties or otherwise exacerbate their struggle to understand text during reading. Reviews of the literature show that the effects of morphological interventions are most beneficial for students who struggle with reading and language difficulties (e.g., Goodwin & Ahn, 2010, 2013; Goodwin, Gilbert, & Cho, 2013; Nagy, Carlisle, & Goodwin, 2014). Taken together, these studies suggest that explicit morphological instruction may help remediate phonological processing difficulties (c.f., Arnbak & Elbro, 2000; Law, Woulters, & Ghesquière, 2015). However, the results of morphological interventions are not always consistent with regard to the impact on reading comprehension (see Baumann, Edwards, Boland, Olejnik, & Kame'enui, 2003; Goodwin & Ahn, 2013). Further research is needed to identify the features of morphological instruction and intervention that are most impactful on reading comprehension, especially for students who struggle with language and literacy. Extending on prior research, this dissertation identifies morphological decoding and morphological analysis as two dimensions that should be included within remedial literacy programs and targeted through explicit and intensive instruction.

In summary, this dissertation provides a greater understanding of the role of specific morphologic skills in children's reading comprehension. Because the development of proficient reading comprehension skills will always be the goal of literacy instruction, the findings of this research have the potential to inform educational programs and reading instructional practices in the classroom (Nunes & Bryant, 2006). Currently, however, morphological instruction is not a major component of reading pedagogy (Abbott & Berninger, 1999; Hurry et al., 2005). For teachers and educators who incessantly strive to support their students' reading comprehension, my findings suggest that nurturing their existing awareness of morphemes and explicitly teaching strategies that foster morphological decoding and morphological analysis may enhance children's achievement in reading comprehension and support its development over time.

4.5. Concluding Remarks

Given the morphophonemic nature of the English language, researchers have long-speculated that morphological awareness might play an important role in reading comprehension (e.g., Carlisle, 2003, 2010; Deacon & Kirby, 2004; Kuo & Anderson, 2006). My research strongly supports this assertion and contributes to the mounting evidence demonstrating an enduring contribution of morphological awareness to reading comprehension in children (e.g., Deacon et al., 2014; Kirby et al., 2012). However, this mounting evidence stands in sharp contrast to the common exclusion of morphology in theories of word reading and reading comprehension (Carlisle & Kearns, 2017; Frost et al., 2005). Building on prior studies, the results of this dissertation further highlight the pressing need to consider the role of morphological awareness in future theories of reading development.

In line with the overall goal of this dissertation, my research contributes to clarifying the relation between morphological awareness and reading comprehension. Namely, the findings elucidate the morphological skills that help explain more precisely how morphological awareness influences reading comprehension in children. This work suggests that with adequate insight into the morphological structure in language, children can actively make use of the meaningful building blocks within words to facilitate the reading and understanding of morphologically complex words. Through these skills of morphological decoding and morphological analysis, children can better tackle the unfamiliar complex words they encounter in text, which ultimately benefits their reading comprehension. Clarifying the specific skills involved in the relation between morphological awareness and reading comprehension informs on the possible mechanisms underlying their relation. More research is needed on this front. Overall, this dissertation suggests that morphological awareness, along with its proximal dimensions of morphological decoding and morphological analysis, supports children's reading comprehension and its development over time.

References

Abbott, S. P., & Berninger, V. W. (1999). It's never too late to remediate: Teaching word recognition to students with reading disabilities in grades 4-7. *Annals of Dyslexia, 49*, 223–250. http://dx.doi.org/10.1007/s11881-999-0025-x

Adams, M. J. (1990). *Beginning to read: Thinking and learning about print*. Cambridge, MA: MIT Press.

Adlof, S. M., Catts, H. W., & Little, T. D. (2006). Should the simple view of reading include a fluency component? *Reading and Writing*, *19*(9), 933–958. http://dx.doi.org/10.1007/s11145-006-9024-z

Adlof, S. M., Perfetti, C. A., & Catts, H. W. (2011). Developmental changes in reading comprehension: Implications for assessment and instruction. In S. J. Samuels & A. E. Farstrup (Eds.), *What research has to say about reading instruction* (pp. 186–214). Newark, DE: International Reading Association.

Agresti, A., & Finlay, B. (2009). Model building with multiple regression. In *Statistical methods for the social sciences 4th ed.* (pp. 441–474). Upper Saddle River, N.J: Pearson Prentice Hall.

Anglin, J. M. (1993). Vocabulary development: A morphological analysis. *Monographs of the Society for Research in Child Development, 58*(10, Serial no. 238), 1–186. http://dx.doi.org/10.2307/1166112

Arnbak, E., & Elbro, C. (2000). The effects of morphological awareness training on the reading and spelling skills of young dyslexics. *Scandinavian Journal of Educational Research*, *44*(3), 229–251. http://dx.doi.org/10.1080/00313830050154485

Bar-Kochva, I. (2016). An examination of an intervention program designed to enhance reading and spelling through the training of morphological decomposition in word recognition. *Scientific Studies of Reading*, *20*(2), 163–172. http://dx.doi.org/10.1080/10888438.2015.1108321

Baumann, J. F., Edwards, E. C., Boland, E. M., Olejnik, S., & Kame'enui, E. J. (2003). Vocabulary tricks: effects of instruction in morphology and context on fifth-grade students' ability to derive and infer word meanings. *American Educational Research Journal*, *40*, 447–494. http://dx.doi.org/10.3102/00028312040002447

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

Beyersmann, E., Iakimova, G., Ziegler, J. C., & Cole, P. (2014). Semantic processing during morphological priming: An ERP study. *Brain Research*, *1579*, 45–55. http://dx.doi.org/10.1016/j.brainres.2014.07.010

Beyersmann, E., Ziegler, J. C., Castles, A., Coltheart, M., Kezilas, Y., & Grainger, J. (2015). Morpho-orthographic segmentation without semantics. *Psychonomic Bulletin & Review, 23*(2), 533–539. http://dx.doi.org/10.3758/s13423-015-0927-z

Blevins, W. (2001). *Teaching phonics & word study in the intermediate grades: A complete sourcebook*. New York, NY: Scholastic Inc.

Bollen, K. A. (1989). *Structural equations with latent variables*. New York: John Wiley.

