

The Connection Among Morphological,  
Phonological, Orthographic, and Processing Skills, and Reading

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A dissertation

submitted in partial fulfillment of the  
requirements for the degree of

Doctor of Philosophy

University of Washington

2017

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Program Authorized to Offer Degree:

Education

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**Abstract**

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Research on morphological awareness has shown that it contributes to literacy outcomes. However, because of the way morphological awareness is traditionally measured, there is speculation that tasks may reflect cognitive flexibility, working memory, or some other type of executive processing, versus awareness of morphology. Further complicating the measurement of morphological awareness is the fact that items with different types of phonological changes are included in morphological tasks, often without differentiating between them. This paper reports on two studies investigating these issues. Study 1 had three main aims: The first was to develop a measure that was parallel in task demands to the morphological production task but involved no morphology, to attempt to separate morphological demands from other task demands. The second was to examine the developmental nature of both morphological skill and

parallel task-processing demands. The third aim of Study 1 was to examine the contribution of morphological skill over and above task demands to literacy skills. With a sample of 274 students in grades 5 and 8, results show that grade 8 students performed better on both the morphological production task and parallel processing task, the orthographic production task. Results also show that one type of traditional morphological awareness task is tapping more than vocabulary and processing skills as the morphological production task made unique contributions to both word reading and comprehension. Additionally, results showed that the orthographic production task made unique contributions to both outcomes.

The main goal of Study 2 was to further examine the nature of the relationship of the morphological and orthographic production tasks with reading comprehension with a sample of 304 fourth- and fifth-grade students. It was hypothesized that both tasks would be correlated with orthographic skill, phonological word skill, vocabulary, and working memory, with the morphological task having a unique effect on reading comprehension. Study 2 furthers the research and results from Study 1 in two ways. First, it investigates what the orthographic production task, from Study 1, is measuring by including assessments that measure orthographic skill, phonological word skill, and a working memory task in addition to vocabulary in a structural equation model predicting reading comprehension. Second, Study 2 again investigates the contribution of morphological awareness to reading comprehension using a larger battery of literacy measures and a more complex statistical model. Interestingly, the unique contribution of the orthographic production task to reading comprehension remained significant even after taking the other variables into account. Further research into this measure is needed to help explain what the unique contribution means theoretically. Results show that the unique contribution of morphological awareness failed to reach significance after accounting for

orthographic skill, phonological word skill, vocabulary, and working memory. However, morphological skill was highly correlated with comprehension and all predictors showing a strong total effect on reading comprehension.

# TABLE OF CONTENTS

List of Figures.....	iii
List of Tables.....	iv
Chapter 1: Morphemes and Morphological Awareness.....	1
Introduction.....	1
Function of Morphology.....	3
Morphology and Orthography.....	4
Morphological Awareness.....	5
Chapter 2: Contribution of Morphological Awareness to Reading.....	7
Overview.....	7
Morphological Awareness and Vocabulary.....	8
Morphological and Phonological Awareness.....	10
Morphological Tasks.....	13
Phonological Transparency in Morphological Tasks.....	15
Processing Skills and Morphological Tasks.....	17
Orthographic Awareness and Morphological Tasks.....	24
Implications.....	33
Chapter 3: Study 1.....	35
Overview.....	35
Study 1: Methods.....	38
Participants.....	38
Materials and Procedures.....	38
Study 1: Results.....	44

Study Goal: Examine the Developmental Nature of Production Tasks.....	44
Study Goal: Examine the Contribution of Morphological Production to Reading Skills.....	47
Study 1: Discussion.....	52
Chapter 4: Study 2.....	57
Overview.....	57
Study 2: Methods.....	59
Participants.....	59
Materials and Procedures.....	60
Study 2: Results.....	64
Data Analysis.....	64
Means and Correlations.....	67
Structural Equation Modeling.....	68
Study 2: Discussion.....	71
Chapter 5: Discussion and Conclusions.....	74
Morphological Production Task.....	74
Orthographic Production Task.....	75
Limitations and Future Research.....	78
References.....	80
Appendix A.....	88
Appendix B.....	91

