Role of Phonological Opacity and Morphological Knowledge in Predicting Reading Skills in School-Age Children

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Gayatri Ram
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This dissertation titled
Role of Phonological Opacity and Morphological Knowledge in Predicting Reading Skills in School-Age Children

by
GAYATRI RAM

has been approved for
the School of Rehabilitation and Communication Sciences
and the College of Health Sciences and Professions by

Sally A. Marinellie
Associate Professor of Health Sciences and Professions

Randy Leite
Dean, College of Health Sciences and Professions
Abstract

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Director of Dissertation: Sally A. Marinellie

The aim of the present study was to investigate different aspects of morphological knowledge for phonologically transparent and opaque derived words in young school-age children. We were also interested in identifying morphological predictors of decoding and reading comprehension in school-age children. A total of 53 typically developing children in grade 3 participated in the project. All children completed three experimental tasks measuring different aspects of morphological knowledge for both kinds of derived words as well as standardized measures for decoding, passage comprehension and phonological awareness. Results indicated that children performed better on phonologically transparent derived words as compared to opaque derived words on all three morphological knowledge tasks. Further, results of hierarchical regression analyses revealed that both phonological awareness and morphological knowledge accounted for unique variance in reading skills in children. Importantly, syntactic knowledge of morphemes emerged as a significant unique predictor of both decoding and passage comprehension skills in children. Theoretical and clinical implications are discussed.
I dedicate this dissertation to my parents (Mr. & Mrs. Somasundaram Ram) and my dear husband Sivakumar Ramanathan for their continued support, encouragement, and trust during this whole process.
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Chapter 1: Introduction

School-age children acquire a significant proportion of their vocabulary through reading, many of which are derived words (Anglin, 1993; Nagy & Anderson, 1984). A derived word contains a derivational suffix that often changes the grammatical class of the word (e.g., play-playful). Phonologically transparent and opaque derived words are examples of two different kinds of derived words that school-age children encounter during reading (Anglin, 1993). Derived words in which the pronunciation of the root word remains the same when a suffix is added are known as phonologically transparent words (e.g., teach-teacher). Derived words in which the pronunciation of the root word changes when a suffix is added are known as phonologically opaque words (e.g., acid-acidic). Although a number of studies highlight the contribution of school-age children’s awareness of phonologically transparent derived words to reading, the contribution of phonologically opaque words to reading is still unclear (Anglin, 1993; Mahony, Singson, & Mann, 2000; Singson, Mahony, & Mann, 2000).

The aim of the present study was to obtain a deeper understanding of the relation between phonological opacity, morphological knowledge of derived words, and reading in school-age children. Importantly, we were interested in studying the contribution of different aspects of morphological knowledge (i.e., relational, syntactic, and distributional) to reading skills for two types of derived words (i.e., transparent and opaque) in typically developing children in grade 3. There is evidence to suggest that the time period spanning grades 3 through 5 is important for acquisition of derivational morphological skills in children given the observed correlation between reading measures and performance on morphological tasks in this age group (Anglin, 1993; Mahony et al.,
2000; Singson et al., 2000). Additionally, researchers have reported that children as young as grade 1 have preliminary awareness of morphological knowledge, and children in grade 3 have the ability to explicitly manipulate morphemic segments of a word by grade 3 (Anglin, 1993; Apel, Diehm, & Apel, 2013; Berko, 1958; Mahony, 1994; Wolter, Wood, & D’zatko, 2009). An in-depth understanding of the contributions of the different aspects of morphological knowledge in children may enable researchers and educators to explain some of the reasons for the observed variability in the contribution of morphological knowledge to reading. Also, given that both morphological awareness and phonological awareness are predictors of reading skills in school-age children (Carlisle, 1995; Nagy, Berninger, & Abbott, 2006), it is necessary to isolate the unique contributions of both to reading as well as the combined contributions of morphology and phonology to reading. Thus, investigating children’s knowledge of morphophonology (i.e., knowledge of the influence of phonology in the processing of derived words) is useful in explaining the relative contributions of morphological awareness and phonological awareness to reading.

Additionally, the findings from this study provide information for models of reading that emphasize the role of morphophonological awareness in the development of reading skills in school-age children. For example, there are several models describing reading acquisition in children (Chall, 1983; Ehri, 1991) or the role of phonological awareness in reading (Adams, 1990); however, models explaining the influence of the interacting effects of phonological and morphological awareness are limited (Jarmuculowicz, Hay, Taran, & Ethington, 2008). Also, there is a need to develop models explaining the contributions of morphological, phonological, and morphophonological
awareness from a developmental perspective (Jarmuculowicz et al., 2008). Importantly, the results fill some gaps in the derivational morphological literature as well as the reading literature.

In summary, in the present study, we investigated the influence of phonological opacity on decoding and reading comprehension in typically developing children in grade 3 with the aim of identifying factors or aspects of morphological knowledge that contribute to the observed difference in performance on tasks measuring knowledge of transparent and opaque derived words. Importantly, we examined the predictive power of different aspects of morphological knowledge in predicting reading performance in typically developing school-age children. In the present study, typically developing children in grade 3 completed three tasks measuring three different aspects of morphological knowledge for two different kinds of derived words. In addition, children completed standardized assessments for reading and phonological skills.

Our results revealed that children found the opaque derived words more challenging than the transparent derived words on all three tasks measuring morphological knowledge. Interestingly, children obtained the highest scores on the syntactic knowledge task followed by relational knowledge and distributional knowledge tasks. Moreover, our results indicated that children’s reading skills are related not only to their phonological awareness skills, but also to the relational and syntactic aspects of their morphological knowledge. Notably, children’s performance on transparent derived words on the syntactic knowledge task emerged as an important unique predictor of their reading skills, after controlling for other predictors.
The findings of the present study contribute to the growing literature on the importance of the relation of morphological knowledge and reading skills in young school-age children (Apel, Wilson-Fowler, Brimo, & Perin, 2012; Carlisle, 1995, 2000; Kirby et al., 2012; Mahony et al., 2000; Nagy et al., 2006; Nagy, Berninger, Abbott, Vaughan, & Vermeulen, 2003; Singson et al., 2000; Windsor, 2000).
Chapter 2: Literature Review

This literature review begins with an overview of morphology and types of morphological knowledge followed by a description of acquisition of derivational morphemes in children. The review then discusses reading theories and models of representation of morphemes in the mental lexicon as well as the factors influencing access and processing of morphemes. Thereafter, findings from some key studies that have investigated the relation between morphological knowledge, phonological awareness, and reading skills in children are reviewed. Finally, the aims and the research questions of the present study along with the hypotheses are presented.

Morphology

Morphology is the study of the structure and formation of words in a particular language (Aronoff & Fudeman, 2010). The smallest meaningful units that form words are called morphemes. Morphological awareness is the ability to consciously reflect upon and manipulate morphemes (Carlisle, 1995). There are two types of morphemes—free and bound morphemes. Free morphemes are also known as base (root) morphemes and can stand alone as single words (e.g., *run, book*). Bound morphemes or affixes cannot stand alone (e.g., *-ish, -ly, -un, -s*) and must be attached to a base morpheme to form a meaningful unit (e.g., *book + ish = bookish*). Bound morphemes can be further divided into two types—prefixes and suffixes. Prefixes are affixes that are attached at the beginning of a root word and modify the meaning of the root word (e.g., *un + happy = unhappy*) but not its grammatical class. Suffixes, on the other hand, are affixes attached at the end of a root word and may result in a change in meaning or grammatical class of the root word (e.g., *run + er = runner; walk + s = walks*) (Arnbak & Elbro, 2000). A
derived word is formed by adding a suffix to a root word to form a word from a different grammatical class (e.g., *play-playful*).

Tyler and Nagy (1989) explained that a complete understanding of derivational morphology includes knowledge of at least three aspects. First, relational knowledge is the ability to understand the internal structure of words and identify relations between two or more words that share a common root word. For example, an ability to identify that *teach* is related to *teacher*. Second, syntactic knowledge is the understanding of the syntactic properties of suffixes. It refers to the ability to recognize the syntactic change that occurs upon addition of a suffix to a base word as well as the knowledge that certain suffixes mark specific syntactic categories. For example, it refers to the knowledge that addition of suffix -ful to a noun converts it to an adjective (e.g., *beauty-beautiful*). Third, distributional knowledge is the awareness of the distributional constraints exhibited by suffixes. It refers to an understanding that certain suffixes attach to only root words belonging to a certain syntactic category. This type of knowledge enables one to distinguish real words from nonwords. For example, suffix -ness usually attaches to adjectives and not to verbs, so *politeness* is a word but *runness* is not.

**Acquisition of Derivational Morphological Skills**

Morphological awareness begins to develop during the early school-age years and continues to develop in adulthood (Anglin, 1993; Berko, 1958; Carlisle, 2000, 2003; Derwing & Baker, 1979; Mahony, 1994; Marinellie & Kneile, 2012; Tyler & Nagy, 1989; Wysocki & Jenkins, 1987). In a seminal study, Anglin (1993) found that inflections are acquired earlier than derived words. In addition, he reported that children begin to acquire knowledge regarding the internal structure of words in grade 1, and by grade 5
they are able to analyze the parts of a derived word to gain meaning. Some researchers have also documented rudimentary morphological awareness in preschool children (Berko, 1958; Clark, 1982). Recently, a few studies have reported evidence of explicit morphological awareness in children as young as those in grades K-2 (Apel et al., 2013; Wolter, Wood, & D’zatko, 2009). Further, Berninger et al. (2010) provided evidence of morphological knowledge in children in grades 1-6.

A number of researchers have suggested that morphological awareness for different types of derived words and the ability to analyze a derived word for meaning (i.e., morphological analysis) develops notably during grades 3 through 5 (Carlisle, 2000; Carlisle & Fleming, 2003; Mahony et al., 2000; Nippold & Sun, 2008; Ram, Marinellie, Benigno, & McCarthy, 2013; Tyler & Nagy, 1989; Wysocki & Jenkins, 1987). Some researchers have focused their investigation on studying the acquisition of suffix knowledge in children (Lewis & Windsor, 1996; Windsor, 1994). For example, Windsor found that children in grades 5 through 8 were better able to comprehend and produce suffixes as compared to children in grades 3 and 4. Similarly, Lewis and Windsor reported that school-age children (i.e., grades 4 through 8) were able to define almost 60% of derived words by providing accurate suffix meanings. Additionally, some researchers have suggested that individual suffixes also follow a developmental trend, with some suffixes (e.g., suffix -er) acquired earlier than the others (e.g., suffix -ly) (Derwing & Baker, 1979). Lastly, different types of morphological knowledge are thought to develop at different ages with relational knowledge as the earliest to develop followed by syntactic and distributional knowledge (Tyler & Nagy, 1989).
As outlined above, there is a general consensus among researchers that the foundation of morphological awareness begins during the preschool years, whereas explicit awareness of derivational morphemes begins during the early school-age years and continues to develop through adulthood (Anglin, 1993; Berko, 1958; Mahony, 1994; Wolter et al., 2009). Although a general developmental trend has been identified to explain the acquisition of derivational morphemes, the role of factors (e.g., the influence of the type of derived word, different types of morphological tasks, properties related to a derived word such as frequency of a derived word) influencing the acquisition of morphological knowledge is still unclear. Additional research is warranted to better explain how these factors influence the rate or depth of morphological knowledge development in children.

Another area in derivational morphology that has gained attention in recent years is the role of morphological knowledge in influencing reading skills in children (Carlisle, 1995; Mahony et al., 2000; Singson et al., 2000). The primary aim of the present study was to explain the contributions of different types of morphological knowledge (i.e., relational, syntactic, distributional) to reading for two different kinds of derived words (i.e., transparent and opaque words). In the following sections, a brief overview of reading theories is provided followed by a description of morphologically based theories of word recognition. Lastly, empirical evidence emphasizing the role of morphological awareness in reading is presented.

Reading Theories

Reading is defined as “a complex cognitive process by which one derives meaning from printed symbols” (Catts & Kamhi, 1986, p. 330). According to the simple
view of reading, decoding and linguistic comprehension are the two main components of reading (Gough & Tunmer, 1986; Hoover & Gough, 1990, as cited in Catts & Kamhi, 2005). Decoding is the process by which a reader translates printed symbols (i.e., text) into words that can be accessed from one’s mental lexicon. Linguistic comprehension includes cognitive processes that enable a reader to determine the meaning of words and/or sentences while reading (Gough & Tunmer, 1986, as cited in Catts & Kamhi, 2005). In the present study, since we were interested in studying the contributions of derivational morphology in predicting reading skills of school-age children, a general understanding of the developmental frameworks and theories of reading is essential.

Given that researchers have been conducting studies in reading for over 100 years, it is not surprising that there are several models of reading that have been proposed. Some researchers have concentrated on investigating the process of reading thereby explaining how an individual learns to make meaning of a word or a sentence from seeing printed symbols on paper. These typically include the bottom-up theories (Gough, 1972; LaBerge & Samuels, 1974), top-down theories (Goodman, 1967; Smith, 1971) or the interactive theories (Rumelhart, 1977; Stanovich, 1980). The proponents of the bottom-up theory believe that reading consists of sequential processes beginning with visual word recognition and ending with comprehension of text. According to the bottom-up models, each stage needs to be completed before moving on to the next stage. Furthermore, bottom-up models emphasize the awareness of perceptual features of letters, the grapheme-phoneme correspondence, and hence the role of decoding while reading (Gough, 1972; LaBerge & Samuels, 1974).
On the other hand, the proponents of the top-down approach to reading suggest that reading is a concept driven process. Top-down theories highlight the role of the reader and the knowledge that a reader has about a given text. For example, Goodman (1967, 1988) suggested that readers form a hypothesis about the meaning of a word/text and test their hypothesis using the information from text. He described reading as a “psycholinguistic guessing game” (Goodman, 1967, p. 127). Top-down theories emphasize a whole-to-part approach to reading whereas bottom-up theories suggest a part-to-whole approach to reading.

Interactive theorists have postulated models that have resulted from the amalgamation of the bottom-up and top-down approaches to reading. Proponents of the interactive theory of reading believe that there is no need for sequential recognition to occur during reading; instead, processing of information can occur simultaneously or in parallel such that higher cognitive processes can influence the recognition of lower level processes (Rumelhart, 1977; Stanovich, 1980, as cited in Samuels & Kamil, 1988). For example, Rumelhart’s Interactive Model (1977) allows for simultaneous processing of different types of knowledge including orthographic, syntactic, semantic, and lexical, thereby leading to an interaction between higher and lower level cognitive processes (Samuels & Kamil, 1988; Tracey & Morrow, 2006). Others have focused on the overall mechanism by which individual words might be processed during reading. Some examples of this viewpoint include the connectionist theories of reading (Seidenberg, 1995; Seidenberg & McClelland, 1989).

In addition, several researchers have attempted to outline a developmental model of reading acquisition by postulating stages of reading acquisition (Chall, 1983; Ehri,
1991). Some stages that have been identified include logographic stage, alphabetic stage, orthographic stage, and automatic word recognition stage (Catts & Kamhi, 2005; Ehri 1991). Others have focused their investigations on the components of reading such as the two-component model including word recognition and reading comprehension (Tunmer & Hoover, 1993) or the three-component model including conceptual abilities, background knowledge, and process strategies (Coady, 1979) or the most recently outlined componential model for explaining reading comprehension from word meaning to text meaning (Perfetti & Adolf, 2012). None of the theoretical frameworks can account for all aspects of reading; however, each theory has its own strengths and limitations. Detailed discussion of all reading theories is beyond the scope of the current manuscript. Refer to Ruddell and Unrau (2004) for detailed descriptions of reading models and theoretical frameworks.

Specifically, the role of morphological knowledge has been acknowledged in some of the early reading models by explaining how readers can make use of morphemic cues for decoding and for gaining meaning of a word during reading (Goodman, 1967; Rumhelhart, 1977). In addition, the role of derivational morphemes during word recognition has further been emphasized by researchers who have postulated models/theories explaining how derivational morphemes might be organized and accessed during reading. Some of these key models/theories are reviewed in the next section.