Bollen, K. A., & Curran, P. J. (2004). Autoregressive latent trajectory (ALT) models: A synthesis of two traditions. Sociological Methods & Research, 32, 336-383. http://dx.doi.org/10.1177/0049124103260222

Bowers, P. N., & Kirby, J. R. (2010). Effects of morphological instruction on vocabulary acquisition. *Reading and Writing*, *23*(5), 515–537. http://dx.doi.org/10.1007/s11145-009-9172-z

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. http://dx.doi.org/10.3102/0034654309359353

Braze, D., Tabor, W., Shankweiler, D.,& Mencl, W. E. (2007). Speaking up for vocabulary: Reading skill differences in young adults. *Journal of Learning Disabilities, 40*, 226–243. http://dx.doi.org/10.1177/00222194070400030401

Browne, M. W., & Cudeck, R. (1992). Alternative ways of assessing model fit. *Sociological Methods & Research, 21*, 230–258. http://dx.doi.org/10.1177/0049124192021002005

Bryant, F. B., & Satorra, A. (2012). Principles and practice of scaled difference chi-square testing. *Structural Equation Modeling, 19*, 372–398. http://dx.doi.org/10.1080/10705511.2012.687671

Bus, A. G., & Van IJzendoorn, M. H. (1999). Phonological awareness and early reading: A meta-analysis of experimental training studies. *Journal of Educational Psychology*, *91*, 403–414. http://dx.doi.org/10.1037//0022-0663.91.3.403

Carlisle, J. F. (1995). Morphological awareness and early reading achievement. In L. B. Feldman (Ed.), *Morphological aspects of language processing* (pp. 189–209). Hillsdale, NJ: Erlbaum.

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

Carlisle, J. F. (2003). Morphology matters in learning to read: A commentary. *Reading Psychology*, *24*(3), 291–322. http://dx.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). New York, NY: The Guilford Press.

Carlisle, J. F. (2010). Effects of instruction in morphological awareness on literacy achievement: An integrative review. *Reading Research Quarterly, 45*(4), 464–487. http://dx.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*(3), 239–253. http://dx.doi.org/10.1207/S1532799XSSR0703_3

Carlisle, J. F., & Katz, L. A. (2006). Effects of word and morpheme familiarity on reading of derived words. *Reading and Writing*, *19*(7), 669–693. http://dx.doi.org/10.1007/s11145-005-5766-2

Carlisle, J. F., & Kearn, D. M. (2017). Learning to read morphologically complex words. In K. Cain, D. L. Compton, & R. K. Parrila (Eds.), *Theories of reading comprehension* (pp. 192–214). Amsterdam, The Netherlands: John Benjamins Publishing Company.

Carlisle, J. F., & Stone, C. A. (2005). Exploring the role of morphemes in word reading. *Reading Research Quarterly*, *40*(4), 428–449. http://dx.doi.org/10.1598/RRQ.40.4.3

Carroll, J. B., Davies, P., & Richman, B. (1971). *Word frequency book*. Boston, MA: Houghton Mifflin.

Casalis, S., & Louis-Alexandre, M. F. (2000). Morphological analysis, phonological analysis and learning to read French: a longitudinal study. *Reading and Writing*, *12*, 303–335. http://dx.doi.org/10.1023/A:1008177205648

Casalis, S., Quémart, P., & Duncan, L. G. (2015). How language affects children's use of derivational morphology in visual word and pseudoword processing: Evidence from a cross-language study. *Frontiers in Psychology*, *6*, 1–10. http://dx.doi.org/10.3389/fpsyg.2015.00452

Catts, H. W., Herrera, S., Nielsen, D. C., & Bridges, M. S. (2015). Early prediction of reading comprehension within the simple view framework. *Reading and Writing*, *28*(9), 1407–1425. http://dx.doi.org/10.1007/s11145-015-9576-x

Chall, J. S. (1983). *Stages of reading development*. New York, NY: McGraw-Hill.

Chomsky, C. (1970). Reading, writing, and phonology. *Harvard Educational Review, 40*(2), 287–309. https://dx.doi.org/10.17763/haer.40.2.y7u0242x76w05624

Chomsky, N., & Halle, M. (1968). *The sound pattern of English*. New York: Harper & Row.

Cohen, J. (1992). A power primer. *Psychological Bulletin, 112,* 155–159. http://dx.doi.org/10.1037/0033-2909.112.1.155

Cole, D. A., & Maxwell, S. E. (2003). Testing mediational models with longitudinal data: questions and tips in the use of structural equation modeling. *Journal of Abnormal Psychology*, *112*(4), 558–577. http://dx.doi.org/10.1037/0021-843X.112.4.558

Colé, P., Segui, J., & Taft, M. (1997). Words and morphemes as units for lexical access. *Journal of Memory and Language*, *37*(3), 312–330. http://dx.doi.org/10.1006/jmla.1997.2523

Cunningham, A. J., & Carroll, J. M. (2015). Early predictors of phonological and morphological awareness and the link with reading: Evidence from children with different patterns of early deficit. *Applied Psycholinguistics*, *36*(3), 509–531. http://dx.doi.org/10.1017/S0142716413000295

Deacon, S. H., Conrad, N., & Pacton, S. (2008). A statistical learning perspective on children's learning about graphotactic and morphological regularities in spelling. *Canadian Psychology*, *49*(2), 118–124. http://dx.doi.org/10.1037/0708-5591.49.2.118

Deacon, S. H., Cook, K., & Parrila, R. (2012). Identifying high-functioning dyslexics: Is self-report of early reading problems enough? *Annals of Dyslexia*, *62*(2), 120–134. http://dx.doi.org/10.1007/s11881-012-0068-2

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*, 223–238. http://dx.doi.org/10.1017/S0142716404001110

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*, 432–451. http://dx.doi.org/10.1080/10888438.2014.926907

Deacon, S. H., Parrila, R., & Kirby, J. R. (2008). A review of the evidence on morphological processing in dyslexics and poor readers: A strength or weakness? In F. Manis, A. Fawcett, G. Reid, & L. Siegel (Eds.), *Sage handbook of dyslexia* (pp. 212–237). USA: Sage Publications.