## LIST OF FIGURES

Figure 3.1. Mean percent correct by type of item for grades 5 and 8 on the morphological production task.....	45
Figure 3.2. Mean percent correct by type of item for grades 5 and 8 on the orthographic production task.....	46
Figure 4.1. Model 1, with the morphological production task, vocabulary, working memory, word decoding, and orthographic skill predicting reading comprehension.....	65
Figure 4.2. Model 2, with the orthographic production task, vocabulary, working memory, word decoding, and orthographic skill predicting reading comprehension.....	65

## LIST OF TABLES

Table 3.1. Morphological Production Task: Mean Frequencies and Examples.....	40
Table 3.2. Orthographic Production Task: Mean Frequencies and Examples.....	43
Table 3.3. Means and SDs by Type of Item in Production Tasks.....	45
Table 3.4. Correlations.....	47
Table 3.5. Multiple Linear Regression: Word Identification.....	48
Table 3.6. Multiple Linear Regression: Reading Comprehension.....	48
Table 3.7. Multiple Linear Regression: Word Identification (With MPT Item Types).....	51
Table 3.8. Multiple Linear Regression: Word Identification (With MPT Item Types).....	51
Table 4.1. Morphological Production Task: Mean Frequencies and Examples.....	63
Table 4.2. Means and Standard Deviations by Grade Level.....	66
Table 4.3. Correlations among Measures.....	67
Table 4.4. Model Correlations among Predictors.....	68
Table 4.5. Structural Equation Models Predicting Reading Comprehension.....	69

## **CHAPTER 1: Morphemes and Morphological Awareness**

### **Introduction**

Over the past two decades, studies have identified morphological awareness as an important contributor to literacy skills, specifically in word reading, comprehension, spelling, and vocabulary (e.g., Apel, Wilson-Fowler, Brimo, & Perrin, 2012; Carlisle, 2000; McCutchen, Green & Abbot, 2008; Nagy, Berninger, & Abbott, 2006; Nunes & Bryant, 2006). However, studies also reveal that morphological awareness, ‘the ability to reflect on and manipulate morphemes and word formation rules’ (Kuo & Anderson 2006; p. 161), is significantly related to other linguistic and verbal skills, which complicates the nature of the relation between morphological awareness and other literacy skills. There is significant overlap among morphological awareness and vocabulary, phonological awareness, orthographic awareness, and processing skills (i.e. working memory; Apel et al., 2012; Deacon, Kirby, & Casselman-Bell, 2009; Kuo & Anderson, 2006; McCutchen et. al., 2008; Nagy, Berninger, Abbot, Vaughan, & Vermeulen, 2003; Nunes & Bryant 2006, 2009; Nunes, Bryant & Olsson, 2003; Roman, Kirby, Parrila, Wade-Woolley, & Deacon, 2009; Singson, Mahony, & Mann, 2000). This overlap can obscure the unique contribution of morphological awareness to literacy skills or may imply that morphological awareness is redundant with the other constructs. Such overlap, along with the variation in morphological awareness tasks and the types of literacy skills being assessed, may call into question the unique contribution of morphological awareness to reading and thus may require further research.

Several studies have included measures of multiple literacy skills along with morphological skill, but with mixed results regarding relationships between morphological skill and reading comprehension and morphological skill and word reading (e.g., Apel et al., 2012;

Carlisle, 2000; Deacon et al., 2009; Nagy et al., 2006; Nunes & Bryant, 2006). Additionally, few of the studies included measures addressing all of the areas that have significant overlap with morphology, namely vocabulary, phonology, and orthography as well as processing skills required by many morphological tasks. Furthermore, the outcomes varied across studies, often leaving unanswered the question as to whether morphology uniquely predicts what many would argue is the end goal in reading, reading comprehension.