**Models of Morphological Representation and Processing**

The mental lexicon, or the human word-store, has been of interest to researchers with regard to lexical representation and lexical access. Although several models have been proposed, it is generally agreed that the mental lexicon is organized in levels of
word meaning, grammatical class, and word forms (phonological structure). A key question in the literature has concerned the primary unit of representation. That is, are lexical representations word-based or are they organized with the morpheme as the primary unit? For example, the word *happiness* may be represented as a single unit and may not be analyzed further. In contrast, it may be represented as the morphemes *happy* and *ness*, in which the morpheme *happy* may also be represented with other words such as *happily* or *unhappy* (Marslen-Wilson, Tyler, Wakshler, & Older, 1994). Basically, there are three main models or hypotheses of lexical representation including the whole-word representation model or the *full listing* hypothesis (Bradley, 1980; Butterworth, 1983; Kempley & Morton, 1982; Lukatela, Gligorijevic, Kostic, & Turvey, 1980, as cited in Marslen-Wilson et al., 1994), the fully decomposed model or the *morphemic* hypothesis (Jarvella & Meijers, 1983; Marslen-Wilson et al.; Taft & Forster, 1975) and the hybrid models or the dual-route models (Baayen & Schreuder, 1999; Baayen, Dijkstra & Schreuder, 1997; Caramazza, Laudanna, & Romani, 1988; Caramazza, Miceli, Silveri, & Laudanna, 1985; Schreuder & Baayen, 1995).

The whole-word model is based on the assumption that each word is represented independently in the mental lexicon (Chialant & Caramazza, 1995; Lukatela et al., 1980). According to the proponents of this model, the mental lexicon contains a *full listing* of all the words (i.e., morphologically simple and complex) previously encountered as separate entities. In this model both simple words (e.g., *work*) and morphologically complex words (e.g., *workable, worked*) are represented and processed in the same way (i.e., as whole words). Word recognition is believed to occur based on a matching process between the orthographic input and lexical representation. The frequency of a word is
assumed to influence the recognition process such that words with higher frequency are recognized faster due to a quicker matching process as compared to words with lower frequency. The whole-word models fail to explain the recognition of novel or unfamiliar morphologically complex words as well as the rejection of illegal forms (Chialant & Caramazza, 1995).

The fully decomposed or the morphemic hypothesis is based on the assumption that the mental lexicon is organized on a morphemic basis (Marslen-Wilson et al., 1994; Taft & Forster, 1975). According to this model, morphologically complex words are represented in a fully decomposed form as base words (i.e., root words), affixes, and inflections. For example, workable is represented as work and –able as separate entities. Word recognition is assumed to occur according to an affix stripping process in which morphologically complex words are stripped off their affixes and accessed via their base words. An individual’s knowledge regarding word structure is used to access lexical representations accurately. The problem with fully decomposed models is that they can only explain morphological representation and lexical access when the relation between the base word and affixes or inflections can be easily parsed (e.g., walk + ed, play + ful); however, it fails to account for morphological relations (such as sought-seek) where additional phonological or semantic information is required for parsing (Chialant & Caramazza, 1995).

The hybrid models or the dual-route models encompass features of both the whole word and the fully decomposed models. Two prominent examples of hybrid models of lexical representation are the Addressed Augmented Model (AAM; Caramazza et al., 1988) and the dual route processing model (Schreuder & Baayen, 1995). The main
assumption of the AAM model by Caramazza and colleagues (1988) is that both the whole word and the morphemic representation are activated by a lexical input, based on individual preset threshold levels. Specifically, they suggested that the whole representation is activated for a known morphologically complex word and the individual morphemes are activated for unknown morphologically complex words. These different types of activation are symbolic of the “addressed” part (i.e., whole representation) and the “augmented” part (i.e., activation of individual morphemes). Further, the AAM model suggests that whole-word representations are activated more quickly than the activation of the constituent morphemes forming a word, although both routes are activated in parallel. This model accounts for the frequency and transparency effect seen in word recognition. These lexical effects are described in the next section.

Based on a similar underlying assumption of parallel activation, Schreuder and Baayen (1995) proposed the Parallel Dual-Route Model. In this model, the mental lexicon consists of access representations for whole words and morphemes. According to this computational model, there are three stages of morphological processing including segmentation, licensing, and composition (Baayen & Schreuder, 1999; Schreuder & Baayen). Segmentation involves the mapping of the speech signal on the lexical representations of the whole word as well as its constituent morphemes (i.e., stem, affixes, and inflections) that exist in the lexicon. The segmentation stage is subdivided into an intermediate access representation stage and an access representation stage. The mapping of sound to form (i.e., segmentation stage) is assumed to be influenced by syllabification, stress shifts, and other phonological properties associated with the unit of representation. For example, derived words that involve phonological shifts between base
and derived forms take longer to be mapped on their access forms as compared to derived words with phonologically transparent relations. Further, each access representation is thought to be connected to one or more concept nodes which are then connected to syntactic and semantic representations. The flow of information from access representations to the syntactic and semantic representations is bidirectional and mediated via concept nodes.

The second stage is the licensing stage during which decisions regarding the appropriateness of coactivated lexical units and combination of two or more lexical units (e.g., base and affix) are made. For example, the decision that *sparkly* is the derived adjective form of *spark* rather than *sparkness* is made at this stage. Finally, during the last stage, the lexical representation of a complex word is computed together based on the available individual representations (i.e., syntactic and semantic) that have been licensed. This model thus allows recognition and pronunciation of unfamiliar morphologically complex words. It differs from the AAM (Carammazza et al., 1988) in that it does not suggest a rigid distinction in processing of known and unknown morphologically complex words. Further, the proponents of the AAM model suggest that high frequency transparent derived words are represented as single entries (i.e., whole forms). The dual-route differs from the AAM in that proponents of the dual-route model suggest that high frequency transparent derived words undergo computation, but it is quicker as compared to shift words. The dual-route model thus incorporates the role of both morphological knowledge and phonological knowledge during word recognition.

Currently, there is no consensus on how derived words are organized in the mental lexicon or accessed during word recognition. A part of this inconsistency can be
attributed to frequency, transparency, and other factors that influence the processing of derived words. These factors not only influence how derived words are represented in the mental lexicon but also the manner and the speed with which words are recognized.

**Factors Influencing Access and Processing of Derivational Morphemes**

**Frequency.** The frequency of a word refers to the number of occurrences of a particular word in print materials. The frequency effect refers to the faster and more accurate recognition of frequently occurring words as compared to words that occur less frequently in print. Specifically, words with higher frequency also tend to be words with higher familiarity, and thus they are recognized faster and more accurately in word recognition tasks (Allen, McNeal, & Kvak, 1992; Jusczyk & Aslin, 1995; Landauer & Streeter, 1973; Lively & Pisoni, 1990; Luce, 1986; Luce, Pisoni, & Manous, 1984; Savin, 1963). In addition, there is large body of empirical evidence documenting significant word frequency effects on spoken word recognition/production, lexical access, and phonological acquisition (Dell, 1988; Foss, 1969; Geirut, Morrisette, & Champion, 1999; Jusczyk, 1997; Leonard & Ritterman, 1971). The basic underlying assumption of the frequency effect is that repeated exposures to a particular word facilitate a stronger connection between the features (i.e., orthographic, semantic, and phonological) of the word leading to a deeper and a more complete representation of the word in the lexicon. Further, this deep interconnected representation aids quicker access for words with high frequency (Carlisle & Katz, 2006; Ehri, 1998; Perfetti, 1992).

In the derivational morphology literature, different types of frequency measures have been identified and investigated with respect to their roles in lexical access and representation. One way of documenting frequency values of words in research studies is
the standard frequency index (SFI) which is computed using a logarithmic equation. For example, a SFI of 90 indicates that the word occurs once every 10 words, whereas a SFI of 70 indicates that the word occurs once in every 1,000 words (Carroll, Davies, & Richman, 1971). Two important frequency measures that were relevant to the present study include surface frequency and base frequency. Both these measures play an important role in processing of derived words and influence the ease with which a reader can arrive at the meaning of derived words (Carlisle, 2003). Surface frequency is the frequency of a whole word (Carlisle & Katz, 2006). For example, confidence has a SFI of 37. Base frequency or root word frequency refers to the frequency of a root word (Carlisle & Katz, 2006). For example, confide has a SFI of 51.2. Thus, we can expect confide to be recognized more quickly than confidence on word recognition tasks. Base frequency plays an important role in lexical access by facilitating the recognition of relatively unfamiliar derived words (Carlisle & Stone, 2005; Reichle & Perfetti, 2003). For example, confidence can be accessed faster if confide is a high frequency word. In addition, base frequency influences not only the processing of the derived word in which it occurs but also the processing of all other derived words containing the same base word (Chialant & Caramazza, 1995). Given these findings, it is important to control for frequency values when designing experiments investigating lexical processing of derived words.

Transparency. The transparency of derived word formation has been found to influence processing and recognition of derived words (Schreuder & Baayen, 1995). Generally, it has been found that lack of phonological and/or orthographic transparency makes it difficult for a reader to identify the relation between the base word and the
derived word thereby influencing morphological awareness and reading skills in children (i.e., speed and accuracy of reading) (Carlisle & Nomanbhoy, 1993; Fowler & Liberman, 1995; Windsor, 2000).

A derived word can be phonologically, orthographically, or semantically transparent. A derived word is said to be phonologically transparent if there is no change in the pronunciation of the root word during the formation of a derived word (i.e., with the addition of a suffix to a root word). For example, the derived word selector is said to be phonologically transparent because the pronunciation of root word select is the same after the addition of the suffix -or. On the other hand, the derived word magician is said to be an opaque derived word because the root word magic undergoes a stress change (i.e., pronounced differently) while forming the derived word magician. Similarly, orthographic transparency is related to the spelling of the root word during the formation of the derived word. For example, badly is an orthographically transparent derived word because the spelling of root word bad is the same in derived word badly. In contrast, decision is orthographically opaque because the spelling of the root word decide has changed during the formation of the derived word. Lastly, semantic transparency refers to the intactness of the meaning of the root word after the formation of the derived word. For example, skill and skillful share a semantically transparent relation because the meaning of skillful is related to the meaning of root word skill; however, flight and flighty share a semantically opaque relation because the meaning flighty is minimally related to the meaning of flight (Carlisle & Stone, 2005; Windsor, 2000). It is important to note that these different kinds of transparency are not mutually exclusive (i.e., a derived word can be phonologically, orthographically, and semantically transparent at the same time, e.g.,
skill-skillful). It is often these simultaneous influences of different kinds of transparency on morphological word formation that make it challenging to explain the contributions of morphology and phonology to processing of derived words.

Theoretically, one example of the role of transparency in morphological model building is the model of morphological processing by Marslen-Wilson et al. (1994). In connection with a series of priming experiments, Marslen-Wilson et al. proposed a model in which semantically transparent derived forms are represented as individual morphemes in the mental lexicon. The authors proposed a slightly different model for semantically opaque forms. Based on their findings, they proposed that these opaque forms (e.g., depart-department) are represented as individual morphologically simple roots words at the level of lexical entry and are thus analyzed as whole words instead of depart + ment. Further, separate morphemes such as –al can be combined with semantically opaque words (e.g., department) to form semantically related forms such as department + al. Overall, there is evidence to support the fact that transparency of a derived word along with frequency influences the processing of morphologically complex words (i.e., derived words).

**Productivity of suffixes.** In addition to frequency and transparency of derived words, productivity of suffixes also plays a role in processing derived words. Productivity refers to the ease with which suffixes attach to root words (Booij, 2005). Some suffixes such as -er, -ful, and -ly attach easily to a large number of root words to form derived nominals or adjectives (e.g., runner, player, sweeper, beautiful, tasteful, simply, happily). These suffixes are called productive suffixes or suffixes with high productivity. On the other hand, suffixes such as -hood, and -dom attach to restricted number of root words to
form derived words (e.g., brotherhood, freedom). These suffixes are said to have low productivity because of their restricted ability to form derived words. Suffix productivity is often thought to be a correlate of frequency because productive suffixes tend to occur more frequently than those with low productivity (Aronoff, 1976; Baayen, 1992). In addition, high productive suffixes are acquired earlier, are more familiar, and children tend to use productive suffixes more often to convey meanings than low productive suffixes (Lewis & Windsor, 1996; Windsor, 1994; Windsor & Hwang, 1999).

**Reading: Role of Phonological Awareness and Morphological Awareness**

The primary function of reading is to gain meaning from text. Further, it is an established fact that reading is a language-based process (Catts & Kamhi, 1986; Perfetti, 1985). In any language, phonemes are the smallest units of sound whereas morphemes are the smallest units of meaning (Bloomfield, 1933). Additionally, sound and meaning are two features of an oral language system that are relevant to the written language system. It then makes sense to expect that awareness of sound structures (i.e., phonological awareness) and units of meaning (i.e., morphological awareness) would influence reading skills. In fact, phonological awareness, measured by the ability of a child to identify, segment, manipulate, and reflect upon the sound structures of a language has been found to strongly influence reading ability in children (Adams, 1990; National Early Literacy Panel, 2008). Specifically, phoneme segmentation (i.e., the ability to segment a word into its constituent phonemes) and the ability to manipulate phonemes (e.g., produce “dog” without /d/) have been found to influence reading (Adams, 1990). In addition, there is sufficient evidence to suggest that a number of difficulties experienced by children with reading difficulties are due to an underlying deficit in phonological skills.
(Adams, 1990; Shankweiler et al., 1995; Stanovich, 1986). Morphological awareness, on the other hand, has received less attention as compared to phonological awareness partly due to its complex nature. Also, the relative contribution of phonological awareness and morphological awareness has been an issue of debate.

There are several ways in which morphological awareness can be expected to contribute to decoding and reading comprehension. Morphemes, in addition to being the smallest unit of meaning, also contain syntactic and phonological properties which have the potential to influence reading comprehension (Mahony et al., 2000). Further, morphological awareness may also influence reading comprehension indirectly via facilitating vocabulary acquisition in children (Anderson & Freebody, 1981; Anglin, 1993; Kuo & Anderson, 2006; Nagy & Anderson, 1984). Another reason to expect a relation between morphological awareness and decoding could be that pronunciation is often influenced by morphological rules. For example, morphological knowledge may facilitate the recognition of allomorphs (e.g., pronunciation of sign in sign and signature) leading to increased fluency and accuracy (Kuo & Anderson, 2006).

As Tyler and Nagy (1989) suggested, morphological awareness includes relational, syntactic and distributional knowledge of morphemes. It is reasonable to expect that each of these different types of knowledge may contribute to different aspects of reading (i.e., decoding and comprehension) either directly or indirectly. For instance, relational knowledge includes ability to detect relations between base words and derived words (Tyler & Nagy, 1989). In order to recognize if the base and derived word are related, a child must first be able to identify the base word in a derived word. Given that both the base word and suffix contribute to the meaning of a derived word and that both
units influence pronunciation of the derived word, we can expect relational knowledge to contribute to both decoding and reading comprehension. Further, being able to identify that *teach* and *teacher* are related may contribute to reading comprehension indirectly via vocabulary (Carlisle & Stone, 2005; Kirby et al., 2012).

Similarly, syntactic morphological knowledge is related to the syntactic properties of the suffixes. Suffixes carry valuable information regarding the syntactic category of a word. For example, the suffix *-ity* is a noun marker, whereas the suffix *-ful* is an adjective marker. Knowledge regarding a syntactic category of a word may contribute to comprehension of sentences and hence to reading comprehension. Basically, morphological cues along with punctuation and word order provide information regarding the syntactic structure of a sentence. Morphological knowledge can enable a reader to parse sentences accurately, thereby contributing to reading comprehension (Carlisle & Stone, 2005; Kirby et al., 2012).