Deacon, S. H., Tong, X., & Francis, K. (2015). The relationship of morphological analysis and morphological decoding to reading comprehension. *Journal of Research in Reading*, 40, 1–16. http://dx.doi.org/10.1111/1467-9817.12056

Deacon, S. H., Whalen, R., & Kirby, J. R. (2011). Do children see the danger in dangerous? Grade 4, 6, and 8 children's reading of morphologically complex words. *Applied Psycholinguistics*, *32*(03), 467–481. http://dx.doi.org/10.1017/S0142716411000166

DeWalt, D. A., Berkman, N. D., Sheridan, S., Lohr, K. N., & Pignone, M. P. (2004). Literacy and health outcomes: A systematic review of the literature. *Journal of General Internal Medicine*, *19*(12), 1228–1239. http://dx.doi.org/10.1111/j.1525-1497.2004.40153.x

Dunn, L. M., & Dunn, D. M. (2007). *Peabody Picture Vocabulary Test* (4th ed.). Toronto, ON: Pearson Education.

Ehri, L. C. (1995). Phases of development in learning to read words by sight. *Journal of Research in Reading*, *18*(2), 116–125. http://dx.doi.org/10.1111/j.1467-9817.1995.tb00077.x

Ehri, L. C. (2005). Learning to read words: Theory, findings, and issues. *Scientific Studies of Reading*, 9, 167–188. http://dx.doi.org/10.1207/s1532799xssr0902_4

Ehri, L. C. (2014). Orthographic mapping in the acquisition of sight word reading, spelling memory, and vocabulary learning. *Scientific Studies of Reading*, *18*(1), 5–21. http://dx.doi.org/10.1080/10888438.2013.819356

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

Field, A. (2009). *Discovering statistics using SPSS*. (3rd ed.). London, UK: SAGE Publications.

Finney, S. J., & DiStefano, C. (2013). Nonnormal and categorical data in structural equation modeling. In G.R. Hancock & R.O. Mueller (Eds.). *A second course in structural equation modeling* (2nd ed., pp. 439–492). Charlotte, NC: Information Age.

Florit, E., & Cain, K. (2011). The Simple View of Reading: Is it valid for different types of alphabetic orthographies? *Educational Psychology Review, 23*, 553–576. http://dx.doi.org/10.1007/s10648-011-9175-6

Foorman, B. R., Koon, S., Petscher, Y., Mitchell, A., & Truckenmiller, A. (2015). Examining general and specific factors in the dimensionality of oral language and reading in 4th–10th grades. *Journal of Educational Psychology*, *107*(3), 884–899. http://dx.doi.org/10.1037/edu0000026

Foorman, B., Herrara, S., Petscher, Y., Mitchell, A., & Truckenmiller, A. (2015). The structure of oral language and reading and their relationship to comprehension in kindergarten through grade 2. *Reading and Writing: An Interdisciplinary Journal*, *28*, 655–681. http://dx.doi.org/10.1155/2012/490647

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,* 792–798. http://dx.doi.org/10.1016/j.lindif.2012.07.009

Frost, R. (2012). Towards a universal model of reading. *Behavioral and Brain Sciences*, *35*(5), 263–329. http://dx.doi.org/10.1017/S0140525X11001841

Frost, R., Grainger, J., & Rastle, K. (2005). Current issues in morphological processing: An introduction. *Language and Cognitive Processes*, *20*, 1–5. http://dx.doi.org/10.1080/01690960444000287

Garcia, J. R., & Cain, K. (2014). Decoding and reading comprehension: A meta-analysis to identify which reader and assessment characteristics influence the strength of the relationship in English. *Review of Educational Research, 84*, 77–111. http://dx.doi.org/10.3102/0034654313499616

Gilbert, J. K., Goodwin, A. P., Compton, D. L., & Kearns, D. M. (2013). Multisyllabic word reading as a moderator of morphological awareness and reading comprehension. *Journal of Learning Disabilities*, *47*(1), 34–43. http://dx.doi.org/10.1177/0022219413509966

Gonnerman, L. M., Seidenberg, M. S., & Andersen, E. S. (2007). Graded semantic and phonological similarity effects in priming: Evidence for a distributed connectionist approach to morphology. *Journal of Experimental Psychology. General*, *136*(2), 323–45. http://dx.doi.org/10.1037/0096-3445.136.2.323

Goodwin, A. P., & Ahn, S. (2010). A meta-analysis of morphological interventions: Effects on literacy achievement of children with literacy difficulties. *Annals of Dyslexia*, *60*(2), 183–208. http://dx.doi.org/10.1007/s11881-010-0041-x

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*, 257–285. http://dx.doi.org/10.1080/10888438.2012.689791

Goodwin, A. P., Gilbert, J. K., & Cho, S. J. (2013). Morphological contributions to adolescent word reading: An item response approach. *Reading Research Quarterly*, *48*, 39–60. http://dx.doi.org/10.1002/rrq.037

Goodwin, A. P., Huggins, A. C., Carlo, M. S., August, D., & Calderon, M. (2013). Minding morphology: How morphological awareness relates to reading for English language learners. *Reading and Writing*, *26*(9), 1387–1415. http://dx.doi.org/10.1007/s11145-012-9412-5

Gough, P. B., & Tunmer, W. E. (1986). Decoding, reading, and reading disability. *Remedial and special education*, *7*, 6–10. http://dx.doi.org/10.1177/074193258600700104

Harm, M. W., & Seidenberg, M. S. (2004). Computing the meanings of words in reading: Cooperative division of labor between visual and phonological processes. *Psychological Review*, *111*(3), 662–720. http://dx.doi.org/10.1037/0033-295X.111.3.662

Hoover, W. A., & Gough, P. B. (1990). The simple view of reading. *Reading and Writing: An Interdisciplinary Journal*, *2*, 127–160. http://dx.doi.org/10.1007/BF00401799

Hu, L.-T., & Bentler, P.M. (1999). Cutoff criteria for fit indices in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling, 6*(1), 1–55. http://dx.doi.org/10 .1080/10705519909540118

Hurry, J., Nunes, T., Bryant, P., Pretzlik, U., Parker, M., Curno, T., et al. (2005). Transforming research on morphology into teacher practice. *Research Papers in Education, 20*(2), 187–206. http://dx.doi.org/10.1080/02671520500078291

Jarmulowicz, L., Hay, S. E., Taran, V. L., & Ethington, C. A. (2008). Fitting derivational morphophonology into a developmental model of reading. *Reading and Writing*, *21*(3), 275–297. http://dx.doi.org/10.1007/s11145-007-9073-y

Jarvis, B. G. (2008). *DirectRT* (Version 2008.1.0.11) [Computer Software]. New York, NY: Empirisoft Corporation.