This paper reports on two studies that attempted to separate morphological demands from other task demands and assess more precisely what skills are assessed by morphological tasks. The research question driving Study 1 was whether a traditional measure of morphological awareness would uniquely predict reading skill when accounting for age, task processing demands, vocabulary, and word reading. Study 1 had three main goals in an effort to address this question. The first goal was to develop and administer a task that would require similar processing skills as the task measuring morphological skill, but involve no morphology. In other words, this parallel task would be formatted the same, require the same type of processing, as much as possible, as the morphological task, but would require letter changes/additions instead of morphological changes. The second goal was to examine the developmental nature of both the morphological task and the parallel processing task (termed the orthographic production task) with the sample of students in grades 5 and 8. The third goal of Study 1 was to determine if morphological skill (taking type of phonological change into account) would make a unique contribution to both reading comprehension and word reading when accounting for processing artifacts (using the orthographic production task) and vocabulary in a regression analysis.

The main research question in Study 2 was whether the morphological production task and the orthographic production task (from Study 1) would continue to make a unique

contribution to reading comprehension after accounting for more variables that address other linguistic skills and processing skills more precisely. Within that question, Study 2 had two main goals. The first goal was to determine if morphological skill would continue to have a unique effect on reading comprehension with a more complex statistical model. This was done using structural equation modeling, using factors versus single measures when possible, and by including measures of orthographic skill, phonological and word skill, vocabulary, and working memory. The second goal of Study 2 was to further examine the nature of the relationship between reading comprehension and the parallel processing task that was developed in Study 1. This parallel task, the orthographic production task, was included in a separate structural equation model along with measures of orthographic skill, phonological and word skill, vocabulary, and working memory with the goal of determining if there remained a significant unique effect of this parallel processing task on reading comprehension or if all of the variance was accounted for via the other variables.

### **Function of Morphology**

Morphology is an aspect of language that deals with the units of meaning and grammatical function that comprise words (Nunes & Bryant, 2006). A *morpheme* is the smallest unit of meaning or grammatical function. Words in English may have only one morpheme, such as *teach*, or may be multi-morphemic (contain multiple morphemes), such as *teacher*. The morpheme *-er* is a unit of meaning that changes the root word *teach*, a verb, to an agentive noun, *teacher*. The word *teachers* has three morphemes because adding *-s* transforms the singular agentive into the plural.

There are also two different types of morphemes: derivational and inflectional. The first example above, adding *-er* to *teach*, transforming a verb to a noun, is a derivational morpheme.

Derivational morphemes use one word as a foundation to create a new word (Nunes & Bryant, 2006). Adding *-ion* to *protect*, a verb, creating *protection*, an abstract noun, is another example of forming a new word with a derivational morpheme. A derivational morpheme usually changes the grammatical class of a word as in the two examples above (Nunes & Bryant, 2006). Adding *-s* to *teacher*, illustrates an inflectional morpheme. Inflectional morphemes do not create a new type of word, but change something within its grammatical class: the *-s* in *teachers* makes the word plural; the *-ed* at the end of *walked* indicates a past-tense verb; adding *-er* or *-est* to *loud* changes it to a comparative or superlative adjective respectively (Nunes & Bryant, 2006). All inflectional and derivational morphemes are bound morphemes because none of them can stand alone and survive as a word; they must be attached to a root word (as opposed to free morphemes, which are morphemes that can stand alone and can also occur in two-morpheme compound words such as *toothbrush* and *notebook*).

### **Morphology and Orthography**

English orthography is morphophonemic (Venezky, 1970) which means that the letter-sound, or grapheme-phoneme, correspondence is inconsistent and insufficient for reading many English words; students must be able to recognize word parts or morphemes. When spelling, reading, and learning new words, children cannot always rely on their phonemic knowledge because one letter or combination of letters can represent several different phonemes (units of sound). In these situations, knowledge of morphology can provide the missing information. Bryant and Nunes (2004) suggest four situations when morphology is needed to read and spell words. In the first situation there are multiple ways a sequence of sounds can be represented. For example, consider the suffixes *-ian* and *-ion* as in *electrician* and *dictation*. Both sound the same but are represented differently due to morphology. Second, when a suffix is added to a word the

pronunciation of the stem can change, but the spelling remains intact to preserve the connection of meaning between the two forms. For example, when *-ian* is added to *electric* the end sound changes but the spelling is maintained. The third situation Bryant and Nunes (2004) suggest is when an affix has a fixed spelling due to morphology but is phonologically inconsistent.