Lastly, knowledge regarding the distributional constraints of a derived word may also contribute to decoding of a word, because the ability to judge whether a particular suffix can be attached to a base word or not may facilitate lexical access, thereby facilitating decoding. Moreover, awareness of the distributional constraints of derived words may facilitate reading comprehension indirectly through vocabulary. In addition, distributional knowledge also provides a reader clues regarding the grammatical class of the root word and the derived word which may assist a reader in determining the meaning of the word, thereby influencing reading comprehension. For example, if a reader is aware that suffix *-ness* attaches only to adjectives and not to verbs, then a reader may know that *harsh* is an adjective whereas *harshness* is a noun, which may facilitate
comprehension of a sentence containing the word *harshness*. In the past several years, researchers have conducted several studies investigating the relation between morphological awareness, phonological awareness, and reading in search of experimental evidence to support these hypotheses. The findings from some of key studies are summarized in the next section.

**Empirical evidence.** Given that the English orthography is morphophonemic, a systematic understanding of the English orthography requires an understanding of both the phonological and morphological systems. In the last 20-25 years, a number of studies have investigated the relation between morphological knowledge and reading in children of various age ranges (Carlisle, 2000; Fowler & Liberman, 1995; Mahony et al., 2000; Nagy et al., 2006; Singson et al., 2000; Tyler & Nagy, 1990). The majority of these studies have documented a positive relation between morphological knowledge and reading skills (i.e., decoding and comprehension); however, the strength of the relation has been found to vary greatly across studies due to several methodological differences.

Mahony et al. (2000) conducted a series of two experiments with children in grades 3 through 6, investigating the contribution of relational morphological knowledge to decoding ability. Phonological awareness and vocabulary were used as control measures. The results of the study suggested that all three variables (i.e., vocabulary, phonological awareness, morphological knowledge) were significantly related to decoding skills in children. Further, it was found that children with higher scores on decoding measures also had greater sensitivity to morphological relations. In addition, the results of the second experiment suggested that relational morphological knowledge accounted for 5% whereas phonological awareness accounted for 13% of the unique
variance in decoding abilities after controlling for vocabulary and grade effects. The
authors recommended additional investigation to better understand the interacting effects
of morphological knowledge and phonological awareness on decoding.

In a similar set of two experiments, Singson et al. (2000) investigated the
influence of syntactic morphological knowledge on decoding abilities in school-age
children (i.e., grades 3 through 6). Results of both experiments indicated a significant
correlation between children’s syntactic morphological knowledge of suffixes and their
decoding skills. In addition, results of correlational and regression analyses suggested
that morphological awareness was significantly related to phonological awareness.
Further, morphological awareness accounted for 4% of unique variance in decoding
abilities after controlling for effects of vocabulary and phonological awareness, whereas
phonological awareness accounted for 9% of the unique variance in decoding skills after
controlling for morphological awareness and vocabulary. Moreover, the authors
suggested that the contributions of both morphological and phonological awareness were
age dependent in that phonological awareness had a strong relation to decoding skills of
younger children, whereas morphological awareness had a strong relation with decoding
skills of older children. Based on their findings, the authors suggested that it was possible
that part of a poor reader’s decoding difficulty with morphological awareness could be
attributed to a phonological limitation. Since their data were not designed to compare
performance on phonologically transparent and opaque words, the authors recommended
a future study with a suitable research design to disentangle the influences of
phonological and morphological awareness on decoding skills in children.
Nagy et al. (2003) used structural equation modeling to examine the contributions of morphological awareness to decoding and reading comprehension in children in grades 2 and 4 who were at risk for reading and writing difficulties, respectively. Morphological awareness was measured with a battery of tests including the suffix choice test measuring syntactic morphological knowledge (Berninger, Abott, Billingsley, & Nagy, 2001), the morphological relatedness test measuring relational morphological knowledge (Carlisle, 1995; Mahony et al., 2000) and the compound structure test which tapped into knowledge of formation of compound words (Berninger & Nagy, 1999). The results of a confirmatory factor analysis revealed that morphological awareness (i.e., as measured by the three tasks) accounted for unique variance in reading comprehension for children in grade 2 after controlling for phonology, orthography, and vocabulary. Surprisingly, although morphological awareness was significantly correlated with decoding abilities in this population, it did not account for any unique variance. Additionally, for older children, morphological awareness failed to account for any unique variance in decoding or reading comprehension; however, morphology and vocabulary were significantly correlated.

In another study, Nagy et al. (2006) examined the contribution of morphological awareness and phonological awareness to literacy outcomes in children in grades 4 through 9. Results of the analyses revealed that awareness of the internal structure of words contributed significantly to vocabulary, reading comprehension, and spelling at all grade levels. Importantly, it was found that morphological awareness significantly contributed to reading accuracy of children in grades 4 and 5 and to reading speed of children in grades 8 and 9. Morphological awareness did not contribute to any reading
measure for children in grades 6 and 7, except for spelling. This pattern is suggestive of a developmental trend in contribution of morphological awareness to reading skills.

Carlisle and Fleming (2003) in a longitudinal study with young elementary children (i.e., grades 3 and 5) investigated the contribution of relational and syntactic morphological knowledge to reading comprehension. Children in grade 3 completed the relational morphological task and a word definition task; the children in grade 5 completed a syntactic morphological task and a reading test. The results showed a trend suggesting a contribution of morphological knowledge to reading comprehension with the strength of the association greater for children in grade 5 compared to grade 3. Importantly, the study emphasized the role of syntactic and semantic morphological knowledge in relation to reading comprehension.

Recently, Kirby et al. (2012) examined the role of relational morphological knowledge on a variety of decoding and reading comprehension measures in young elementary school-age children (i.e., grade 1 to 3). The results suggested that the contribution of relational morphological knowledge to reading (decoding and comprehension) increased with grade level. Further, morphological awareness accounted for unique variance in reading comprehension after controlling for intelligence, phonological awareness, and word reading abilities. The study emphasized the connection between morphological awareness and reading in young children.

Similarly, Apel et al. (2012) investigated the contributions of phonological awareness, morphological awareness, and orthographic awareness to reading and spelling abilities in children in grades 2 and 3. Morphological awareness was measured using a modification of the derivational suffix test (Carlisle, 1995; Nagy et al., 2003). Results
suggested a moderate to strong correlation between morphological awareness and the literacy measures for both age groups. Further, morphological awareness accounted for unique variance in spelling, decoding, and reading comprehension, after controlling for vocabulary and naming speed measures. The findings provided additional support for the influence of morphological awareness on literacy measures in typically developing young children.

**Phonological opacity, morphological awareness and reading.** The extant literature provides clear evidence that morphological knowledge influences decoding and reading comprehension in children (Mahony et al., 2000; Nagy et al., 2006; Singson et al., 2000). In addition, morphological and phonological awareness both account for some unique variance in reading skills (Mahony et al., 2000; Singson et al., 2000). Further, morphological and phonological awareness are highly correlated with each other and with reading skills (Carlisle, 1995; Carlisle & Stone, 2005). Given the high degree of intercorrelation between phonological awareness, morphological awareness, and reading, some researchers have suggested that phonological knowledge may influence morphological processing of derived words (Singson et al., 2000; Fowler & Liberman, 1995; Shankweiler et al., 1995). Moreover, there is some evidence to suggest that the contribution of phonological awareness and morphological awareness to reading might be age-dependent, with phonological awareness being more important in younger children and morphological awareness in older children (Singson et al., 2000). Given these findings, some researchers have opined that the issue at hand is not about explaining the role of morphological or phonological awareness as it contributes to reading, but explaining the role of morphophonology or the interface between morphology and
phonology along with individual contributions of morphological and phonological awareness to reading (Carlisle, 2000; Jarmulowicz et al., 2008).

Jarmulowicz et al. (2008) proposed a sequential developmental model explaining the role of morphophonology in reading in a study with children in grade 3. Specifically, the authors explained the relation between morphological awareness, phonological awareness, morphophonological awareness, reading, and receptive language. A relational morphological knowledge task was used as a measure of morphological awareness. 

*Elision* and *Blending* subtests from the *Comprehensive Test of Phonological Processing* (CTOPP; Wagner, Torgesen, & Rashotte, 1999) were used as measures of phonological awareness. Morphophonological awareness was measured using an investigator-developed production task. Children were given the base word and the suffix and were asked produce the correct derived word. A measure of morphophonological accuracy was computed based on the accuracy of children’s productions. Reading skills were measured using standardized reading tests. In addition, receptive language was measured using standardized receptive language test (i.e., CELF-4). The results of path analysis indicated that the development of phonological awareness influenced the development of morphological awareness, which influenced the morphophonological accuracy of children. Further, morphophonological accuracy was found to be a better predictor of decoding than phonological awareness, whereas receptive language and decoding skills were stronger predictors of reading comprehension. The study thus highlighted the importance of further exploring the contribution of morphophonology to reading. See Figure 1 for the model proposed by Jarmuculowicz and colleagues.
One way to study morphophonology is to investigate the morphological knowledge of children for shift words (because these words require phonological processing) and compare it with their knowledge for transparent words. A few researchers have studied this morphophonological interface and its relation to reading skills in children. These studies are reviewed below.

Carlisle and Nomanbhoy (1993) conducted a study with children in grade 1 to investigate the contribution of phonological and morphological awareness on word reading. The stimuli consisted of equal numbers of inflectional, transparent derived words and shift words for both the morphological tasks (i.e., judgment and production). Derivatives primarily included agentive forms (e.g., washer, teacher). Results indicated that morphological and phonological awareness together accounted for 37% of the
variance in word reading; however, the contribution of phonological awareness was
greater than that of morphological awareness. Additionally, children with higher
phonemic awareness performed better on morphological tasks as compared to children
with poor phonemic awareness. Thus, the study highlighted the interrelation between
morphological and phonological awareness and its contribution to word reading. Given
that the stimuli for the production task contained one-third shift words and it accounted
for a significant variance in reading comprehension as compared to the other
morphological task (i.e., judgment task), the findings from the study emphasized the
higher processing demands required for shift words as compared to transparent words.
The authors concluded that phonological shifts in opaque derived word may make it
challenging for children to notice the morphological relation between root and derived
words.

Carlisle (1995) continued this line of research by investigating the ability of
young children’s performance on morphological and phonological awareness tasks to
predict reading achievement scores in a longitudinal study with children from
kindergarten through grade 2. Two tasks were used to measure morphological awareness.
The first task was the morphological production task, which required children to
complete a sentence with a correct derived form of the base word. For example, “(farm)
My uncle is a farmer” (p. 198). The second task was a morphological judgment task,
which required children to make a judgment whether the derived word “came from” the
base word. For example, “Do you think fabulous comes from fable?” (p. 199). The target
words contained equal numbers of inflectional, phonologically transparent, and shift
words. The results suggested that performance of children in grade 1 on the
morphological and phonological awareness tasks together accounted for 34% of variance in reading comprehension scores obtained in grade 2. Importantly, the morphological production task was found to be a better predictor of reading comprehension than the judgment task. Both morphological and phonological awareness measured in grade 1 were significantly related to decoding scores in grade 2; however, phonological awareness was a better predictor of decoding skills than morphological awareness. Because the shift words were particularly challenging for kindergarteners and to an extent even for first graders, no separate analysis was conducted to examine the difference in the contribution of shift and transparent derived words to reading comprehension. The link between morphological and phonological awareness was acknowledged as an area of future investigation.

In another study, Carlisle (2000) investigated the relation between morphological awareness, knowledge regarding the meaning of derived words, and reading abilities (i.e., decoding and reading comprehension) in elementary school-age children in grades 3 and 5. Morphological awareness was measured using the Test of Morphological Structure (TMS) which included the derivation and decomposition tasks used in previous studies (Carlisle, 1988; 1995). Both transparent and shift words were used as stimuli. Results suggested that children from both grades achieved higher scores on tasks measuring morphological knowledge, definition and reading for transparent words as compared to shift words. Also, derivation tasks were found to be more difficult than production with children obtaining the lowest scores in the shift derivation condition. Importantly, the measure of syntactic morphological knowledge was significantly related to reading skills. Specifically, for grade 3, morphological awareness accounted for 43% of the variance in
reading comprehension and for grade 5, it accounted for 55% of the variance in reading comprehension. As with other studies that have investigated morphological awareness of shift words, the data in this study were not analyzed for individual contributions of transparent and shift words.

Carlisle and Stone (2005) extended this line of research by conducting two experiments with school-age children. In the first experiment, children from grades 2, 3, 5, and 6 read high frequency transparent derived words (e.g., *shady*) and pseudo-derived words (i.e., *lady*) as well as low frequency derived words containing high frequency base words. Results indicated that children from all grades read the derived words more quickly and with greater accuracy than the pseudo-derived words. The second experiment investigated the role of phonological transparency on reading of derived words. Results indicated that middle and high school children read phonologically transparent words with greater accuracy and speed as compared to shift words. The authors attributed the difficulty in reading shift words to the fact that phonological opacity reduces the clarity of morphological relation between base word and the derived word. In addition, they also suggested that competing differences in the pronunciation of base word and derived word may have interfered with accurate and rapid word reading. Together, findings from both experiments suggest that children as young as that in grade 2 use morphemic information while reading derived words. Further, phonological transparency influences the speed and accuracy of reading derived words. Lastly, they recommended additional research to understand the contribution of phonological, orthographic and semantic transparency of word reading.
Fowler and Liberman (1995) studied the relation between morphological awareness and decoding in children (good and poor readers) aged 7.5-9.5 years using phonologically transparent and opaque words. Morphological awareness was measured using a modified version of the production task (Carlisle, 1988) in which children were asked to provide the derived word, given the base word or vice versa. All children performed with greater accuracy on phonologically transparent words than opaque words. In addition, it was found that poor readers differed significantly from good readers on their performance on opaque words but not for transparent words. Further, producing the base forms when the derived word was presented in a sentence was found to be easier than providing the derived word, given the base word. Interestingly, results of a step-wise multiple regression analysis showed that performance on the base production task for phonologically opaque words best predicted word recognition (42%) and pseudo-word decoding (34%) abilities of children as compared to other tasks used in the study. Also, performance on transparent derived words did not account for any additional significant variance in word recognition scores beyond that accounted by age, vocabulary, and performance on opaque derivatives. This study thus highlights the role of morphological awareness of phonological opaque words in predicting decoding skills in children.

Shankweiler et al. (1995) compared the contributions of morphological and phonological awareness to reading skills for phonologically transparent and opaque words in a larger study with 353 elementary school-age children that included the children from Fowler and Liberman’s study. Children with and without reading and math disabilities were included in this study. Results were identical to Fowler and Liberman in that children performed more poorly on opaque words compared to transparent words.
Further, children with disabilities differed most from their normal peers on their performance on opaque words. Analyses indicated a significant correlation between morphological awareness and phonological awareness as well as between linguistic awareness measures (i.e., morphological awareness and phonological awareness) and reading (i.e., decoding, reading comprehension). Lastly, regression analyses suggested that phonological awareness accounted for greater unique variance in reading (i.e., 10%) as compared to morphological awareness (i.e., 5%) after controlling for all other variables. The authors interpreted the findings to suggest that at least part of the difficulty associated with poor readers on the morphological production tasks could be attributed to an underlying deficit in phonological abilities.

Windsor (2000) added to this growing body of literature by examining the role of phonological opacity in reading achievement in children (i.e., 10-12 years of age) with and without language impairments. Morphological awareness was measured using two experimental tasks including the base production task and the suffix identification task. In the base production task, children were asked to produce “the smaller related word at the beginning of the word” (Windsor, 2000, p. 54). In the suffix identification task, children were asked to identify the “right ending or suffix” given three choices (p. 54). For both the tasks, children first heard a target word, saw a video skit related to the word, heard the sentence containing the target word, which was then followed by the target word again and the question prompt. Stimuli included equal numbers of transparent and opaque derived words and were balanced for semantic transparency. Windsor was among the few researchers who analyzed her data using separate regression analyses for transparent and opaque derived words and their ability to predict reading achievement scores in children.
Overall, the results suggested that children found it particularly challenging to identify correct bases and suffixes of opaque words as compared to transparent words.

Specifically, children with language impairment performed poorly on opaque derived words in both the tasks as compared to typically developing children. Results of the regression analyses indicated that performance on opaque derived words accounted for additional significant variance in both decoding (19.9%) and reading comprehension (16.5%) after controlling for age, vocabulary, and performance on transparent derived words. These results suggested that morphological awareness of opaque words was a stronger predictor of reading achievement in children than morphological awareness of transparent derived words.