Jeon, E. (2011). Contribution of morphological awareness to second-language reading comprehension. *Modern Language Journal, 95*, 217–235. http://dx.doi.org/10.1111/j.1540-4781.2011.01179.x

Kearns, D. M. (2015). How elementary-age children read polysyllabic polymorphemic words. *Journal of Educational Psychology, 107*(2), 364–390. http://dx.doi.org/10.1037/a0037518

Kendeou, P., van den Broek, P., White, M. J., & Lynch, J. S. (2009). Predicting reading comprehension in early elementary school: The independent contributions of oral language and decoding skills. *Journal of Educational Psychology*, *101*(4), 765–778. http://dx.doi.org/10.1037/a0015956

Kieffer, M. J. & Box, C. D. (2013). Derivational morphological awareness, academic vocabulary, and reading comprehension in linguistically diverse sixth graders. *Learning and Individual Differences, 24*, 168–175. http://dx.doi.org/10.1016/j.lindif.2012.12.017

Kieffer, M. J., & Lesaux, N. K. (2008). The role of derivational morphology in the reading comprehension of Spanish-speaking English language learners. *Reading and Writing*, *21*(8), 783–804. http://dx.doi.org/10.1007/s11145-007-9092-8

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. http://dx.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. http://dx.doi.org/10.1080/10888438.2016.1214591

Kim, Y. S. G. (2015). Developmental, component-based model of reading fluency: An investigation of predictors of word-reading fluency, text-reading fluency, and reading comprehension. *Reading Research Quarterly*, *50*(4), 459–481. http://dx.doi.org/10.1002/rrq.107

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 and Writing*, *25*(2), 389–410. http://dx.doi.org/10.1007/s11145-010-9276-5

Kirby, J. R., & Savage, R. S. (2008). Can the simple view deal with the complexities of reading? *Literacy*, *42*(2), 75–82. http://dx.doi.org/10.1111/j.1741-4369.2008.00487.x

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

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

Ku, Y., & Anderson, R. C. (2003). Development of morphological awareness in Chinese and English. *Reading and Writing: An Interdisciplinary Journal*, *16*, 399–422. http://dx.doi.org/10.1023/A:1024227231216

Kuo, L., & Anderson, R. C. (2006). Morphological awareness and learning to read: A cross-language perspective. *Educational Psychologist*, *41*(3), 161–180. http://dx.doi.org/10.1207/s15326985ep4103

Language and Reading Research Consortium (2015). Learning to read: Should we keep things simple? *Reading Research Quarterly, 50*, 151–169. http://dx.doi.org/10.1002/rrq.99

Law, J. M., Wouters, J., & Ghesquière, P. (2015). Morphological awareness and its role in compensation in adults with dyslexia. *Dyslexia*, *21*, 254–272. http://dx.doi.org/10.1002/dys.1495

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. http://dx.doi.org/10.1016/j.jecp.2017.02.015

Little, T. D., Card, N. A., Preacher, K. J., & McConnell, E. (2009). Modeling longitudinal data from research on adolescence. In R. M. Lerner & L. Steinberg (Eds.), *Handbook of adolescent psychology* (3rd ed. pp. 15–54). New York: Wiley.

MacGinitie, W., MacGinitie, R., Maria, K., & Dreyer, L. G. (2000). *Gates-MacGinitie Reading Test* (4th ed.). Itasca, IL: Riverside Publishing Company.

MacKay, E. J., Levesque, K. C., & Deacon, S. H. (2017). Unexpected poor comprehenders: An investigation of multiple aspects of morphological awareness. *Journal of Research in Reading*, *40*, 125–138. http://dx.doi.org/10.1111/1467-9817.12108

Mann, V., & Singson, M. (2003). Linking morphological knowledge to English decoding ability: Large effects of little suffixes. In E. M. H. Assink & D. Sandra (Eds.), *Reading complex words: Cross-language studies* (pp. 1–25). New York: Kluwer Academic.

Marslen-Wilson, W. D., Bozic, M., & Randall, B. (2008). Early decomposition in visual word recognition: Dissociating morphology, form, and meaning. *Language and Cognitive Processes*, *23*(3), 394–421. http://dx.doi.org/10.1080/01690960701588004

Maxwell, S. E., & Cole, D. A. (2007). Bias in cross-sectional analyses of longitudinal mediation. *Psychological Methods*, *12*(1), 23–44. http://dx.doi.org/10.1037/1082-989x.12.1.23

McCormick, S. F., Rastle, K., & Davis, M. H. (2007). Is there a fete in fetish? Effects of orthographic opacity on morpho-orthographic segmentation in visual word recognition. *Journal of Memory and Language*, *58*, 307–326. http://dx.doi.org/10.1016/j.jml.20

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. http://dx.doi.org/10.1002/RRQ.003

McCutchen, D., Green, L., & Abbott, R. D. (2008). Children's morphological knowledge: Links to literacy. *Reading Psychology*, *29*(4), 289–314. http://dx.doi.org/10.1080/02702710801982050

McCutchen, D., Logan, B., & Biangardi-Orpe, U. (2009). Making meaning: Children's sensitivity to morphological information during word reading. *Reading Research Quarterly*, *44*(4), 360–376. http://dx.doi.org/10.1598/RRQ.44.4.4

Mol, S. E., & Bus, A. G. (2011). To read or not to read: A meta-analysis of print exposure from infancy to early adulthood. *Psychological Bulletin*, *137*(2), 267–296. http://dx.doi.org/10.1037/a0021890

Müller, K., & Brady, S. (2001). Correlates of early reading performance in a transparent orthography. *Reading and Writing: An Interdisciplinary Journal, 14*, 757–799. http://dx.doi.org/10.1023/A:1012217704834

Murnane, R., & Levy, F. (1996). *Teaching the new basic skills: Principles for educating children to thrive in a changing economy*. New York, NY: Martin Kessler.

Muthén, L.K. and Muthén, B.O. (1998-2017). *Mplus User's Guide*. Seventh Edition. Los Angeles, CA: Muthén & Muthén.