Consider the past-tense suffix *-ed*. In *kissed*, *listened*, and *educated* the *-ed* is phonologically different (/t/, /d/, and /id/) but morphologically consistent. The fourth situation concerns where to parse words which is very important for word identification. For example, *uninformed* and *uniform* share the same initial letters but are parsed and pronounced differently due to morphology. This is also true of *mishap* and *wished*. Based on this information, knowledge of morphology is essential to read, write, and spell correctly in English. These situations also exemplify why phonological awareness, the ability to recognize and manipulate groups of sounds or phonemes in language, is important for reading and other literacy skills, but also demonstrates why morphological awareness is important, especially as the words students encounter increase in complexity and difficulty. It is because of these situations, where knowledge of phonology falls short, that research into knowledge of morphology is an important aspect of reading research. As will be shown in the review of literature, morphological knowledge is often predictive of reading skills after accounting for phonological skill.

### **Morphological Awareness**

Kuo and Anderson (2006) define morphological awareness as ‘the ability to reflect on and manipulate morphemes and word formation rules in a language’ (p. 161). They outlined three reasons why morphological awareness is important in reading development: morphemes contain semantic, syntactic, and phonological properties all of which are important in learning to read; complex words are processed and possibly organized in the mental lexicon using

morphological information; and morphological awareness provides insight into writing systems that rely on both morphology and phonology. Pragmatically, these three reasons mean that knowledge of morphology can help children decode multi-morphemic words, and facilitates the spelling and writing of words that are not consistent phonologically but are consistent at the morphemic level. Because English is morphophonemic, as discussed previously, morphological awareness is related to readers' insights into phonology, orthography, vocabulary, and even syntax. This can make separating the effects of each on reading skills difficult.

This difficulty plays out in research in two ways which the current studies seek to address. First, studies that investigate the relationship between morphological awareness and reading should include measures of as many of the related skills as possible in order to attempt to separate the effects of each. Research that does not include measures of many other skills paint an incomplete picture. Second, studies that include a measure of morphological awareness have not necessarily evaluated what other skills the morphological awareness task may be measuring. It is possible that the tasks used to measure morphological awareness are also tapping one of the related skills mentioned above or some type of processing skill. The two studies reported here seek to address these two issues in research in order to better understand the relationship between morphological awareness and reading skill.

## **CHAPTER 2: Contribution of Morphological Awareness to Reading**

### **Overview**

While there is an established relationship between morphological awareness and reading skills, many studies also show that morphological awareness is significantly related to other linguistic and verbal processing skills. There is often significant overlap between morphological awareness and several skills that are known contributors to reading skill such as vocabulary, phonological awareness, orthographic awareness, and processing skills (i.e. short-term memory and working memory; Apel et al., 2012; Deacon et al., 2009; Kuo & Anderson, 2006; McCutchen et. al., 2008; Nagy et al., 2003; Nunes & Bryant 2006, 2009; Nunes et al., 2003; Roman et al., 2009; Singson et al, 2000). Because of the connection among all of these skills, the task of determining a unique contribution of morphological awareness to reading skills is challenging. The question arises as to whether morphological awareness is redundant with the other skills, or whether there is a true unique contribution. Based on previous research conducted on this issue, the answer to that question seems to depend on several factors including the types of literacy skills being assessed, the populations studied, and the type of morphological tasks used as measures in the studies. Different studies assessed different literacy skills, typically spelling, word reading, or reading comprehension, sampled different ages of students, usually within the range of grades 2-9, and used different types of morphological tasks. Depending on the combination of the above factors, results vary and are inconsistent. Additionally, while several studies have examined the relations between morphological awareness and one or two of the other skills mentioned above, there are very few studies that included measures of all of the skills that are known to be related to morphological awareness and reading skills (vocabulary, phonological skill, orthographic skill, and some type of processing skill).