Recently, McCutchen et al. (2008) examined the contributions of morphological and phonological awareness to various measures of literacy using a broad-based measure of morphological awareness measuring relational, syntactic, and distributional morphological knowledge in children from grades 4 and 6. Reading skills, vocabulary, and phonological awareness were measured using standardized assessments. In the case of morphological awareness, relational knowledge was assessed using a “comes from task” (Derwin & Baker, 1979); syntactic knowledge was assessed using a sentence completion task in which children produced either the base or derived word to complete a sentence (Carlisle, 1988, 1995); and, distributional knowledge was assessed using a “yes”/ “no” task in which children decided whether a given word was an English word or not. All tasks included transparent and opaque words, but the numbers varied across tasks. Results from correlation and regression analyses suggested that morphological awareness of phonologically opaque words accounted for unique variance in decoding
and comprehension scores for both grades, after controlling for phonological awareness. Performance on opaque words did not account for unique variance in comprehension after vocabulary was added to the model along with phonological awareness.

The findings from the McCutchen et al. study support the line of research investigating the role of phonological opacity in reading; however, several questions still remain unanswered. The authors did not report findings from analyses of the contribution of individual morphological tasks and their ability to predict reading achievement. Given that all three tasks tap into different aspects of morphological knowledge and develop differentially across grades, it is necessary to determine how different aspects of morphological knowledge contribute to reading achievement. Such information will add to an understanding of the role of morphophonology in reading. Also, the authors did not report regression analyses with performance on transparent derived words. Controlling for performance of transparent derivatives in a regression model may have yielded some interesting information.

**Summary**

There are several important findings that emerge from the extant literature. First, children’s knowledge of transparent derived words has been more extensively studied as compared to children’s knowledge of opaque derived words (Mahony et al., 2000; Nagy et al., 2006; Singson et al., 2000). Importantly, although there is evidence to suggest that children perform poorly on morphological tasks with phonologically opaque derived words as compared to transparent derived words, little is known about the potential reasons for this observed difference (Carlisle & Nomanbhoy, 1993; McCutchen et al., 2008; Windsor, 2000). Second, the majority of the studies investigating the relation
between morphological knowledge and reading in school-age children have investigated relational and/or syntactic morphological knowledge as compared to distributional morphological knowledge (Carlisle, 1995, 2000; Mahony et al., 2000; McCutchen et al., 2008; Nagy et al., 2006). Third, there is much variability in terms of the tasks used to measure morphological knowledge in children. This may be a potential factor contributing to the observed wide range of scores on morphological tasks across studies. For example, relational knowledge has been assessed using variations of a judgment task, a “comes from” task, or an identification of parts task (Carlisle & Nomanbhoy, 1993; Carlisle, 1995; Mahony et al., 2000; Windsor, 2000). Syntactic knowledge has been assessed using variations of a sentence completion task or a suffix choice task (Nagy et al., 2006, 2003; Singson et al., 2000), and distributional knowledge has been assessed using a lexical decision task (McCutchen et al., 2008; Tyler & Nagy; 1989). In order to systematically assess children’s morphological knowledge as well as to reduce the influence of task variability, it is necessary to develop a single broad-based assessment protocol with items measuring children’s knowledge of all three aspects of morphology. Thus, there is clearly a gap in the derivational morphological literature in terms of explaining how the different aspects of morphological knowledge in young children influence their reading skills for different types of derived words. Also, there is a need for additional studies investigating young children’s knowledge of phonologically opaque derived words and its role in predicting reading skills in children. Additionally, few studies have assessed all three aspects of morphological knowledge using a single assessment protocol. The present study is designed with the aim of providing information to fill some of these observed gaps in the derivational morphology literature.
The Present Study

School-age children encounter a large number of derived words in their texts (Anglin, 1993). Therefore, it is essential to investigate how children’s knowledge of derived words influences their reading abilities. Importantly, a number of studies suggest a strong correlation between vocabulary, morphological knowledge, phonological awareness, and reading in school-age children (Anglin, 1993; Carlisle, 2000; Mahony et al., 2000; Nagy et al., 2006; Windsor, 2000). In the present study, by including both phonologically transparent and opaque derived words, our aim was to explain the relation between phonological opacity, morphological knowledge, and reading skill in school-age children, a relation that is still not clearly understood in the derivational morphology literature. Also, by including phonological awareness as a control measure, our aim was to find unique variance accounted for by phonological opacity in reading measures.

There is growing evidence to suggest that the contributions of morphological awareness and phonological awareness to reading skills in children might be age related, with phonological awareness being more important in younger children (i.e., preschool children) and morphological knowledge gaining importance in the elementary years (Carlisle, 2000; Jarmuculowicz et al., 2008). It then becomes necessary to explain the relative contributions of both phonological and morphological awareness to reading skills in children during the elementary years. A deeper understanding of the contributions of morphophonology to reading will enable researchers and educators to develop newer models of reading explaining this interrelation between phonological awareness, morphological awareness and reading. For example, Jarmuculowicz et al. (2008) proposed a model of reading comprehension explaining the relative contributions of
morphological awareness, phonological awareness, morphophonological accuracy, receptive language, and decoding to reading comprehension in a study with children in grade 3. Although the aim of the present study was not to test a specific model of word recognition or reading comprehension, the findings from the present study provide information to make comparisons with the model proposed by Jarmuculowicz et al. (2008). Given that Jarmuculowicz and colleagues used only a relational morphology task to measure morphological awareness, the findings from the current study will add to the information provided by their model of reading comprehension.

Traditionally, morphological assessments in children have focused on measuring only a unitary aspect of morphological knowledge such as relational knowledge (Tyler & Nagy, 1989), or syntactic knowledge of suffixes (Carlisle, 1995; Tyler & Nagy, 1989). However, findings from recent studies investigating morphological knowledge have indicated a need to develop assessment protocols that go beyond investigating such unitary aspects of morphological knowledge (Kirby et al., 2012; McCutchen et al., 2008). In the present study, by using a multitask assessment protocol with items measuring not only relational but also, syntactic, and distributional morphological knowledge, we expected to obtain a deeper understanding of school-age children’s morphological knowledge. Given the fact that there have been few studies that have investigated syntactic knowledge and even fewer that have studied distributional knowledge in school-age children, the findings from this study add to the limited list of studies investigating different aspects of morphological skills in school-age children (Carlisle, 1995; Carlisle & Katz, 2006; Tyler & Nagy, 1989). Additionally, the use of both decoding and reading comprehension tasks to measure reading achievement in children
enable us to isolate the influence of different aspects of morphology on these reading skills.

In the present study, we tested typically developing children in grades 3 based on findings from previous studies which have documented increasing contribution of morphology to reading during elementary years (Mahony et al., 2000; Singson et al., 2000). Many studies have included participants who are in grade 4 or older (Tyler & Nagy, 1989; Windsor, 2000). Findings from recent studies suggest that even children in grade 1 have some emerging awareness of a word’s structure (e.g., identifying if it is a simple or derived word) and that by grade 3 children begin to demonstrate morphological knowledge that can be assessed by various experimental measures (Anglin, 1993; Carlisle, 1995). In the present study, our aim was to add to this growing literature by assessing morphological knowledge in children as young as grade 3 using a broad-based morphological assessment protocol. This information will enable us to explain the contributions of different aspects of morphological knowledge (i.e., relational, syntactic and distributional) for different kinds of derived words (i.e., phonologically transparent and opaque) to reading skills (i.e., decoding and reading comprehension) in children

**Research Questions.**

1. Does the performance of children in grade 3 on morphological tasks differ for phonologically transparent and opaque words?

2. Do measures of morphological knowledge (i.e., relational, syntactic, distributional) in children in grade 3 predict performance on reading achievement tests differentially for transparent and opaque words?
Hypotheses.

1. We predicted that overall, phonologically opaque derived words would be more difficult than transparent derived words. Phonologically opaque words require an additional level of processing (i.e., acknowledging the stress change in pronunciation of root words) as compared to transparent derived words. Additionally, phonological opacity should create a challenge in identifying the relation between root and derived words contributing to the difficulty in processing opaque words. Specifically, school-age children will obtain lower scores on measures of morphological knowledge for opaque words as compared to transparent words. This is based on findings from previous research which suggest that children perform poorly on morphological awareness tasks assessing knowledge of opaque as compared to transparent words (Carlisle, 2000; Fowler & Liberman, 1995; Windsor, 2000). Our unique contribution was to obtain insights on the differences observed between performance on opaque and transparent derived words for different aspects of morphological knowledge including awareness of relational, syntactic, and distributional knowledge of morphemes. We expected that children would find phonologically opaque words more challenging than transparent words on all three tasks measuring different aspects of morphological knowledge (i.e., relational knowledge, syntactic knowledge, and distributional knowledge).
2. We expected that morphological knowledge of both phonologically transparent and opaque words will account for unique variance in both decoding and reading comprehension in school-age children, after controlling for phonological awareness. We included a measure of phonological awareness as a control measure because we were interested in isolating the effects of phonological opacity on reading skills in children. Importantly, we predicted that the morphological awareness tasks for the phonologically opaque words should account for greater variance in reading achievement measures as compared to performance on phonologically transparent derived words. This prediction was based on findings from previous studies which have reported a greater degree of correlation between the performance on phonologically opaque and reading achievement as compared to performance on transparent words (Carlisle et al., 2000; Fowler & Liberman, 1995; McCutchen et al., 2008; Windsor, 2000). Based on our assumption that the three types of morphological knowledge can influence lexical access of derived words, we expected that performance on all three experimental tasks would account for significant variance in decoding scores. Further, we hypothesized that all three experimental tasks would influence reading comprehension abilities in children indirectly via vocabulary. For example, the experimental tasks may aid the meaning making process of derived words thereby influencing comprehension of sentence containing
the derived words. All of these predictions were based on findings from previous studies (McCutchen et al., 2008; Windsor, 2000).
Chapter 3: Method

Participants

A total of 110 children from grade 3 were initially recruited. All children who gave consent for participation were tested, but only children who met the inclusionary criteria for our study were included in the data analyses. All children were attending elementary schools in Southeast Ohio. The investigators obtained information from parents via a questionnaire to confirm that all children that were included in the data analyses were: a) typically developing; b) performing at expected levels on all subjects based on state standards; c) without history of learning difficulties or delayed development; and, d) not receiving special services for academics or speech and language skills at the time of the study. The questionnaire was also used to obtain parent consent and basic developmental information regarding each child before the start of the study. See Appendix A for questionnaire. In addition, parents were also asked to complete the Children’s Communication Checklist-2 (CCC-2; Bishop, 2003). The CCC-2 was used to obtain information regarding a child’s speech and language skills in the areas of syntax, morphology, semantics, pragmatics, and speech. Specifically, it was used as an additional screening measure to identify children with a speech and language impairment as well as children who may be on the autistic spectrum. Only 79 children were considered to be typically developing according to our inclusionary criteria and were further screened for typical reading development.

The investigators obtained consent from the parents to release their child’s reading achievement scores (i.e., TerraNova 3; McGraw-Hill, 2012) administered at the beginning of the school year. The reading achievement scores provided information
regarding the reading proficiency levels and were used as an additional measure of
typical reading development. These scores were used only to classify children as
typically developing in terms of reading skills or as children in need of services; the
scores were not used in any analyses. Those children who received a score of 400 or
above (\( M = 416.86 \) points, \( SD = 11.86 \) points, range = 402-471 points) were included in
the study indicating that they met the state standards for reading skills (Ohio Department
of Education) and the rest were excluded. Only 53 children met all the inclusionary
criteria for the study. Thus, this study includes data from a subset of a larger population.

Fifty three typically developing children from grade 3 (\( M \) age = 8.97 years, \( SD = 
0.45 \) years, range = 8.10-9.90 years) were included in the final data analysis. Further, all
included children were monolingual and native speakers of English. A total of 23 boys
and 30 girls participated in the study. Most of the children who participated in the study
were White (98.1%). Further, the three elementary schools that participated in this study
had a significant percentage of economically disadvantaged children in their schools (i.e.,
number of students receiving free lunch). The percentages were 71.5%, 75.6% and
50.6%, respectively (http://vinton.k12.oh.us/).

**Stimuli**

A 70-item task was developed for this study. There were three experimental sub-
tasks of 20 items each. In addition, the first experimental task included 10 foil items.
Each task contained an equal number of transparent and opaque target derived words.
The root word in each word pair was a high frequency word, and the derivative was a low
frequency word. The standard frequency index (SFI) was used as a measure of frequency
for both root and derived words. The SFI values for all stimulus words were obtained
from the *American Heritage Word Frequency Book* (Carroll, Davies, & Richman, 1971). For the present study, any word with a SFI of 50 or higher (i.e., occurring at least once in 100,000 words of text) was considered to be a high frequency word and any word with a SFI lower than 37.0 (i.e., occurring less than once in 1 million words of text) was considered a low frequency word (standards similar to Larsen & Nippold, 2007; Ram et al., 2013; Windsor, 2000). The stimulus words are shown in Table 1. In addition, the mean frequency values (i.e., SFI values) for transparent and opaque words are listed in Table 2.

The phonologically opaque derived words were formed by the addition of a non-neutral suffix to a root word that resulted in stress and/or vowel change in a derived word (e.g., *final-finality*). The phonologically transparent words were formed by the addition of a neutral suffix to a root word (e.g., *payable*). Target derived words for all three tasks were matched for grammatical class. Five neutral and non-neutral suffixes each were used to create the target derived words for the three tasks. There were two target derived words for each suffix resulting in 10 transparent and 10 opaque derived words for each task. Further, only productive suffixes (i.e., for both neutral and non-neutral) were used to form derived words. Additionally, all of the stimulus words were single derivatives with the exception of *methodical* and *orchestration*. 
Table 1

*Transparent and Opaque Derived Words for Each Task*

<table>
<thead>
<tr>
<th>Relational task</th>
<th>Syntactic task</th>
<th>Distributional task</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transparent</td>
<td>Opaque</td>
<td>Transparent</td>
</tr>
<tr>
<td>Transparent</td>
<td>Opaque</td>
<td>Transparent</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>alertness</th>
<th>angelic</th>
<th>crawly</th>
<th>actuality</th>
<th>accountable</th>
<th>acidity</th>
</tr>
</thead>
<tbody>
<tr>
<td>allowable</td>
<td>beautify</td>
<td>exactness</td>
<td>approximation</td>
<td>artful</td>
<td>consultation</td>
</tr>
<tr>
<td>anciently</td>
<td>cyclic</td>
<td>fateful</td>
<td>conceptual</td>
<td>believer</td>
<td>continuity</td>
</tr>
<tr>
<td>breakable</td>
<td>finality</td>
<td>hurtful</td>
<td>estimation</td>
<td>beastly</td>
<td>emphatic</td>
</tr>
<tr>
<td>brotherly</td>
<td>floatation</td>
<td>packer</td>
<td>echoic</td>
<td>blocker</td>
<td>glorify</td>
</tr>
<tr>
<td>eventful</td>
<td>limitation</td>
<td>payable</td>
<td>habitual</td>
<td>flavorful</td>
<td>medicinal</td>
</tr>
<tr>
<td>harvester</td>
<td>signify</td>
<td>preventable</td>
<td>liquefy</td>
<td>harshness</td>
<td>orchestration</td>
</tr>
<tr>
<td>knocker</td>
<td>methodical</td>
<td>shortness</td>
<td>telescopic</td>
<td>remotely</td>
<td>schematic</td>
</tr>
<tr>
<td>quickness</td>
<td>modernity</td>
<td>hugely</td>
<td>totality</td>
<td>sharpness</td>
<td>solidify</td>
</tr>
<tr>
<td>trustful</td>
<td>triumphal</td>
<td>trucker</td>
<td>typify</td>
<td>wearable</td>
<td>spatial</td>
</tr>
</tbody>
</table>


Table 2

Mean Scores of Root and Derived Word Frequencies for Each Task

<table>
<thead>
<tr>
<th></th>
<th>Relational task</th>
<th>Syntactic task</th>
<th>Distributional task</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Root</td>
<td>Derived</td>
<td>Root</td>
</tr>
<tr>
<td></td>
<td>MSFI (SD)</td>
<td>MSFI (SD)</td>
<td>MSFI (SD)</td>
</tr>
<tr>
<td>Transparent</td>
<td>54.57 (4.05)</td>
<td>31.89 (3.79)</td>
<td>57.00 (4.28)</td>
</tr>
<tr>
<td>Opaque</td>
<td>55.21 (4.78)</td>
<td>32.61 (4.27)</td>
<td>54.21 (3.50)</td>
</tr>
<tr>
<td>p-value</td>
<td>0.46</td>
<td>0.36</td>
<td>&lt; 0.001**</td>
</tr>
</tbody>
</table>

Note: * significant t-test at 0.01 level; ** significant t-test at 0.001 level.