Nagy, W. E. (2007). Metalinguistic awareness and the vocabulary–comprehension connection. In R. K. Wagner, A. E. Muse, & K. R. Tannenbaum (Eds.), *Vocabulary acquisition: Implications for reading comprehension* (pp. 52–77). New York, NY: Guilford Press.

Nagy, W. E., & Anderson, R. C. (1984). How many words are there in printed school English? *Reading Research Quarterly*, *19*(3), 304–330. http://dx.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. http://dx.doi.org/10.1037/0022-0663.98.1.134

Nagy, W. E., Berninger, V. W., Abbott, R. D., 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. http://dx.doi.org/10.1037/0022-0663.95.4.730

Nagy, W. E., Carlisle, J. F., & Goodwin, A. P. (2014). Morphological Knowledge and Literacy Acquisition. *Journal of Learning Disabilities*, *47*(1), 3–12. http://dx.doi.org/10.1177/0022219413509967

Nation, K. (2009). Form-meaning links in the development of visual word recognition. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences*, *364*, 3665–3674. http://dx.doi.org/10.1098/rstb.2009.0119

Nation, K., & Angell, P. (2006). Learning to read and learning to comprehend. *London Review of Education*, *4*(1), 77–87. http://dx.doi.org/10.1080/13603110600574538

Nation, K., & Snowling, M. J. (2004). Beyond phonological skills: Broader language skills contribute to the development of reading. *Journal of Research in Reading*, *27*(4), 342–356. http://dx.doi.org/10.1111/j.1467-9817.2004.00238.x

Nunes, T., & Bryant, P. (2006). *Improving literacy by teaching morphemes*. New York, NY: Routledge.

Nunes, T., & Bryant, P. (2011). Morphemic approaches for reading words. In P. Vadasy & R. O'Connor (Eds.), *Handbook of reading interventions* (pp. 88–112). New York, NY: Guilford Press.

Nunes, T., Bryant, P., & Barros, R. (2012). The development of word recognition and its significance for comprehension and fluency. *Journal of Educational Psychology*, *104*(4), 959–973. http://dx.doi.org/10.1037/a0027412

Nunes, T., Bryant, P., & Olsson, J. (2003). Learning morphological and phonological spelling rules: An intervention study. *Scientific Studies of Reading, 7*, 289–307. http://dx.doi.org/10.1207/S1532799XSSR0703_6

Oakhill, J. V, & Cain, K. (2012). The precursors of reading ability in young readers: Evidence from a four-year longitudinal study. *Scientific Studies of Reading*, *16*, 91–121. http://dx.doi.org/10.1080/10888438.2010.529219

OED Online (2015). *Oxford English Dictionary Online*. Oxford University Press. Retrieved from http://www.oed.com/

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 and Adult Literacy, 56*(7), 541–553. http://dx.doi.org/10.1002/JAAL.181

Perfetti, C. A. (1999). Comprehending written language: A blueprint of the reader. In C. Brown & P. Hagoort (Eds.), *The neurocognition of language* (pp. 167–208). Oxford University Press.

Perfetti, C. A. (2007). Reading ability: Lexical quality to comprehension. *Scientific Studies of Reading, 11*(4), 357–383. http://dx.doi.org/10.1080/10888430701530730

Perfetti, C. A, & Hart, L. (2001). The lexical bases of comprehension skill. In D. Gorfien (Ed.), *On the consequences of meaning selection* (pp. 67–86). Washington, DC: American Psychological Association.

Perfetti, C. A., & Hart, L. (2002). The lexical quality hypothesis. In L. Verhoeven, C. Elbro, & P. Reitsma (Eds.), *Precursors of functional literacy* (pp. 189–213). Philadelphia, PA: John Benjamins Publishing Company. http://dx.doi.org/10.1075/swll.11.14per

Perfetti, C. A., & Stafura, J. (2014). Word knowledge in a theory of reading comprehension. *Scientific Studies of Reading*, *18*(1), 22–37. http://dx.doi.org/10.1080/10888438.2013.827687

Perfetti, C. A., Landi, N., & Oakhill, J. (2005). The acquisition of reading comprehension skill. In M. J. Snowling & C. Hulme (Eds.), *The science of reading: A handbook* (pp. 227–247). Malden, MA: Blackwell. http://dx.doi.org/10.1002/9780470757642.ch13

Plaut, D. C. (2004). Connectionist approaches to reading. In M. Snowling, C. Hulme, & M. Seidenberg (Eds.), *The science of reading: A Handbook* (pp. 24–38). Oxford, UK: Blackwell Publishing Ltd. http://dx.doi.org/10.1002/9780470757642.ch2

Plaut, D. C., McClelland, J. L., Seidenberg, M. S., & Patterson, K. (1996). Understanding normal and impaired word reading: computational principles in quasi-regular domains. *Psychological Review*, *103*(1), 56–115. http://dx.doi.org/10.1037/0033-295X.103.1.56

Preacher, K. J., & Hayes, A. F., (2008). Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models. *Behavior Research Methods, 40*, 879–891. http://dx.doi.org/10.3758/BRM.40.3.879

Protopapas, A., Simos, P. G., Sideridis, G. D., & Mouzaki, A. (2012). The components of the simple view of reading: A confirmatory factor analysis. *Reading Psychology*, *33*, 217–240. http://dx.doi.org/10.1080/02702711.2010.507626

Quémart, P., & Casalis, S. (2015). Visual processing of derivational morphology in children with developmental dyslexia: Insights from masked priming. *Applied Psycholinguistics*, 36, 345–376. http://dx.doi.org/10.1017/S014271641300026X

Quémart, P., Casalis, S., & Colé, P. (2011). The role of form and meaning in the processing of written morphology: A priming study in French developing readers. *Journal of Experimental Child Psychology*, *109*(4), 478–496. http://dx.doi.org/10.1016/j.jecp.2011.02.008

Rastle, K., Davis, M. H., Marslen-Wilson, W. D., & Tyler, L. K. (2000). Morphological and semantic effects in visual word recognition: A time-course study. *Language and Cognitive Processes*, *15*, 507–537. http://dx.doi.org/10.1080/01690960050119689