The goal of this chapter is to review studies that have examined the connections among morphological awareness and other linguistic or processing skills. First, the relationships between morphological awareness and vocabulary then morphological and phonological awareness are discussed. Then morphological awareness tasks are discussed along with the possible confound of phonological transparency within the tasks and the processing skills that may be inherently involved in and therefore measured by those tasks. Studies involving morphological awareness and orthographic awareness are then reviewed.

### **Morphological Awareness and Vocabulary**

There are several factors and skills, often overlapping, that contribute to different aspects of reading. It is well established that vocabulary predicts both word reading and reading comprehension (Nagy & Anderson, 1984; Nagy & Scott, 2000). Students with larger vocabularies are generally better readers. However, knowledge of morphology also contributes to vocabulary in both recognizing and remembering words. Nunes and Bryant found, for example, that children were more likely to remember pseudowords with a morphemic structure than those without (e.g., *unsausagish* compared to *hampent*) (Nunes and Bryant, 2009; Nunes, Bryant & Evans, 2010). This suggests that children recognize morphemes and use them as clues when remembering words and learning their meanings. Nagy and colleagues (Nagy & Anderson, 1984; Nagy & Scott, 2000) are in agreement, asserting that awareness of morphological relationships between words may contribute to reading ability and citing students' rapid vocabulary growth in the later elementary years as evidence. Students' vocabularies grow too rapidly for it to be attributable only to vocabulary instruction (i.e. memorizing the surface form of words), and knowledge of morphology is suggested as an explanation in two ways. First, stems and suffixes affect words in consistently the same manner. For example, the word

*unspeakable* is made up of three morphemes: *un-*, *speak* and *-able*. If children recognize how this prefix and suffix change the meaning of verbs, they can understand many words such as *unbreakable* and *untouchable* (Nagy & Anderson, 1984; Nunes et al., 2010). Second, for every word that is learned through printed school English, Nagy and Anderson (1984) approximate that there is a three to one ratio of derived words to stems that are recognizably related in meaning (e.g., the stem *converse* can become *conversation*, *conversational*, and *conversationalist* by adding different derivational morphemes) and that 60% of new words encountered by students ages 11 to 14 contain derivational morphemes which provide relatively transparent clues about their meaning.

Considering all of this, it is evident why it is so difficult to separate the effects on reading of morphological awareness from vocabulary. As McCutchen et al. (2008) state, “reading is not simply the process of decoding written versions of words that are already part of one’s oral vocabulary; rather, reading contributes to growth in oral vocabulary (as well as reading vocabulary) via morphological analysis of words never before encountered” (p. 290). Thus, morphology reveals clues about a word’s meaning and provides a basis for greater reading comprehension. Instruction in morphology goes beyond direct vocabulary instruction of the surface form of words because instruction with a focus on morphology aims to make students more aware of word parts and the relationships between words and their roots and suffixes. The challenge in research that investigates the role of morphological awareness in reading is separating those words that are already part of a students’ vocabulary from those that students may be using knowledge of morphology to analyze, interpret, and produce.

### **Morphological and Phonological Awareness**

The relation of morphological awareness to phonological awareness is also complicated. While a *morpheme* is the smallest unit of meaning (as discussed above), *phonemes* are the basic speech sounds in a language that serve to distinguish words from each other (Hayes, 2009). For example, *pan* and *tan* are distinguished as different words because /p/ and /t/ are distinct phonemes in English. One letter may represent multiple phonemes (e.g., in *mix* the letter *x* represents the phonemes /k/ and /s/) or multiple letters may represent one phoneme (e.g., in *brought* the letters *ou* represent the phoneme /ɑ/ and the letters *ght* represent the phoneme /t/). Hence, morphemes are inherently made up of phonemes and awareness of how the two work in language is related as well. As noted by many researchers in the field, morphological awareness and phonological awareness are significantly correlated (Kuo & Anderson, 2006; McCutchen et al., 2008; Nagy et al., 2003, 2006). Decades of research studies have investigated and established the relationship between phonological awareness and literacy (e.g., Blachman, 2000; Bryant, Bradley, MacLean, & Crossland, 1988; Bryant, MacLean, Bradley, Crossland, & Parke, 1990; Gray & McCutchen, 2006). Because phonology and morphology are related, it is important to establish a unique relation between morphological awareness and literacy acquisition above and beyond that of phonological awareness.