The transparent and opaque derivatives were matched for root word and derived word frequency as well as for semantic opacity. Results from t-tests indicated no significant differences between the SFI mean values for root and derived words for all three tasks except the mean frequencies of root words on the syntactic knowledge task and the mean frequencies of derived words on the distributional task. The p values for t-tests are indicated in Table 2. Semantic opacity was determined using a 5-point Likert rating scale with a score of “0” representing “minimal similarity in meaning between the base and the derived word” and “4” representing “maximal similarity in meaning between the base and derived word.” Ten adult native speakers of English were asked to judge the semantic relation between the root word and the derived word for all 60 target derived words. In addition 20 foil items (e.g., cape-capable) were added to the list to balance the number of words with transparent and opaque relations. All the raters were
given individual booklets containing a list of 80 derived words and were asked to circle
the corresponding number for each derived word in their booklets. The primary
investigator explained the task and did two practice items with the entire group. Any
questions regarding the rating scale were clarified before the raters were asked to mark
their responses. The mean rating score for the transparent and opaque derived words was
3.80 points, SD = 0.25 points and 3.69 points, SD = 0.17 points, respectively. A t-test
confirmed that the means were not significantly different, t(18) = 1.15, p > 0.05. See
Appendix B1 for sample of the semantic opacity rating scale.

In addition, the same 10 speakers were also asked to rate the phonological opacity
of all 60 target derived words. A 5-point Likert rating scale similar to the one used for
semantic opacity rating was used to rate the phonological opacity of all the derived
words. In the phonological opacity rating scale, “0” represented “minimal similarity (i.e.,
minimal similarity between the pronunciation of the base and the derived word”) and “4”
represented “maximal similarity (i.e., the base word is pronounced exactly the same in
the derivative as when it is said by itself). Again, the primary investigator explained the
rating scale and did two practice items with the group before they marked their responses.
The mean rating for the transparent and opaque derived words was 3.86 points, SD = 0.13
points and 2.26 points, SD = 0.53 points respectively. A t-test indicated that the means
were significantly different, t(18) = 9.27, p > 0.05. See Appendix B2 for sample of the
phonological opacity rating scale.

Each derived word appeared in a sentence for experimental tasks 1 and 2. The
sentences were controlled for length, contextual support, and word familiarity. There was
one exposure of the target derived word at or near the end of each sentence. The average
number of words/sentence was balanced for transparent and opaque derived words and across tasks as well. For example, the sentences for the relational knowledge task included 9-10 words each on average \((M = 9.4\text{ words})\). Similarly, the sentences for the syntactic knowledge task included 10-11 words each on average \((M = 10.65\text{ words})\). Words familiar to a first grader were used to construct sentences. Word familiarity was determined using the *Vocabulary of First-Grade Children* corpus (Moe, Hopkins, & Rush, 1982). Further, all target derived words were controlled for syllable length across tasks to the greatest extent possible. Three separate \(t\)-tests were conducted to compare syllable lengths across tasks. Results indicated no significant difference in syllable lengths between transparent and derived words across all three tasks, \(t (18) = 0.41, p > 0.05, t (18) = 1.42, p > 0.05\) and \(t (18) = 1.43, p > 0.05\) respectively for the three tasks.

**Tasks and Measures**

**Screening Tool.** The CCC-2 (Bishop, 2003) is a standardized caregiver response form used with children aged between 4;0 to 16;11 years. The CCC-2 was used as a screening tool to document typical speech and language development of children participating in the study. Any questions regarding the questionnaire were clarified by the investigator. Two types of composite scores were calculated including the general communication composite score (GCC) and social interaction difference index (SIDI). The GCC is a norm-referenced composite score with mean of 100 and standard deviation of 15. SIDI is a special index computed to identify children with communication impairments or autism. The scores were interpreted according to the guidelines indicated in the test manual. Children who obtained a GCC score of +/- 1 SD above or below the
mean were included in the study ($M = 111.37$ points, $SD = 12.16$ points). In addition, all children who scored within typical limits on the SIDI were included in the study.

**Relational Knowledge Task.** Relational knowledge was measured using two subtasks including root word identification and suffix identification. The purpose of the root word identification and suffix identification tasks were to measure the ability of children to identify root words and suffixes accurately. Both these subtasks were adapted from the base production and the suffix identification tasks used by Windsor (2000). For both subtasks, children first heard the stimulus word (e.g., *natural*) and then heard a sentence containing the stimulus word, followed by the stimulus word again (i.e., *natural*). For example, *natural* . . . *The fifth grade students won a prize for their science project on natural disasters* . . . *natural*. The derived word (e.g., *natural*) and the sentence containing the derived word were printed in the test booklet given to each child. Further, the target derived word was underlined and printed in bold for both subtasks.

On the root word identification task booklets, below each sentence, the following two multiple-choice options were printed, “a) The smaller, related word is ______ and b) There is no smaller, related word.” Children were instructed as follows: “select choice “a” if you think there is a smaller, related word to the underlined word (Windsor, 2000; p. 54). Please write the related word in the blank provided. Select choice “b” if you think the underlined word does not contain a smaller, related word. On the suffix identification subtask, children heard a list of four suffix choices or “word endings” after each target sentence (e.g., -al, -ral, -tural, no suffix). These four suffixes were also printed in the test booklets as multiple choice options. Children were instructed as follows, “Please circle the correct word ending or suffix of the underlined word (e.g., *natural*) in your booklets.
Sometimes, a word might not have a word ending. In that case, please circle ‘no suffix’ in your booklet.” Children were not asked to provide a verbal response in order to avoid additional confounds due to pronunciation errors. A similar procedure was used for both transparent and opaque derived words. The entire relational knowledge task included a total of 30 derived words: 10 transparent, 10 opaque, and 10 foil words. The foil words were all pseudo-derived words (e.g., jackal, corner, capable). They were included as an additional control measure for testing relational knowledge of children. For example, if a child correctly rejects jackal by indicating it includes no smaller related word, then there is evidence of relational knowledge. Further, given that the relational knowledge task was a multiple choice option task with two options (with the options being a: “The smaller, related word is _______ and b: There is no smaller, related word”), the foil words were included to balance the derived words with pseudo-derived words so that the children had the opportunity to select “b” as the correct answer. Children were tested on the exact same items for root word identification and suffix identification subtasks. All audio instructions were recorded by a native speaker and played to a group of participants via standard speakers. Both subtasks were printed on separate test booklets and administered on different days to avoid influencing performance on either task. For example, on the suffix identification task, the suffix choices were printed under each sentence; seeing those options may have acted as a clue to identify the root word which was a more “open ended” response task. In order to avoid such unintentional clues, separate test booklets were created for each task. See Appendix C1 and C2 for sample relational knowledge test booklets (i.e., tasks 1 and 2).
Syntactic Knowledge Task. This task was similar to the sentence completion task used by Carlisle (1995). The requirement of this task was to complete a sentence with a correct derived form of a root word from a choice of four derived words. In this task, children heard a root word followed by a sentence. Following the sentence, children heard four multiple choice options. All four options were derivatives of the same root word but differed in their suffixes and hence their syntactic categories. The root word, the sentence, and the multiple choice options were all printed in the test booklet given to each child. Children were instructed to complete the sentence by circling the correct derived word from the given four choices. For example, acid . . . Julia ate a piece of orange and she said it was ___ (acidic, acidly, acidity, acidify). The task consisted of 20 derived words, 10 transparent, and 10 opaque derived words. Syntactic structure was controlled by limiting each sentence to no more than two independent clauses, and not including sentences with passive structures. Further, the blank occurred as the last word of the sentence, or near the end of the sentence. See Appendix D for sample task 3 test booklet.

Distributional Knowledge Task. This task was designed by the authors specifically to measure children’s knowledge of distributional constraints of different suffixes that form derived words. In this task, children heard a root word followed by four suffixes. The root word and the suffix options were printed in match-the-column format in the test booklet given to each child. The child’s task was to match the root word with a suffix to form a derived word. Only one of the four suffixes formed an English word with the root word. Children were instructed as follows: “Please match the word in column A with one word ending or suffix from column B to form a new word.” For example, match the word rare with any one of the following suffixes (i.e., -ify, -ize, -ity, -
ic) to form a new word (target word *rarity*). The accuracy of matching a root word with a correct suffix provided information regarding the ability of children to distinguish between English and nonce words, thereby providing a measure of their distributional knowledge. See Appendix E for sample task 4 test booklet.

**Reading Measure: Decoding.** The *letter-word identification* subtest and the *word attack* subtest of the *Woodcock-Johnson Tests of Achievement III* (Woodcock, McGrew, & Mather, 2001) were used as measures of word and nonword reading respectively. Both these subtests are untimed standardized measures of decoding abilities in children. Further, both these subtests have been used as measures of decoding abilities of children in previous studies investigating the relation between morphological awareness and reading skills (e.g., McCutchen et al., 2008; Windsor, 2000). In the letter-word identification task, children were required to read out aloud words printed on a page. In the word attack subtest, children were asked to read nonsense words out loud. Responses on both the subtests were scored according to the criteria described in the test manual. The reliability coefficients for the *letter-word identification* subtest and *word attack* subtests are 0.94 and 0.87 respectively.

**Reading Measure: Comprehension.** The *passage comprehension* subtest of the *Woodcock-Johnson Tests of Achievement III* (Woodcock, McGrew, & Mather, 2001) was used to measure reading comprehension skills. This task required children to complete a sentence with a correct word after reading a sentence or a short passage. The passage length increased as the test progressed. This subtest is also a standardized measure of reading comprehension in children. The reliability coefficient of this subtest is 0.88.
Measure of Phonological Abilities. The Comprehensive Test of Phonological Processing (Wagner et al., 1999) was used as a measure of phonological skill of children. In this study, the elision and blending subtests were used as measures of phonological awareness. The elision subtest is a 20-item subtest measuring the ability of children to pronounce words without specific sounds. For example, children first heard the word “bold” and then were instructed to “say bold without /b/” (p. 10). The elision subtest has an alpha coefficient of .89 for 9-year olds and .91 for 10-year olds. The blending subtest is a 20-item subtest that required children to blend parts of a word together and produce the correct word. For example, children were asked, “what words do these sounds make: t-oi?” (p. 10). The correct answer is toy. The blending subtest has an alpha coefficient of .83 for 9-year olds and .87 for 10 year olds.

General Procedure

The investigators obtained consent from the parents and assent from children to participate in the study. The primary investigator also collected the CCC-2 questionnaire forms from the parents before testing children. The experimental tasks were administered in group fashion in a public school classroom. All participating children were given test booklets containing the experimental tasks. First, all children were instructed to fill out the first page which contained basic information regarding the child (i.e., name, age). At this point, the primary investigator instructed the participants to turn to the next page which included the practice items for the first experimental task (i.e., relational knowledge task). The primary investigator explained the task with the help of two practice items. After explaining the practice items, she gave time for the children to ask questions regarding the task. Additionally, all participating children were asked to say
“yes” if they understood the task following which the investigator presented the test items for the first task (i.e., played the recording). All stimuli items for the experimental tasks were presented through standard speakers. Children first heard a “beep” followed by the stimulus item and then heard a silent pause. “Silent pauses” of 30 seconds were built into the recording to control for the time of response for each item. Children were instructed to mark their responses during the silent phase. They heard a “beep” before the start of the next stimulus item. Throughout the task, all children were strictly instructed to refrain from turning the page until they are asked to do so. Upon completion of the first experimental task, children were given a short break. The second and third experimental tasks were administered in a similar fashion. At the end of each experimental task, the investigator collected the test booklets back before beginning the next task. All children followed the testing protocol as instructed by the investigator. The experimental tasks took about 20-25 minutes each on average to complete. The root word identification subtask and syntactic knowledge task were administered on day 1 whereas the suffix identification subtask and distributional knowledge task were administered on day 2 of group testing. The root word identification and suffix identification tasks were administered on different days to avoid learning effects and repetition of stimuli (i.e., over exposure) since both the tasks had the same stimuli words and sentences. Also, only two tasks were administered on a single day to avoid test fatigue.

The reading measures and the phonological tests were administered on an individual basis in a quiet room within the school premises as a separate session. Standard testing protocols as instructed in the test manuals were followed. On average, the reading and phonological tests took about 25-30 minutes per child.
Scoring

All three experimental tasks were multiple choice tasks, thus there was one correct answer for each question. Each correct response was given a score of 1 and an incorrect answer was scored as 0. Notably, for the relational knowledge task, an item was given a score of 1 only if a child was correct for both subtasks (i.e., root identification and suffix identification). For example, if a child identified the root word in *eventful* as *even* but circled *-ful* as the answer on the suffix identification task, the item was scored as 0 because the child made an error on the root word identification subtask. Even though partial credit (0.5 points) was given for correctly identifying the suffix; it was not used in the final analyses. This information was used to obtain a better understanding of error patterns in children’s responses. Given that the root word identification subtask was an open ended task (i.e., children had to write the root word in the blank) a few additional guidelines were followed during the scoring of items on this subtask. For example, no credit was given for identifying “any smaller word” as the root word (i.e., *even* in *eventful*, *all* in *allowable*, *mode* in *modernity*). Further, no credit (i.e., scored as 0 points) was given for spelling errors in writing the root word except for the following errors, “*cyl*” for “*cycle*” in *cyclic* and “*beauti*” for “beauty” in *beautify*. Credit was given to these spelling errors after confirming with the school teachers regarding the spelling rules/skills taught to children. Teachers from the three schools indicated that these spelling errors were common for children in grade 3. Examples of spelling errors that were not given credit include “*trump*” for “*triumph*” in *triumphal*, “*moder*” for “*modern*” in *modernity*. These responses were scored as incorrect and given a score a 0 because often they reflected a deeper conceptual error than a spelling error. For example,
children often also made a corresponding error in identifying the suffix correctly for these words. That is, the child selected “hal” as a suffix for *triumphal*, “nity” as the suffix for *modernity*. In an attempt to keep the scoring consistent across the items, all such spelling errors were scored as 0.

A total of six scores were computed; the maximum possible score for each was 10. These included transparent relational knowledge score, transparent syntactic knowledge score, transparent distributional knowledge score, opaque relational knowledge score, opaque syntactic knowledge score, and opaque distributional knowledge score. Thus, a maximum of 20 points was possible for each task (i.e., relational knowledge, syntactic knowledge, and distributional knowledge) and a total score of 60 was possible for the entire protocol. Further, the standardized assessments including decoding, reading comprehension, and phonological awareness subtests were scored according to the guidelines indicated in their respective test manuals. Notably, the computer scoring software was used to calculate the standardized and the composite scores for the reading subtests.

**Reliability**

To check scoring reliability, 30% of the total experimental data (i.e., 10% from each task) was analyzed by a trained graduate student using the same scoring guidelines. The graduate student was given the answer key and scoring guidelines used by the investigator to aid the scoring process. The graduate student remained blind to the primary investigator’s scores. Interscorer agreement was 95.83% between the graduate student’s scores and the primary investigator’s scores. Any disagreement was resolved through discussion.
Internal consistency of the assessment protocol was measured by computing the split-half reliability all the three tasks. The split-half reliability correlation coefficient for the three experimental tasks (i.e., relational knowledge, syntactic knowledge, and distributional knowledge) was found to be 0.48, 0.49, and 0.16, respectively. The correlation coefficient for the distributional task was low. It may be attributed to the fact that this task was a new task developed by the authors. However, limited information is available in the extant literature regarding tasks used to measure distributional knowledge in children. Finally, Cronbach’s alpha (α) was calculated as an additional measure of internal consistency for the entire assessment protocol (i.e., all 60 items) and was 0.67 indicating that the internal consistency of the complete assessment protocol was within the acceptable range (Cronbach, 1951).