Rastle, K., Davis, M. H., & New, B. (2004). The broth in my brother's brothel: Morpho-orthographic segmentation in visual word recognition. *Psychonomic Bulletin & Review*, *11*(6), 1090–1098. http://dx.doi.org/10.3758/BF03196742

Reichle, E. D., & Perfetti, C. A. (2003). Morphology in word identification: A word-experience model that accounts for morpheme frequency effects. *Scientific Studies of Reading*, *7*(3), 219–237. http://dx.doi.org/10.1207/S1532799XSSR0703_2

Rogosa, D. (1987). Causal models do not support scientific conclusions: A comment in support of Freedman. *Journal of Educational Statistics, 12*, 185–195. http://dx.doi.org/10.3102/10769986012002185

Roman, A. A., Kirby, J. R., Parrila, R. K., Wade-Woolley, L., & Deacon, S. H. (2009). Toward a comprehensive view of the skills involved in word reading in Grades 4, 6, and 8. *Journal of Experimental Child Psychology*, *102*(1), 96–113. http://dx.doi.org/10.1016/j.jecp.2008.01.004

Rueckl, J. G. (2010). Connectionism and the role of morphology in visual word recognition. *Mental Lexicon*, *5*(3), 371–400. http://dx.doi.org/10.1075/ml.5.3.07rue

Rueckl, J. G., & Raveh, M. (1999). The influence of morphological regularities on the dynamics of a connectionist network. *Brain & Language, 68*, 110–117. https://dx.doi.org/10.1006/brln.1999.2106

Salceda, J. C. R., Alonso, G. A., & Castilla-Earls, A. P. (2014). The simple view of reading in elementary school: A systematic review. *Revista de Logopedia, Foniatría y Audiología*, *34*(1), 17–31. http://dx.doi.org/10.1016/j.rlfa.2013.04.006

Sandra, D. (1994). The morphology of the mental lexicon: Internal word structure viewed from psycholinguistic perspective. *Language and Cognitive Processes, 9*, 227–269. http://dx.doi.org/10.1080/01690969408402119

Satorra, A., & Bentler, P. M. (2010). Ensuring positiveness of the scaled chi-square test statistic. *Psychometrika, 75*, 243–248. http://dx.doi.org/10.1007/s11336-009-9135-y

Schafer, J. L., & Graham, J. W. (2002). Missing data: Our view of the state of the art. *Psychological Methods, 7*, 147–177. http://dx.doi.org/10.1037/1082-989X.7.2.147

Schlueter, E., Davidov, E., & Schmidt, P. (2007). Applying autoregressive cross-lagged and latent growth models to a three-wave panel study. In K. van Montfort, J. H. L. Oud, & A. Satorra (Eds.), *Longitudinal models in the behavioral and related sciences* (pp. 315–336). Mahwah, NJ: Erlbaum.

Seidenberg, M. S., & McClelland, J. L. (1989). A distributed, developmental model of word recognition and naming. *Psychological Review*, *96*(4), 523–568. http://dx.doi.org/10.1037/0033-295X.96.4.523

Selig, J. P., & Little, T. D. (2012). Autoregressive and cross-lagged panel analysis for longitudinal data. In B. Laursen, T. D. Little, & N. A. Card (Eds.), *Handbook of developmental research methods* (pp. 265–278). New York, NY: Guilford.

Selig, J. P., & Preacher, K. J. (2009). Mediation models for longitudinal data in developmental research. *Research in Human Development*, *6*, 144–164. http://dx.doi.org/10.1080/15427600902911247

Seymour, P. H. K. (1997). Foundations of orthographic development. In C. Perfetti, L. Rieben, M. Fayol (Eds.), *Learning to spell* (pp. 319–337). Hillsdale, NJ: Erlbaum.

Share, D. L. (1995). Phonological recoding and self-teaching: Sine qua non of reading acquisition. *Cognition*, *55*(2), 151–218. https://doi.org/10.1016/0010-0277(94)00645-2

Silverman, R. D., Speece, D. L., Harring, J. R., & Ritchey, K. D. (2013). Fluency has a role in the Simple View of Reading. *Scientific Studies of Reading*, *17*, 108–133. http://dx.doi.org/10.1080/10888438.2011.618153

Snow, C. E. (2002). *Reading for understanding: Toward a R&D program in reading comprehension*. Santa Monica, CA: Rand.

Spencer, M., Muse, A., Wagner, R. K., Foorman, B. R., Petscher, Y., Schatschneider, C., Tighe, E. L., & Bishop, M. D. (2015). Examining the underlying dimensions of morphological awareness and vocabulary knowledge. *Reading and Writing*, *28*(7), 959–988. http://dx.doi.org/10.1007/s11145-015-9557-0

Taft, M. (1994). Interactive-activation as a framework for understanding morphological processing. *Language and Cognitive Processes*, *9*(3), 271–294. http://dx.doi.org/10.1080/01690969408402120

Taft, M., & Forster, K. I. (1975). Lexical storage and retrieval of prefixed words. *Journal of Verbal Learning and Verbal Behavior*, *14*(6), 638–647. http://dx.doi.org/10.1016/S0022-5371(75)80051-X

Taylor, J. S. H., Plunkett, K., & Nation, K. (2011). The influence of consistency, frequency, and semantics on learning to read: an artificial orthography paradigm. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *37*(1), 60–76. http://dx.doi.org/10.1037/a0020126

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. http://dx.doi.org/10.1002/rrq.102

Tong, X., Deacon, S. H., Kirby, J. R., Cain, K., & Parrila, R. (2011). Morphological awareness: A key to understanding poor reading comprehension in English. *Journal of Educational Psychology*, *103*(3), 523–534. http://dx.doi.org/10.1037/a0023495

Torgesen, J. F., Wagner, R. K., & Rashotte, C. A. (1999). *Test of Word Reading Efficiency (TOWRE)*. Austin, TX: Pro-Ed.

Tunmer, W.E. & Chapman, J.W. (1998). Language prediction skill, phonological recoding ability, and beginning reading. In: C. Hulme & R.M. Joshi (eds.), *Reading and spelling: Development and disorders* (pp. 33–67). Mahwah, New Jersey: Lawrence Erlbaum Associates.