In a study aimed at investigating a unique contribution of morphology over phonology to literacy outcomes, Nagy et al. (2006) used structural equation modeling to evaluate distinct contributions of morphological awareness, phonological memory, and phonological decoding to comprehension, reading, vocabulary, spelling, and decoding multi-morphemic words. Their sample included 607 students from grade four to grade nine. They found that morphological awareness made a significant and unique contribution to comprehension, spelling, and

vocabulary for all grades. In fact, morphological awareness was the strongest predictor for these three outcomes. This study suggests that morphological awareness has important implications for reading beyond phonological awareness (but did not include a measure of orthographic awareness). In a 4-year longitudinal study, Deacon and Kirby (2004) found that morphological awareness contributed uniquely to comprehension and pseudoword reading after controlling prior measures of general intelligence, reading ability, and phonological awareness, (but again, many of the other variables of interest to the current studies were not included). This contribution of morphological awareness was comparable to that of phonological awareness. In summary, morphological awareness contributes uniquely to literacy skills above and beyond the established contribution of phonological awareness.

However, the type of morphological change a word undergoes is suspected to have an effect on whether morphology or phonology is more important. Phonological transparency is an aspect of the representation of morphologically complex words in the mental lexicon. Jarmulowicz and Taran (2013) describe phonological transparency as “the degree of similarity in the sound patterns of the base and derived form” (p. 63). Some morphologically complex words have a phonologically more transparent relationship between the base word and the derived form (e.g., *forget/forgetful*) while others have a phonologically more opaque relationship (little to no similarity in the sound patterns) between the base and the derivation (e.g., *maintain/maintenance*). Some studies have investigated students’ performance (accuracy and/or speed) on phonologically transparent items versus phonologically opaque items and found significant differences (McCutchen et al. 2008; McCutchen, Logan, & Biangardi-Orpe, 2009; Nagy et al., 2006). In the same study described previously, Nagy et al. (2006) found that morphological awareness only made a significant unique contribution to reading words that were

phonologically opaque, not to those that were phonologically transparent. These findings could suggest that awareness of morphology is not the factor that is causing some measures of morphological awareness to correlate with or contribute to reading skills, but could be phonological awareness via the phonologically transparent items in a measure.

In a study employing a primed decision task, McCutchen et al. (2009) found that grade 5 ( $n=81$ ) and grade 8 ( $n=82$ ) students took longer to respond to items that had a phonologically opaque relationship with the prime than to items that had a phonologically transparent relationship with the prime. They also found that 8<sup>th</sup> graders were faster and more accurate than 5<sup>th</sup> graders and that more skilled readers were faster and more accurate than less skilled readers. These findings show that there is a difference in the way these students process morphologically complex words depending on whether they are phonologically transparent or opaque. Because the students in the older grade were faster and more accurate, the findings also suggest a developmental continuum.

In another study, McCutchen et al. (2008) again found differences in performance on morphological awareness tasks with their sample of 36 grade 4 students and 36 grade 6 students based on the type of phonological relationship between the base and the derived form. First, they found that morphological awareness continued to develop from 4<sup>th</sup> to 6<sup>th</sup> grade. While all students performed similarly on phonologically transparent items, the 6<sup>th</sup> graders were significantly more accurate than 4<sup>th</sup> graders on phonologically opaque items. Additionally, performance on opaque items in their morphological awareness task significantly predicted word reading ability above and beyond the contribution of both phonological awareness and vocabulary. However, neither phonological awareness nor morphological awareness (phonologically transparent or opaque) uniquely predicted reading comprehension after

vocabulary was entered into the equation. This suggests that vocabulary, not phonological awareness, is a more important factor for older elementary students in trying to establish the unique contributions of morphological awareness to reading, especially when dividing morphological changes into categories of opaque and transparent.