**Data Analyses**

The independent variables in the present study were type of morphological knowledge (relational, syntactic, distributional) and opacity (transparent, opaque). The dependent variables were decoding and reading comprehension scores. Data were analyzed using General Linear Models (GLMs), correlation, and regression analyses. The SPSS 18 software was used to analyze all data.

To examine the difference in performance between transparent and opaque derived words, a one-way ANOVA (i.e., transparent score vs. opaque score) was conducted. In addition, three separate GLMs (i.e., repeated measures ANOVA) for each morphological task (i.e., relational, syntactic knowledge, distributional knowledge) were conducted with opacity (transparent, opaque) as the within-subjects factor.
The contributions of different types of morphological knowledge and phonological awareness to reading as investigated using correlational and regression analyses. First, correlational analyses were conducted to explore the relation between the scores obtained on the three experimental tasks, reading measures, and phonological awareness scores. This was followed by conducting two separate hierarchical regression analyses; one for decoding and one for reading comprehension. The correlation analyses were also used as a guide to enter variables into the regression models. For both models, the control variable of phonological ability score (i.e., score on CTOPP) was added first to the model. The predictor variables included scores on each of the morphological tasks (i.e., relational, syntactic, and distributional) for transparent words and opaque words that correlated with the dependent variables. The predictor variables representing scores for the transparent words were entered first followed by the variables representing scores for the opaque words.
Chapter 4: Results

Standardized Measures

The standard scores for the standardized tests and mean raw scores for the experimental tasks along with their standard deviations for all participants are located in Table 3. The decoding cluster score is a combination of standard scores obtained on the word identification and word attack subtests of the *Woodcock-Johnson Tests of Achievement III* (Woodcock, McGrew, & Mather, 2001). Similarly, the phonological awareness cluster score is a combination of standard scores obtained on the Elision and Blending subtests of *The Comprehensive Test of Phonological Processing* (Wagner et al., 1999).

Performance on Transparent Versus Opaque Words

In our first research question, we were interested in whether there would be significant differences between the scores obtained on transparent and opaque derived words across all three experimental tasks. A repeated measures ANOVA was conducted to examine the difference in the total performance scores between transparent and opaque derived words. Effect sizes, measured by partial eta squared ($\eta^2$) were characterized using Cohen’s (1988) criteria (small = .01-.05, medium = .06 -.13, large > .13). The results of the ANOVA revealed a significant difference between the total scores obtained on transparent and opaque derived words, $F(1, 52) = 956.29, p <0.001$ ($\eta^2 = 0.94$), with children achieving higher scores on transparent derived words ($M = 23.87, SD = 2.96$) as compared to opaque derived words ($M = 9.64, SD = 3.33$). The effect size was large (Cohen, 1988).
In addition, three separate repeated measures ANOVA (i.e., one for each morphological task) were conducted with opacity (transparent, opaque) as the within-subjects factor. The results revealed significant effects for opacity for all three morphological knowledge tasks with $F(1, 52) = 414.20, p < 0.001$ ($\eta^2 = 0.88$), $F(1, 52) = 173.84, p < 0.001$ ($\eta^2 = 0.77$), and $F(1, 52) = 391.23, p < 0.001$ ($\eta^2 = 0.88$), respectively for relational, syntactic, and distributional knowledge tasks. The effect sizes were large (Cohen, 1988). Additionally, children obtained higher scores on transparent derived words as compared to opaque derived words on all three tasks of morphological knowledge. Refer to Table 3 for means and standard deviations of scores obtained on transparent and opaque derived words.

Lastly, we conducted a repeated measures ANOVA to examine the differences in the type of morphological knowledge according to task (i.e., relational, syntactic, distributional) as the within-subject variable. Results indicated a significant main effect for type of knowledge, $F(2, 104) = 17.81, p < 0.001$ ($\eta^2 = 0.25$). The effect size was large (Cohen, 1988). On examining overall performance across the three tasks, it was noted that children obtained significantly higher total scores on syntactic ($M = 12.53, SD = 2.79$) as compared to relational ($M = 11.06, SD = 2.86$), $t(104) = 2.67, p < 0.001$ or distributional tasks ($M = 9.92, SD = 1.92$), $t(104) = 5.61, p < 0.001$. Further, performances on all three tasks were significantly different from each other at 95% confidence interval level. Refer to Figure 2 for a graphical representation of the mean performance scores of all the participants on the three tasks measuring morphological knowledge.
Table 3

Mean Performance Scores and Standard Deviations

<table>
<thead>
<tr>
<th>Measure</th>
<th>Mean score (SD)</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Word identification&lt;sup&gt;a&lt;/sup&gt;</td>
<td>106.85 (8.34)</td>
<td>92-135</td>
</tr>
<tr>
<td>Word attack&lt;sup&gt;a&lt;/sup&gt;</td>
<td>108.17 (10.20)</td>
<td>94-136</td>
</tr>
<tr>
<td>Decoding cluster&lt;sup&gt;a&lt;/sup&gt;</td>
<td>108.19 (9.49)</td>
<td>94-139</td>
</tr>
<tr>
<td>Reading comprehension&lt;sup&gt;a&lt;/sup&gt;</td>
<td>101.45 (7.30)</td>
<td>85-118</td>
</tr>
<tr>
<td>Phonological awareness cluster&lt;sup&gt;a&lt;/sup&gt;</td>
<td>102.49 (10.10)</td>
<td>76-127</td>
</tr>
<tr>
<td>Relational knowledge score for transparent items&lt;sup&gt;b&lt;/sup&gt;</td>
<td>8.26 (1.81)</td>
<td>4-10</td>
</tr>
<tr>
<td>Relational knowledge score for opaque items&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.79 (1.65)</td>
<td>0-7</td>
</tr>
<tr>
<td>Syntactic knowledge score for transparent items&lt;sup&gt;b&lt;/sup&gt;</td>
<td>8.02 (1.48)</td>
<td>4-10</td>
</tr>
<tr>
<td>Syntactic knowledge score for opaque items&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4.51 (1.88)</td>
<td>1-8</td>
</tr>
<tr>
<td>Distributional knowledge score for transparent items&lt;sup&gt;b&lt;/sup&gt;</td>
<td>7.58 (1.36)</td>
<td>4-10</td>
</tr>
<tr>
<td>Distributional knowledge score for opaque items&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.34 (1.35)</td>
<td>0-6</td>
</tr>
<tr>
<td>Total morphological score&lt;sup&gt;c&lt;/sup&gt;</td>
<td>33.51 (5.35)</td>
<td>21-44</td>
</tr>
<tr>
<td>Total transparent score&lt;sup&gt;d&lt;/sup&gt;</td>
<td>23.87 (2.36)</td>
<td>16-29</td>
</tr>
<tr>
<td>Total opaque score&lt;sup&gt;d&lt;/sup&gt;</td>
<td>9.64 (3.33)</td>
<td>4-18</td>
</tr>
</tbody>
</table>

<sup>Note</sup>. <sup>a</sup>Standard score \( (M = 100, SD = 10) \); <sup>b</sup>raw Score (maximum possible = 10); <sup>c</sup>raw score (maximum possible = 60); <sup>d</sup>raw score (maximum possible = 30).
Morphological Knowledge and Reading Performance

In our second research question, we were interested in identifying significant predictors of reading skills in children. The contribution of three types of morphological knowledge and phonological awareness as potential predictors of reading skills in children were investigated using correlational and regression analyses. First, correlational analyses were conducted to explore the relation between the scores obtained on the three experimental tasks, reading measures and phonological awareness scores. This was followed by conducting two separate hierarchical regression analyses; one for decoding and one for reading comprehension. The correlation analyses were used as a guide to

Figure 2. Mean performance scores of all participants on tasks measuring morphological knowledge. Maximum possible score for transparent and opaque derived words for each task was 10. Maximum possible total score for each task was 20.
enter variables into the regression models. The results obtained from these two sets of analyses are described below.

**Correlational Analyses.** Zero-order Pearson correlations were conducted on all measures and are shown in Table 4. The cluster scores represent decoding and phonological awareness skills instead of the individual subtest scores. As indicated in Table 4, significant moderate correlations were noted between decoding abilities of children and their phonological awareness skills, $r (51) = 0.42, p < 0.01$, as well as performance on transparent, $r (51) = 0.46, p < 0.05$, and opaque items on the syntactic knowledge task, $r (51) = 0.43, p < 0.05$. Further, significant weak to moderate correlations were obtained between children’s decoding skills and their performance on transparent items on the relational knowledge task, $r (51) = 0.35, p < 0.05$. Similarly, significant weak to moderate correlations were obtained between passage comprehension abilities of children and their phonological awareness skill, $r (51) = 0.32, p < 0.001$, and their performance on opaque items on the syntactic knowledge task $r (51) = 0.30, p < 0.05$. Further, significant moderate correlations were noted between children’s passage comprehension abilities and their performance on transparent items on the syntactic knowledge task, $r (51) = 0.44, p < 0.05$. Performance on the distributional task (i.e., both transparent and opaque items) did not correlate significantly with either decoding or passage comprehension skills in children and hence these scores were not included in the regression analyses. The lack of correlation between distributional knowledge tasks and reading measures may be attributed to low internal consistency of the distributional task.
### Table 4

*Correlations Between Reading Skills, Phonological Awareness (PA) and Morphological Knowledge Tasks for Transparent (T) and Opaque (O) Derived Words*

<table>
<thead>
<tr>
<th>Measure</th>
<th>Passage comprehension</th>
<th>Decoding</th>
<th>PA</th>
<th>Rel (T)</th>
<th>Rel (O)</th>
<th>Syn (T)</th>
<th>Syn (O)</th>
<th>Dist (T)</th>
<th>Dist (O)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passage comprehension</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decoding</td>
<td>0.65**</td>
<td>1</td>
<td>0.32*</td>
<td>0.42**</td>
<td>0.24</td>
<td>0.01</td>
<td>0.23</td>
<td>0.24</td>
<td>0.36**</td>
</tr>
<tr>
<td>PA</td>
<td></td>
<td></td>
<td>0.42**</td>
<td></td>
<td></td>
<td>0.35**</td>
<td></td>
<td>0.19</td>
<td>1</td>
</tr>
<tr>
<td>Rel (T)</td>
<td></td>
<td></td>
<td>0.19</td>
<td>0.22</td>
<td>0.36**</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rel (O)</td>
<td></td>
<td></td>
<td>0.24</td>
<td>0.36**</td>
<td>0.36**</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Syn (T)</td>
<td></td>
<td></td>
<td>0.03</td>
<td>0.03</td>
<td>0.06</td>
<td>0.09</td>
<td>0.16</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Syn (O)</td>
<td></td>
<td></td>
<td>0.43*</td>
<td>0.47**</td>
<td>0.41**</td>
<td>0.33*</td>
<td>0.36**</td>
<td>1</td>
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</tr>
<tr>
<td>Dist (T)</td>
<td></td>
<td></td>
<td>0.02</td>
<td>0.06</td>
<td>0.04</td>
<td>0.04</td>
<td>0.12</td>
<td>-0.005</td>
<td></td>
</tr>
<tr>
<td>Dist (O)</td>
<td></td>
<td></td>
<td>0.09</td>
<td>0.36**</td>
<td>0.36**</td>
<td>0.36**</td>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note.* **Correlations significant at 0.001 level (2-tailed); *correlations significant at 0.05 level (2-tailed). T = transparent; O = opaque; PA = phonological awareness; Rel (T) = relational transparent; Rel (O) = relational opaque; Syn (T) = syntactic transparent; Syn (O) = syntactic opaque; Dist (T) = distributional transparent; Dist (O) = distributional opaque.*
**Regression Analyses.** The contributions of phonological awareness and morphological knowledge in predicting reading skills in children were analyzed using hierarchical regression analyses. The effect sizes for each model on addition of a predictor were calculated using the formula, \( f^2 = \Delta R^2 / 1 - R^2 \). Cohen’s (1988) guidelines were used to interpret the effect sizes: small = 0.02, medium = 0.15, large = 0.35. The summary of the regression analyses for decoding and reading comprehension are displayed in Tables 5 and 6, respectively.

**Model for decoding.** Table 5 is a summary of hierarchical regression for decoding. In Model I, phonological awareness (PA) significantly accounted for 18% of the variance in decoding with medium to a large effect size, \( p < 0.001 \). In addition, model I was a significant predictor of decoding skills in children, \( F(1, 51) = 11.53, p < 0.001 \).

Further, as indicated in Model II, together with phonological awareness, performance on transparent derived words from relational (Rel T) and syntactic knowledge (Syn T) tasks significantly accounted for 34% of variance in decoding skills in children with a medium to a large effect size, \( p < 0.05 \). Specifically, performance on the transparent derived words (i.e., relational and syntactic) significantly explained 16% of the unique variance in decoding skills in children. Additionally, all three predictors together significantly predicted decoding skills in children, \( F(3, 49) = 8.56, p < 0.001 \). Lastly, as seen in Model III, together the predictors (i.e., phonological awareness, performance on relational transparent, syntactic transparent, and syntactic opaque derived words) accounted for 36% of variance in decoding skills of children with a small to a medium effect size. Performance on syntactic opaque items (Syn O) did not account for additional significant unique variance in decoding (i.e., \( p > 0.05 \)) than that explained by the transparent scores.
and phonological awareness. Together as a model, however, the variables significantly predicted decoding skills in children, $F(4, 48) = 6.82, p < 0.01$. This suggested that there was at least one significant predictor of decoding skills among the four predictors.