Tyler, A., & Nagy, W. E. (1989). The acquisition of English derivational morphology. *Journal of Memory and Language*, *28*(6), 649–667. https://doi.org/10.1016/0749-596X(89)90002-8

Vellutino, F. R., Tunmer, W. E., Jaccard, J. J., & Chen, R. (2007). Components of reading ability: Multivariate evidence for a convergent skills model of reading development. *Scientific Studies of Reading*, *11*(1), 3–32. http://dx.doi.org/10.1080/10888430709336632

Verhoeven, L., & Perfetti, C. A. (2011). Morphological processing in reading acquisition: A cross-linguistic perspective. *Applied Psycholinguistics*, *32*(3), 457–466. http://dx.doi.org/10.1017/S0142716411000154

Wagner, R. K., & Torgesen, J. K. (1987). The nature of phonological processing and its causal role in the acquisition of reading skills. *Psychological Bulletin*, *101*(2), 192–212. http://dx.doi.org/10.1037//0033-2909.101.2.192

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

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

Zeno, S., Ivens, S., Millard, R., & Duvvuri, R. (1995). *The educator's word frequency guide*. Brewster, NY: Touchstone Applied Science Associates.

Zhang, D., & Koda, K. (2012). Contribution of morphological awareness and lexical inferencing ability to L2 vocabulary knowledge and reading comprehension among advanced EFL learners: Testing direct and indirect effects. *Reading and Writing*, *25*(5), 1195–1216. http://dx.doi.org/10.1007/s11145-011-9313-z

Zhang, D., Koda, K., & Leong, C. K. (2016). Morphological awareness and bilingual word learning: A longitudinal structural equation modeling study. *Reading and Writing*, *29*(3), 383–407. http://dx.doi.org/10.1007/s11145-015-9603-y

Zhang, H. S. (2014). Morphological awareness in vocabulary acquisition among chinese-speaking children: Testing partial mediation via lexical inference ability. *Reading Research Quarterly*, *50*, 129–142. http://dx.doi.org/10.1002/rrq.89

Ziegler, J. C., & Goswami, U. (2005). Reading acquisition, developmental dyslexia, and skilled reading across languages: A psycholinguistic grain size theory. *Psychological Bulletin*, *131*(1), 3–29. http://dx.doi.org/10.1037/0033-2909.131.1.3

Appendix A
Research Ethics Board Approval Letter

DALHOUSIE UNIVERSITY
Inspiring Minds

Social Sciences & Humanities Research Ethics Board Letter of Approval

December 12, 2012

Mr Kyle Levesque
Science\Psychology & Neuroscience

Dear Kyle,

REB #: 2012-2861
Project Title: Break-ing Up Words: The Science of How Children Understand What They Read

Effective Date: December 10, 2012
Expiry Date: December 10, 2013

The Social Sciences & Humanities Research Ethics Board has reviewed your application for research involving humans and found the proposed research to be in accordance with the Tri- Council Policy Statement on *Ethical Conduct for Research Involving Humans.* This approval will be in effect for 12 months as indicated above. This approval is subject to the conditions listed below which constitute your on-going responsibilities with respect to the ethical conduct of this research.

Sincerely,

Dr. Sophie Jacques, Chair

APPENDIX B

Halifax Regional School Board Approval Letter

Halifax Regional School Board

January 16, 2013

Kyle Levesque
Dalhousie University
Department of Psychology & Neuroscience
1355 oxford Street PO Box 15000, Halifax, NS B3H 4R2

Dear Mr. Levesque:

"Break-ing up Words: The science of how children understand what they read
Approved Project Duration April, 2013 to May, 2013

I am writing in response to your application to conduct external research in the Halifax Regional School Board and to advise that your project is approved. **Due to the length of your research, please re-submit a letter of intent annually.**

It is the Committee's requirement that all projects with student participation have signed parental/guardian consent. Further to that requirement, it is the request of the Committee that the parental/guardian consent form clearly outlines the information to be collected.

You are required to seek school's permission from the principal regarding the school's participation in the project. As noted in the Halifax Regional School Board's External Research Application, the participation of a school or an individual in your research is voluntary. Our approval does not compromise a school's or an individual's right to decline participation in external research projects.

You are reminded that the personal identity of all participants must remain confidential and may not be included in any publication or communication describing the research; nor released to any other party. Any media publicity regarding the project must be reviewed and discussed fully with the Halifax Regional School Board's Communications Unit prior to publication.

Researchers are required to request, in writing or by email to lmckenzie@hrsb.ca, approval of any changes or extensions to the research application.

As noted above, your research in the school must be concluded by the end of May 31, 2013. Please keep in mind that due to the large number of activities that take place during the early and final weeks of school, external research activities are not permitted during the months of September or June.

Should you have any questions regarding this approval, please contact Loretta McKenzie at 464-2000, Extension 2567.

We are very interested in your research and look forward to meeting you to discuss your findings. We wish you every success with this effort and look forward to reading your final report.

Sincerely,

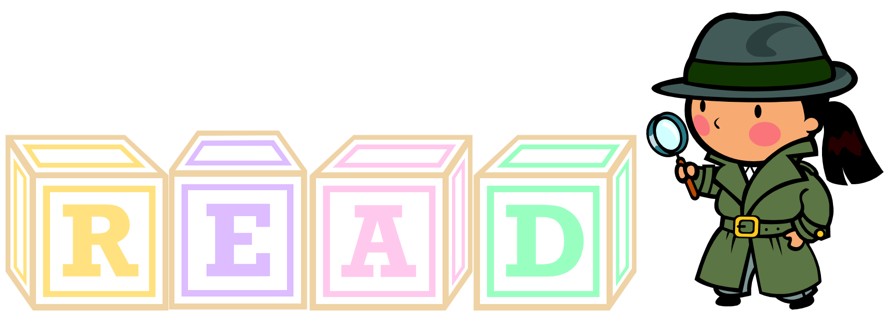
Kim Matheson
Coordinator
Research, Planning & Program

APPENDIX C

Parental Consent Form

"Break-ing" up words!

The science of how children understand what they read



We invite your child to take part in a scientific exploration into reading.

Please read the attached letter to find out more!

If you would like your child to participate, please

1) **Sign** the last page, and
2) **Return** the last page to your child's teacher.