The individual coefficients of each predictor provided valuable information in identifying significant predictors of decoding in each model. As seen in Table 5, in Model I, phonological awareness was a significant predictor of decoding skill in children ($\beta = 0.42, p < 0.01$). Upon adding the transparent scores to the model (i.e., Model II), only phonological awareness ($\beta = 0.26, p < 0.05$) and syntactic transparent score ($\beta = 0.31, p < 0.05$) still uniquely predicted decoding skills in children. Upon adding syntactic opaque scores to the model (i.e., Model III), only syntactic transparent score continued to be a significant unique predictor of decoding skill in children ($\beta = 0.28, p < 0.05$).
Table 5

**Summary of Hierarchical Regression Predicting Decoding Skills in Children**

<table>
<thead>
<tr>
<th>Variable</th>
<th>$R^2$</th>
<th>$Adj. R^2$</th>
<th>$\Delta R^2$</th>
<th>$F$</th>
<th>$\Delta F$</th>
<th>b</th>
<th>SE. b</th>
<th>$\beta$</th>
<th>T</th>
<th>$f^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model I</td>
<td>0.18</td>
<td>0.16</td>
<td>0.18</td>
<td>11.53**</td>
<td>11.53**</td>
<td>0.40</td>
<td>0.11</td>
<td>0.42</td>
<td>3.39**</td>
<td>0.21</td>
</tr>
<tr>
<td>PA</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model II</td>
<td>0.34</td>
<td>0.30</td>
<td>0.16</td>
<td>8.56**</td>
<td>5.96**</td>
<td>0.25</td>
<td>0.11</td>
<td>0.26</td>
<td>2.11*</td>
<td>0.24</td>
</tr>
<tr>
<td>PA</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rel (T)</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>1.24</td>
<td>0.62</td>
<td>0.23</td>
<td>1.97</td>
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<tr>
<td>Syn (T)</td>
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<td></td>
<td></td>
<td></td>
<td>1.99</td>
<td>0.80</td>
<td>0.31</td>
<td>2.47*</td>
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<tr>
<td>Model III</td>
<td>0.36</td>
<td>0.30</td>
<td>0.01</td>
<td>6.82**</td>
<td>1.37</td>
<td>0.20</td>
<td>0.12</td>
<td>0.21</td>
<td>1.59</td>
<td>0.03</td>
</tr>
<tr>
<td>PA</td>
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</tr>
<tr>
<td>Rel (T)</td>
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<td></td>
<td></td>
<td></td>
<td>0.97</td>
<td>0.66</td>
<td>0.18</td>
<td>1.46</td>
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<tr>
<td>Syn (T)</td>
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<td></td>
<td>1.81</td>
<td>0.81</td>
<td>0.28</td>
<td>2.22*</td>
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<tr>
<td>Syn (O)</td>
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<td>0.83</td>
<td>0.70</td>
<td>0.16</td>
<td>1.17</td>
<td></td>
</tr>
</tbody>
</table>

*Note.** Predictor/ model significant at 0.001 level; *predictor/ model significant at 0.05 level. Effect size $f^2 = \Delta R^2 / 1 - R^2$; small $f^2 = 0.02$; medium $f^2 = 0.15$; and large $f^2 = 0.35$ (Cohen, 1988). PA = phonological awareness; Rel (T) = relational transparent; Syn (T) = syntactic transparent; Syn (O) = syntactic opaque.*
**Model for reading comprehension.** Table 6 is a summary of hierarchical regression for passage comprehension. In Model I, phonological awareness (PA) explained 10% of the variance in reading comprehension skill in children, $p < 0.05$, with a small to a medium effect size. Further, Model I (i.e., phonological awareness) was found to be a significant predictor of reading comprehension, $F(1, 51) = 5.91, p < 0.05$. In addition, when performance on syntactic transparent derived words (SynT) was added to the model, both predictors (i.e., phonological awareness and performance on syntactic transparent derived words) together significantly accounted for 22% of variance in reading comprehension abilities in children, $p < 0.05$, with a medium effect size. Specifically, syntactic transparent performance accounted for 12% unique variance in reading comprehension abilities in children. Overall, Model II, including phonological awareness and performance on syntactic transparent derived words was found to be a significant predictor of reading comprehension abilities in children, $F(2, 50) = 7.38, p < 0.05$. Lastly, Model III including phonological awareness, performance on syntactic transparent and syntactic opaque derived words (i.e., syn O) significantly explained 23% of variance in reading comprehension skills in children, $p < 0.05$ with a small effect size. Results of Model III indicated that addition of syntactic opaque performance to the model did not account any additional significant variance in reading comprehension than that accounted for by predictors in model II. Again, Model III, which included all three predictors, significantly predicted reading comprehension, $F(3, 49) = 5.09, p < 0.05$.

Individual coefficient values were examined to identify significant unique predictors of reading comprehension at each stage of the analyses. As seen in Table 6, in Model I, phonological awareness significantly predicted reading comprehension abilities
in children ($\beta = 0.32$, $p < 0.05$). However, upon adding performance on syntactic transparent derived words to the model (i.e., Model II), phonological awareness was no longer a significant predictor of reading comprehension ($\beta = 0.18$, $p > 0.05$). Only performance on syntactic transparent items significantly predicted reading comprehension abilities in children ($\beta = 0.38$, $p < 0.05$). Further, upon adding syntactic opaque performance to the model (i.e., Model III), only performance on syntactic transparent derived words continued to be a significant predictor of reading comprehension abilities in children ($\beta = 0.35$, $p < 0.05$). Neither phonological awareness ($\beta = 0.10$, $p > 0.05$) nor syntactic opaque performance ($\beta = 0.11$, $p > 0.05$) were found to be significant predictors of reading comprehension skill in children.
Table 6

Summary of Hierarchical Regression Predicting Reading Comprehension Skills in Children

<table>
<thead>
<tr>
<th>Variable</th>
<th>$R^2$</th>
<th>$Adj. R^2$</th>
<th>$\Delta R^2$</th>
<th>$F$</th>
<th>$\Delta F$</th>
<th>$b$</th>
<th>SE. $b$</th>
<th>$\beta$</th>
<th>$t$</th>
<th>$f^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model I</td>
<td>0.10</td>
<td>0.08</td>
<td>0.10</td>
<td>5.91*</td>
<td>5.91*</td>
<td>0.23</td>
<td>0.09</td>
<td>0.32</td>
<td>2.43*</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model II</td>
<td>0.22</td>
<td>0.19</td>
<td>0.12</td>
<td>7.38*</td>
<td>8.04*</td>
<td>0.13</td>
<td>0.09</td>
<td>0.18</td>
<td>1.34</td>
<td>0.15</td>
</tr>
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<td>PA</td>
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<td></td>
</tr>
<tr>
<td>Syn (T)</td>
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<td></td>
<td>1.86</td>
<td>0.65</td>
<td>0.38</td>
<td>2.83*</td>
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<tr>
<td>Model III</td>
<td>0.23</td>
<td>0.19</td>
<td>0.01</td>
<td>5.09*</td>
<td>0.61</td>
<td>0.10</td>
<td>0.10</td>
<td>0.14</td>
<td>0.96</td>
<td>0.01</td>
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<td>PA</td>
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<td>Syn (T)</td>
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<td>1.74</td>
<td>0.67</td>
<td>0.35</td>
<td>2.56*</td>
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<tr>
<td>Syn (O)</td>
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<td></td>
<td></td>
<td>0.43</td>
<td>0.55</td>
<td>0.11</td>
<td>0.78</td>
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</tbody>
</table>

Note. **Predictor/ model significant at 0.001 level; * predictor/ model significant at 0.05 level. Effect size $f^2 = \Delta R^2/(1-R^2)$; small $f^2 = 0.02$; medium $f^2 = 0.15$; and large $f^2 = 0.35$ (Cohen, 1988). PA = phonological awareness; Syn (T) = syntactic transparent; Syn (O) = syntactic opaque.
Summary of Regression Findings

To summarize the findings of the regression analyses, phonological awareness accounted for 16% unique variance whereas morphological knowledge or performance on transparent derived words (i.e., relational and syntactic) accounted for 18% unique variance in decoding skills in school-age children. In terms of reading comprehension, phonological awareness accounted for 10% of unique variance whereas morphological knowledge (i.e., syntactic transparent derived words) accounted for 12% unique variance in passage comprehension abilities in children. Additionally, performance on opaque derived words did not account for any unique variance in decoding or passage comprehension abilities. Furthermore, only performance on transparent derived words on the syntactic knowledge task was a significant unique predictor of both decoding and passage comprehension skills in school-age children, after controlling for all other variables (i.e., phonological awareness, relational transparent derived words and syntactic opaque derived words).
Discussion

The present was designed to investigate the contributions of morphological knowledge and phonological opacity to reading skills in children in grade 3. A total of 53 typically developing children participated in the study. Results indicated children’s performance on transparent derived words significantly differed from their performance on opaque derived words for all three experimental tasks measuring three types of morphological knowledge. Additionally, children obtained the highest overall score on the syntactic knowledge as compared to relational and distributional knowledge tasks. Further, performance on transparent derived words was found to be the only unique predictor of decoding and reading comprehension, after controlling for all other predictors. Lastly, the role of phonological opacity was not clear from the findings of the study due to the low scores obtained on opaque derived words on three experimental tasks.

Performance on the Morphological Knowledge Tasks

Our first research question focused on explaining young school-age children’s performance on three different types of morphological knowledge tasks—relational, syntactic, and distributional—for transparent and opaque derived words. A unique contribution of our study was the information obtained regarding children’s knowledge of distributional constraints for transparent and opaque derived words. In each task, we found an advantage for transparency. That is, children performed better on transparent compared to opaque derivatives in identifying root words, completing sentences with the correct derived word, and identifying morphological constraints for the relational, syntactic, and distributional tasks respectively. These findings are consistent with
previous studies which have suggested that children perform better on transparent as compared to opaque derived words (Carlisle, 1995, 2000; Carlisle & Stone, 2005; Fowler & Liberman, 1995; McCutchen et al., 2008; Nagy et al., 2006; Windsor, 2000). The results of the present study indicate that young school-age children are in the process of acquiring aspects of morphological knowledge of opaque derived words including knowledge of the internal structure, the syntactic information of different suffixes, as well as distributional constraints. It has been acknowledged in the literature (Carlisle, 2000; Carlisle & Stone, 2005, Nagy et al., 2003; Windsor, 2000) that phonological opacity makes it more challenging to identify the relation between root and derived words, contributing to the difficulty for opaque words. Opaque derived words require an additional level of processing, for example, acknowledging a stress change in pronunciation of root words, as compared to transparent derived words (Jarmulowicz et al., 2008).

Interestingly, children obtained the highest overall scores (i.e., transparent and opaque words combined) on the task measuring syntactic knowledge. This is contradictory to the findings from previous studies in which children have typically performed better on relational compared to syntactic knowledge tasks (Carlisle, 1995; McCutchen et al., 2008; Nagy et al., 2003; Tyler & Nagy, 1989). There are two possible explanations to this finding, one being the scoring of the relational task in the present study. The task had two parts, namely a root word identification task and a suffix identification task. An item was scored as correct only if a child answered both parts correctly (i.e., identified both the root word and suffix correctly). Furthermore, the root word identification and suffix identification were administered on different days so
children were unable to see their answers on both parts of the task. Task-related factors have been attributed to variation in children’s performance on morphological tasks (Carlisle, 2003; McCutchen et al., 2008). Second, it is possible that this finding is related to performance on transparent and opaque words across these tasks. For instance, regarding the mean scores obtained for only transparent derived words, children obtained higher mean scores on the relational knowledge task as compared to the syntactic knowledge task. This finding is consistent with findings from previous studies in which researchers have only investigated morphological knowledge of transparent derived words (Carlisle & Fleming, 2003; Nagy et al., 2006, 2003). However, when the mean scores for opaque derived words on both the tasks were examined, children obtained higher mean scores on the syntactic knowledge task as compared to the relational knowledge task. Thus, it is possible that higher scores on the opaque derived words on the syntactic knowledge task accounted for the difference in the overall scores between syntactic and relational knowledge tasks (i.e., higher overall scores on syntactic knowledge task than relational knowledge task). This finding is interesting, given that opaque items on both tasks were relatively well balanced for the factors of frequency and productivity. Perhaps the sentence completion task with four derived word options was less challenging for children than identifying root words or suffixes for opaque derived words.

Children’s performance on the distributional knowledge task suggests that children at this age are in the process of developing an understanding of the distributional constraints in the formation of derived words, especially for opaque derived words. This is not necessarily surprising given that Tyler and Nagy (1989) found that children’s
development of distributional knowledge lagged behind relational and syntactic knowledge. Our findings are consistent with findings of McCutchen et al. (2008) in which children in grades 4 and 6 obtained the lowest scores on the distributional knowledge task as compared to relational and syntactic knowledge tasks. Importantly, our findings add to the limited literature available on children’s knowledge of distributional knowledge of derived words. Additionally, our results for the distributional tasks may also be attributed to the low internal consistency obtained for this task which could have led to unstable results.

**Contributions of Phonological Awareness and Morphological Knowledge to Reading**

**Decoding Model.** Our second research question focused on identifying predictors of decoding and reading comprehension for children in grade 3. Correlation and regression analyses were conducted to better explain the contributions of morphological knowledge and phonological awareness to the development of decoding skills. Analyses revealed significant correlations between decoding scores and phonological awareness, relational transparent scores, and syntactic transparent and opaque scores. This suggested that children’s ability to decode words and nonwords is related to knowledge of sound structure, ability to parse a derived word into its parts, and awareness of the syntactic information conveyed by suffixes. Awareness of relational and syntactic properties of derived words may aid lexical access of a derived word by facilitating recognition as well as decoding of larger units of a derived word (i.e., base word and suffix as compared to individual phonemes) (Carlisle & Stone, 2005; Kirby et al., 2012). Our findings add to the literature emphasizing the relation between
morphological knowledge and decoding during the early school-age years (Carlisle, 1995, Deacon & Kirby, 2004; Fowler & Liberman, 1995; Kirby et al., 2012; Mahony et al., 2000; McCutchen et al., 2008; Nagy et al., 2006, 2003; Singson et al., 2000; Windsor, 2000). Importantly, the findings provided valuable insights into which aspects of morphological knowledge are related to decoding skills in young school-age children.

No significant correlations were noted between performance on the distributional knowledge task and performance on decoding. Recall that distributional knowledge is the awareness of the constraints for suffixes; certain suffixes attach to only root words belonging to a particular syntactic category. For example, suffix \(-ness\) mostly attaches to adjectives and not to verbs or verbs, so \textit{happiness} is a word but \textit{jumpness} and \textit{candleness} are not words. Distributional knowledge, then, likely facilitates metalinguistic determination about whether a string of letters constitutes a word or a nonword, but not necessarily aid in the decoding process. In terms of contributions to decoding, it is well established that phonological awareness accounts for a significant amount of variance in decoding in young school-age children (Adams, 1990; National Early Literacy Panel, 2008). Also, there is evidence to suggest that relational and syntactic aspects of morphological knowledge significantly influence the decoding process (Carlisle, 1995; 2000; Mahony et al., 2000; Windsor, 2000). Given the low reliability of the distributional task in our study, the contribution of distributional knowledge to reading needs further investigation.

The results of the hierarchical regression model revealed that phonological awareness and performance on transparent items on the relational and syntactic knowledge task accounted for unique variance in decoding; however, performance on
opaque items on the syntactic knowledge task did not account for unique variance in decoding. Phonological awareness accounted for 18% of variance in decoding whereas performance on transparent items on the relational and syntactic knowledge task together accounted for 16% of unique variance in decoding. These percentages are within the same range as previous studies that have used tasks measuring relational or syntactic knowledge of morphemes in children; however, differences in the percentages may be attributed to task and methodological differences among studies. Although a large amount of variability has been noted regarding the contribution of morphological knowledge to decoding, it is clear that morphological awareness does influence decoding skills in children during the school-age years (Apel et al., 2012; Carlisle, 1995; Fowler & Liberman, 1995; Mahony 2000; Windsor, 2000). The influence of morphological knowledge to decoding has been attributed to its role in facilitating lexical access during morphological processing of derived words (Carlisle, 1995; McCutchen et al., 2008; Windsor, 2000).

We had predicted that performance on opaque items on all three morphological tasks would account for greater variance in decoding than performance on transparent items; however, this prediction did not hold true. The scores for the opaque items fell in the low range of possible values. We likely did not capture the contribution of the performance on opaque items because of these low scores. It is possible that several of the items used to test knowledge of opaque derived words were too difficult for children in grade 3. Additionally, children in this grade are acquiring knowledge regarding opaque relations between root word and their derived forms and hence may not be able to apply their knowledge during reading. Perhaps the contribution of opaque derived words to
decoding gains importance with age as documented in some of the studies conducted with older children (Carlisle, 1995, 2000; Nagy et al., 2006; Singson et al., 2000).

The hierarchical regression yielded some interesting results in terms of the individual contributions of each predictor. For example, in the first step, as expected, phonological awareness was a significant predictor of decoding skills in children. However in the second step, when the transparent scores (i.e., relational and syntactic scores) were added to the model, only performance on the transparent items measuring syntactic knowledge emerged as a significant predictor of decoding skills in children. Perhaps the most interesting result was that only performance on the transparent items measuring syntactic knowledge continued to be a significant predictor of decoding when all predictors were added to the model. In other words, syntactic knowledge of morphemes emerged as the single most important predictor of decoding skills for children in this study. This finding is consistent with previous studies that have established a relation between syntactic knowledge of morphemes and decoding skills in children (Nagy et al., 2006, 2003; Singson et al., 2000). As a reminder, the syntactic knowledge task was a sentence completion task in which children were required to complete the sentence with the correct derived form of a root word from a choice of four derived words. The decoding tasks included reading words and nonwords aloud. Given that suffixes carry meaning and the root words in our study were all high frequency words, it is possible that familiarity with the transparent derived forms aid lexical access of derived words thereby facilitating decoding skills in children. Further, there is some evidence from previous studies to indicate that awareness of the information provided by suffixes helps to parse words as well as provides clues regarding the syntactic category of
a word (Tyler & Nagy, 1989, 1990). Importantly, the syntactic knowledge task required children to use both their syntactic knowledge of suffixes and semantic knowledge of derived word to complete the sentence. Some researchers have suggested that this ability to use both syntactic and semantic knowledge is similar to the process used by children while reading unfamiliar derived words encountered in text (Apel et al., 2012).

**Passage Comprehension Model.** Correlation analyses revealed significant correlations between passage comprehension and phonological awareness and performance on the transparent and opaque items on syntactic knowledge task. As expected, phonological awareness correlated with passage comprehension abilities. Among the three morphological knowledge tasks, only performance on the syntactic knowledge task correlated with passage comprehension abilities in children. Specifically, this finding further highlighted the importance of syntactic knowledge of morphemes and its relation to passage comprehension. Our findings from the correlational analyses are similar to the findings from a few other studies that have investigated the interrelation between syntactic knowledge of morphemes and reading skills in school-age children (Carlisle, 2000; Nagy et al., 2006, 2003).

The results of hierarchical regression analyses for passage comprehension revealed that both phonological awareness and performance on the transparent items on the syntactic knowledge task accounted for unique variance in passage comprehension. However, performance on opaque items in the syntactic knowledge task did not account for unique variance in passage comprehension abilities. Again, it is possible that the scores obtained on the opaque items may have been too low to capture a statistically significant effect. Also, it is possible that similar to results obtained for the decoding
model, performance on opaque items may gain importance with age in their contribution to reading comprehension. In our study, phonological awareness accounted for 10% unique variance, and performance on transparent items on the syntactic knowledge task accounted for 19% unique variance in passage comprehension skills of children. Our results support the findings from previous researchers, who have found greater contributions of morphological knowledge to reading comprehension than to decoding in school-age children (Carlisle, 1995, 2000; Kirby et al., 2012; McCutchen et al., 2008; Singson et al., 2000). Our findings clearly highlight the importance of syntactic knowledge of morphemes in relation to reading comprehension, and provide support to studies on the role of syntactic knowledge of morphemes in relation to reading (Carlisle, 2000; Nagy et al., 2006, 2003). In addition, results from our regression analyses for both decoding and reading comprehension evidently highlight the contribution of morphological knowledge, especially syntactic knowledge of morphemes to the development of reading skills in children over and above the contribution made by phonological awareness.

**Theoretical and Clinical Implications**

**Theoretical Implications.** Although our study was not designed to verify a specific model, the findings from our study added support to some aspects of the reading model proposed by Jarmuculowicz et al. (2008). In their reading model, Jarmuculowicz et al. postulated that receptive language influenced phonological awareness skills which in turn influenced morphological awareness. Further, morphological awareness had the strongest influence on morphophonological awareness which then predicted decoding skills in children. Lastly, they suggested that decoding skills predicted reading
comprehension. Additionally, in their model, phonological awareness had influence on decoding. Moreover, receptive language had an influence on both morphological awareness and reading comprehension. Refer to Figure 1 for the model outline.

Similar to their model, we found strong relations between phonological awareness and decoding for children in grade 3. In the Jarmuculowicz et al. (2008) model, the influence of morphological awareness on decoding was mediated via morphophonological awareness. Further, decoding skills had the strongest influence on reading comprehension in their model. In our study, syntactic knowledge of morphemes for transparent derived words was a strong predictor of both decoding and reading comprehension, and it accounted for significant unique variance in both decoding and reading comprehension. This difference can be attributed to differences in the type of morphological tasks used to measure morphological and morphophonological knowledge in children in both studies. Overall, our findings suggest that the predictive power of morphological knowledge in relation to reading is influenced by the type of morphological task that is used to measure morphological knowledge. Basically, our results indicated that both phonological awareness and morphological awareness are important in the development of reading skills in young children; however, their contribution is influenced by task-related factors. Further, the findings emphasize the claim of previous researchers that the contributions of morphological awareness to reading exist over and above those made by phonological awareness even in children as young as grade 3 (Deacon & Kirby, 2004; Kirby et al., 2012). Importantly, our findings support the need to include morphological awareness in models of reading development,
a claim that is echoed by other researchers in their recent investigations (Jarmuculowicz et al., 2008; Kirby et al., 2012)

**Clinical Implications.** Our study has important clinical implications. We used three different tasks to measure morphological knowledge in children. The same tasks (i.e., procedure) may be adapted to assess knowledge of derived words that appear in children’s textbooks or other reading material. This has potential to provide insights to educators and clinicians regarding a child’s morphological knowledge. Importantly, our study emphasized the role of morphological knowledge, especially syntactic knowledge of morphemes in the development of both decoding and reading comprehension skills in children. Additionally, the information obtained from our study provides support to the growing literature on the importance of morphological knowledge (and intervention) for the acquisition of literacy skills such as decoding and reading comprehension (Apel et al., 2012, 2013; Bowers, Kirby, & Deacon, 2010; Kirby et al., 2012; Larsen & Nippold, 2007; McCutchen et al., 2008; Windsor, 2000; Wolter et al., 2009).

**Limitations and Future Directions**

This study was conducted with a limited number of children. Additionally, a large proportion of the children who participated in the study were from economically disadvantaged families. Another study with a larger and/or different population sample may have yielded different results. Further, we only tested children in grade 3; a future study with older children using the same assessment protocol would provide valuable information regarding the developmental growth in the contribution of phonological opacity and reading skills in children. Further, a larger study including more tasks measuring different aspects of reading such as reading accuracy, speed, and fluency along
with a wider range of item set measuring morphological knowledge (i.e., different kinds of derived words like semantically opaque, orthographically opaque, derived words with different kinds of stress changes) would provide valuable information regarding the interrelation between reading and morphological knowledge. In addition, we obtained very low scores for several of the opaque items. A future study with more variety of opaque derived words may provide additional information regarding the contributions of phonological opacity to reading. It is likely that this dichotomy (transparent, opaque) may be better characterized as a continuum, with words “more or less opaque” as defined by morphological rules used to create derived forms. Further, this study was conducted only with typically developing children. A future study with children with language and/or reading difficulties would contribute to the knowledge base on language impairments and reading achievement. Lastly, a future study examining the error patterns obtained on the three morphological tasks of this study would reveal interesting insights regarding morphological knowledge of children in grade 3.

Conclusions

Our study provided valuable insights regarding the contributions of different aspects of morphological knowledge to reading skills in children in grade 3. Importantly, the findings add to the growing body of literature emphasizing the impact of developing morphological knowledge in children on their reading skills (Apel et al., 2012, 2013; Bowers, Kirby, & Deacon, 2010; Kirby et al., 2012; Larsen & Nippold, 2007; McCutchen et al., 2008; Windsor, 2000; Wolter et al., 2009). Our novel contribution to this growing literature was isolating and examining the specific contributions of different types of morphological knowledge for two different kinds of derived words to reading.
skills in children in grade 3. Syntactic knowledge of morphemes emerged as an important predictor of reading skills in children in grade 3. Notably, even though our distributional task had low reliability, our study was an attempt to develop a single broad-based assessment protocol that can be adapted for assessing the three aspects of morphological knowledge in children. Additionally, the findings from our study suggest that both phonological opacity and morphological knowledge influence reading skills in children. The role of phonological opacity; however, was not clear in our study possibly due to the overall low scores obtained for opaque items. Additional studies are required to further investigate the role of phonological opacity in development of reading skills in children.
References


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on speech perception (Progress Report No. 10, pp. 303-310). Bloomington, IN: Indiana University, Speech Research Laboratory


Mahony, D. (1994). Using sensitivity to word structure to explain variance in high school and college level reading ability. Reading and Writing, 6, 19-44.


    Reading Research Quarterly, 19, 304-330.


experience model that accounts for morpheme frequency effects. *Scientific Studies of Reading, 7*, 219-237.


Appendix A: Parent Questionnaire

If you have given consent for your child to participate, then please complete this questionnaire.

We look forward to working with your child. Please fill out the questionnaire below so that we can better understand your child’s performance in the project. This information will be kept confidential. Thank you!

Name of Child: ____________________________________________ (please print)

Child’s date of birth ____________________________________________

Child’s race/ethnicity---please check one:  ☐ (Asian/Pacific Islander)  ☐ (Black/ Non-Hispanic)  ☐ (American Indian/Alaskan Native)  ☐ (Hispanic)  ☐ (White/ Non-Hispanic)  ☐ (Multi- Racial)

1. My child achieved all his/her physical developmental milestones (standing, sitting, walking etc.) at expected ages. YES ☐ NO ☐

If yes, please explain:

____________________________________________________________________
____________________________________________________________________

2. Currently, my child has difficulty with hearing, or has had a history of hearing difficulty. YES ☐ NO ☐

If yes, please explain:

____________________________________________________________________

3. Currently, my child receives speech language therapy to help with speech and language skills, or has had a history of speech or language difficulties (i.e., late talker, difficulty with producing sounds correctly, not talking enough or any other special services to help with speech or language skills).

YES ☐ NO ☐

If yes, please explain:

____________________________________________________________________

____________________________________________________________________
4. Currently, my child receives special services in school for problems with learning, or has had a history of learning problems (i.e., learning disability, attention deficit disorder, behavioral disorder, etc.)

   YES □  NO □

If yes, please explain:
_____________________________________________________________________

5. In an average week, how often does your child read at home?

   5 everyday or five-six days  4 three-four days  3 one-two days  2 never

   every night

Type of reading:
□ academic (school related)
□ pleasure reading (e.g., fiction, comic books)
□ newspapers/magazines
□ Other. Please list:
_____________________________________________________________________

6. On average, how many hours per day does your child read at home?

   More than 2 hrs  More than 1 hr  Less than 1 hr

   academic (school related) □  □  □
   pleasure reading
   (e.g., fiction, comic books) □  □  □
   newspapers/magazines □  □  □
   Other □  □  □
   Please list: _____________________________________________

7. How often do you do reading activities together with your child? (e.g., reading books, letters, newspapers, magazines, etc.)

   5 everyday or five-six days  4 three-four days  3 one-two days  2 never

   every night
8. Please indicate your educational level (highest attained)

☐ Less than high school  ☐ High school  ☐ Undergraduate  ☐ Graduate  ☐ Post – Graduate  ☐ N/A

THANK YOU!
Appendix B1: Semantic Opacity Rating Scale (sample)

Instructions: Please read each of the 80 derived word pairs listed below. A derived word is formed by adding a suffix to a root word which may cause a change in the grammatical category of the root word. For example, *watchful*, is a derived adjective which consists of a base word *watch* (verb) and a suffix *–ful*. The first word in each pair is the base word (e.g., puzzle) and second word is a derivative of the base word (e.g., puzzlement). Consider each pair from the point of view of the degree of similarity in meaning (not sound or spelling) which you judge to exist between them. Please rank this similarity on a rating scale of 0 - 4 indicated below. Please circle the appropriate number next to each word pair.

Scale:
0: minimal similarity in meaning between the base word and the derived word
4: maximal similarity in meaning between the base word and the derived word

Examples:
- a) profit-profitable
  - minimal similarity: 0 1 2
  - maximal similarity: 3 4
- b) pet-petal
  - minimal similarity: 0 1 2
  - maximal similarity: 3 4

Word Pairs
- 1. alert-alertness
  - minimal similarity: 0 1 2
  - maximal similarity: 3 4
- 2. angel-angelic
  - minimal similarity: 0 1 2
  - maximal similarity: 3 4
- 3. crawl-crawly
  - minimal similarity: 0 1 2
  - maximal similarity: 3 4
- 4. actual-actuality
  - minimal similarity: 0 1 2
  - maximal similarity: 3 4
- 5. jack-jackal
  - minimal similarity: 0 1 2
  - maximal similarity: 3 4
- 6. account-accountable
  - minimal similarity: 0 1 2
  - maximal similarity: 3 4
- 7. acid-acidity
  - minimal similarity: 0 1 2
  - maximal similarity: 3 4
- 8. allow-allowable
  - minimal similarity: 0 1 2
  - maximal similarity: 3 4
- 9. flight-flighty
  - minimal similarity: 0 1 2
  - maximal similarity: 3 4
Appendix B2: Phonological Opacity Rating Scale (Sample)

**Directions:** Please read each of the 60 derived word pairs listed below. A derived word is formed by adding a suffix to a root word which may cause a change in the grammatical category of the root word. For example, *watchful*, is a derived adjective which consists of a base word *watch* (verb) and a suffix *–ful*. In each of the following word pairs, the first word is the base word (e.g., puzzle) and second word is a derivative of the base word (puzzlement). Consider each pair from the point of view of the degree of similarity **in sound and/or stress pattern** (not meaning or spelling) which you judge to exist between them. Please rank this similarity using the rating scale indicated below. Please circle the appropriate number next to each word pair.

**Rating Scale:**

0: minimal similarity

4: maximal similarity (i.e., the base word is pronounced exactly the same in the derivative as when it is said by itself)

<table>
<thead>
<tr>
<th>Examples:</th>
<th>minimal similarity</th>
<th>maximal similarity</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) puzzle-puzzlement</td>
<td>0 1 2</td>
<td>3 4</td>
</tr>
<tr>
<td>b) clear- clarify</td>
<td>0 1 2</td>
<td>3 4</td>
</tr>
<tr>
<td>c) celebrate- celebratory</td>
<td>0 1 2</td>
<td>3 4</td>
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</tbody>
</table>

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<tr>
<th>Word Pairs</th>
<th>minimal similarity</th>
<th>maximal similarity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. alert-alertness</td>
<td>0 1 2</td>
<td>3 4</td>
</tr>
<tr>
<td>2. angel-angelic</td>
<td>0 1 2</td>
<td>3 4</td>
</tr>
<tr>
<td>3. crawl-crawly</td>
<td>0 1 2</td>
<td>3 4</td>
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<tr>
<td>4. actual-actuality</td>
<td>0 1 2</td>
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<td>5. account-accountable</td>
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<td>6. acid-acidity</td>
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<tr>
<td>7. allow-allowable</td>
<td>0 1 2</td>
<td>3 4</td>
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Appendix C1: Relational Knowledge (Task 1 Sample Items)

Directions: Please select “a” or “b”

Select choice “a” if you think there is a smaller, related word to the underlined word.

Please write the related word in the blank provided.

Select choice “b” if you think the underlined word does not contain a smaller, related word.

1. (alertness): Regular exercise and good diet helps to improve our alertness.

   alertness
   
   a) The smaller, related word is ____________________
   
   b) There is no smaller, related word.

2. (allowable): Dad gave Shawn a list of expenses that were allowable.

   allowable
   
   a) The smaller, related word is ____________________
   
   b) There is no smaller, related word.

3. (angelic): With her blue eyes and blond hair Jamie looked angelic.

   angelic
   
   a) The smaller, related word is ____________________
   
   b) There is no smaller, related word
Appendix C2: Relational Knowledge (Task 2 Sample Items)

Directions: Please circle the word ending or suffix for all the underlined words.

1. (alertness): Regular exercise and good diet helps to improve our alertness.

   alertness
   a) s
   b) ness
   c) ertness
   d) no suffix

2. (allowable): Dad gave Shawn a list of expenses that were allowable.

   allowable
   a) able
   b) ble
   c) no suffix
   d) wable

3. (angelic): With her blue eyes and blond hair Jamie looked angelic.

   angelic
   a) ic
   b) gelic
   c) lic
   d) no suffix
Appendix D: Syntactic Knowledge (Task 3 Sample Items)

Directions: Please complete the following sentences by selecting the correct word from the four choices.

1. (crawl) Jennifer doesn’t like insects because they are creepy and ______________.
   a) crawly
   b) crawled
   c) crawler
   d) crawls

2. (actual): The rumors about the thief turned out to be true in ______________.
   a) actually
   b) actualization
   c) actuality
   d) actualize

3. (exact): The accountant was known for his attention to detail and ______________.
   a) exacter
   b) exactly
   c) exactness
   d) exactable

4. (fate): 11th of September will always be remembered as a ______________ day.
   a) fatefulness
   b) fateful
   c) fatefully
   d) fated
### Appendix E: Distributional Knowledge (Task 4 Sample Items)

Directions: Please match the word from column A with a correct word ending or suffix from column B to form a new word.

<table>
<thead>
<tr>
<th>Column A</th>
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