Thanks very much!

from: Dr. Hélène Deacon

DALHOUSIE UNIVERSITY
Inspiring Minds

Informed Consent Form

Project Title: **"Break–ing" Up Words: The Science of How Children Understand what they Read**

Dear parent/guardian,

We invite your child in grade 3 to take part in a study on how children learn to read and comprehend written text. It is being conducted by Dr. Hélène Deacon and Kyle Levesque (PhD Candidate) from the Language and Literacy Lab (http://langlabatdal.weebly.com) at Dalhousie University . The study will take place in your child's school. It is a study that we have designed to be fun for children. We hope that you will allow your child to participate.

Purpose of the study
As you are well aware, reading is an important skill that children learn. This study is examining the skills that children use when they tackle the reading of complex words (e.g., *unquestionable*), both ones that they may have encountered before and ones that are new to them, and how these skills influence their reading comprehension. We hope that our work will contribute to the understanding of reading development and to curriculum design for schools.

What your child will be asked to do
We have specially designed reading and language-based tasks for children that are quick, fun, and easy. In total, these tasks take a maximum of 1 hour and 45 minutes; this time is divided into shorter sessions that are completed over several days, individually and in groups. Children will be asked to read sets of known words and some new ones as well. They will also take part in fun language-based activities. Importantly, we make it clear to the children that we are interested in *how* they think about words, rather than whether or not they get the "right" answer. Based on our experiences, children find these activities fun and engaging, and they tend to enjoy the opportunity to work one-on-one with members of our research team. Children are thanked for their participation with a prize, such as a sticker or a pencil, as well as a certificate of participation.
If you agree, we will arrange convenient times for visits to the school with your child's principal and teacher. We will visit the school over the next 3 years (spring 2014, 2015, & 2016). Exact dates will be arranged in advance with your child's school. Each testing session begins *only* if your child agrees to take part. Taking part in this study is completely voluntary and children may withdraw from the study at any time.

Who can participate in the study and who will conduct the research?
Any child who is in Grade 3 in your child's school can participate. Trained research assistants will conduct the study. All researchers have completed Criminal Record, Vulnerable Sector, and Child Abuse Registry checks and have years of experience working with children.

What will we do with the information that we gain?
The information gathered from this project is for research purposes only. We expect to present our findings, based on group results, in academic journals and education conferences. We may also contrast group results from the children in this study to other groups of participants (such as adults). As a parent/guardian, you will receive a letter explaining what we have found (for the group as a whole) for each year of the study.

As an added benefit of having your child participate in our study, you have the option to receive feedback about your child's general reading level based on standardized tests of reading for each year they participate. You also have the option of letting us pass on this information to your child's teacher/school if you so choose. Please indicate your preference on the Signature Page below.

Possible Risks and Benefits
Aside from working closely on reading activities with a trained researcher, individual children are unlikely to benefit greatly from their short participation. However, we hope that our results may be useful in teacher education and curriculum development in the future.
One possible foreseeable risk lies in missing time from regular classroom instruction. Having said this, all testing times will be carefully arranged with the teacher to minimize lost time. Every effort will be made to accommodate the needs and preferences of individual children and teachers.

Confidentiality & Anonymity
It is very important to us to protect the privacy of children who participate in our research projects. All data files will have only the coded ID numbers and no names, so that no individual child, teacher, or school can be identified. Only the researchers and their trained assistants will have access to the data. Combined results for groups of children, never individuals, will be reported in our publications and presentations. The only individual data that will be shared with you and/or with your child's school will be your child's reading level; we will do so only with your permission. Anonymized data will be retained indefinitely in a secure location.

To participate and for more information
We are happy to answer any questions about this study! You can contact Kyle Levesque at our lab at (902) 494-3229, or kyle.levesque@dal.ca; he will be coordinating the testing at your child's school and welcomes your comments and questions. You are also welcome to call the Lab Director, Dr. Hélène Deacon, at 494-2538. If you have any difficulties with, or wish to voice concern about any aspect of your child's participation in this study, you may contact Catherine Connors, Director of Dalhousie University's Office of Human Research Ethics, for assistance (902-494-1462 / catherine.connors@dal.ca).

In summary: We are very excited about our new research study and would love the opportunity to work with your child! With your consent, we will work with your child as they complete a series of enjoyable reading activities at three different time points; once in the spring of 2014 (3^{rd} grade), and then twice more over the span of two years as 4^{th} and 5^{th} graders. We are excited to track their development as young readers and look forward to sharing our findings with you!

If you would like your child to participate, please *SIGN* and *RETURN*
the Signature Page to your child's teacher.

We thank you for considering your child's participation in this study!

Dr. Hélène Deacon, Associate Professor
Lab Director, Language & Literacy Lab
Dalhousie University
helene.deacon@dal.ca / (902) 494-2538

Kyle Levesque, PhD Candidate
Principal Investigator
Dalhousie University
kyle.levesque@dal.ca / (902) 494-3229

Signature Page

"Break–ing" Up Words: The Science of How Children Understand what they Read

If you wish for your child to participate, please complete the following page and return it to your child's teacher as soon as possible

I have read the explanation about this study. I consent for my child to take part in this study. I realize that participation is voluntary and that my child is free to withdraw from the study at any time.

________ I **give permission** for my child to participate in this study

If you consent to participate, please provide us with the following information:

Name of child (please print): ____

Child's date of birth **(day/month/year)**: _____________________________________

What is the first language that your child learned to speak? ______________________

Does your child speak any other languages? If yes, list: _________________________

Name of parent/guardian (please print): _______________________________________

Signature of parent/guardian: ____

Follow-up information

Please let us know if you would like to receive information about the results of this study by circling an answer for each question below. If requested, we will send this information as a sealed letter to the school, and this letter will be brought home to you by your child (completing this section is not required for your child's participation in the study).

- Would you like to receive a general results letter based on the findings for the whole group? **YES** **NO**
- Would you like to receive information on your child's reading ability (based on standardized tests of word reading and reading comprehension)? **YES** **NO**

Please note that this information will provide you with a single snapshot of your child's reading ability, and should be considered in relation to other indicators of your child's development. The information provided cannot be used for diagnostic purposes.

- Would you like us to pass on information about your child's reading ability to your child's teacher and school? **YES** **NO**

APPENDIX D

Copyright Release for Study 1: Levesque, Kieffer, & Deacon (2017)