This question of what is driving the correlations and contributions of morphological awareness tasks with measures of reading skill is an important one in order to determine if the relationship is truly morphological, based on a combination of other related factors, or dependent on the type of phonological change (which could suggest the relationship is more phonological and/or limited to one type of phonological change). From the studies described above, it seems that students, particularly students in grades 4-8, process and respond to morphologically complex words differently depending on whether they are phonologically transparent or opaque. However, many other studies that find a significant correlation with or contribution of morphological awareness and reading skills are not reporting what kind of items (phonologically transparent or opaque) they are using in their measures. When phonological transparency is not included as a factor in a statistical model, it could be that one type of morphologically complex word is carrying any significant effects that are found. For this reason, it is important to control phonological transparency in measures of morphological skill and then investigate how the measure relates to reading skill.

### **Morphological Tasks**

Further complicating the question of the unique contribution of morphological awareness to reading are the tasks themselves that are used in different studies. Tasks from studies investigating morphological awareness range from tasks tapping only knowledge of inflectional morphology (i.e., tasks involving plurals, past tense endings, or *-ing*) (Nunes et al., 1997;

Deacon et al., 2009) to tasks tapping knowledge of derivational morphology, which vary level of knowledge required by participants. Derivational tasks range from asking students if words are related (e.g., “Does *farmer* come from *farm*?”) (Tyler & Nagy, 1989), to asking students to complete a sentence with the correct form when given the stem (e.g., “*farm*: My uncle is a \_\_\_\_.”) (Carlisle, 1995, 2000; McCutchen et al., 2008, 2009), to tasks requiring students to decide if an affix fits on a stem or not (McCutchen et al., 2008). These three types of tasks map onto knowledge of relational, syntactic, and distributional morphology respectively (Tyler & Nagy, 1989), increasing in difficulty and explicitness from relational to distributional. Tyler and Nagy (1989) describe relational knowledge of morphology, which develops first, as the ability to recognize that words are morphologically related and that they can share a root, or base, morpheme (e.g., recognizing that *farm* and *farmer* are morphologically related but *me* and *media* are not). Syntactic knowledge is described as the understanding that derivational suffixes convey which syntactic category words belong to. For example, syntactic knowledge is required to understand that *specialize* is a verb due to the derivational ending *-ize* and *specialty* is a noun due to the derivational ending *-ty*. Finally, they describe distributional knowledge as the ability to understand the constraints when putting suffixes with stems, such as understanding that *-ness* does not typically attach to verbs, but to adjectives (e.g., *neatness* is a typical word in English, but *playness* is not) (Tyler and Nagy, 1989).

In their 2008 study, McCutchen et al. designed a broad assessment of morphological awareness with subtasks that were intended to tap relational, syntactic, and distributional morphological knowledge. They controlled the difficulty of the words using word frequency and still found a significant effect of subtask type on percentage of items correct. Students got a significantly higher percentage correct on relational items compared to syntactic and

distributional items while there was no significant difference between syntactic and distributional.

In a recent study, Goodwin, Petscher, Carlisle, and Mitchell (2017) examined the dimensionality of morphological knowledge with seventh- and eighth-graders. They argue that the various morphological tasks used in different studies are tapping different facets of a very complex construct, morphological awareness, and investigate whether tasks should be grouped based on whether they require tacit morphological knowledge, intuitive or implicit, or a more strategic and explicit morphological knowledge. They investigated the links of reading comprehension and vocabulary with seven tasks of morphological knowledge (which included inflectional and derivational tasks as well as relational and syntactic tasks). Results showed that a bifactor model (one general factor of morphological knowledge with seven specific factors representing each task) was the best fit. While the general morphological knowledge factor strongly predicted reading comprehension and vocabulary, results of the specific factors showed that some had small significant unique effects on one or both outcomes, other factors had no effect or, in a few cases, a negative effect. These results, significant differences in the type of relationship between various morphological tasks and literacy skills, show that it is important to consider what a task of morphological knowledge is measuring and whether it is appropriate for a specific literacy outcome.

### **Phonological Transparency in Morphological Tasks**

Embedded within the various task types, both transparent and opaque phonological changes from stem to derivation are typically included in study designs. However, a distinction between transparent and opaque may not be enough. Looking at the items in different tasks used in morphological studies (when provided by the authors), it is apparent that tasks included both

transparent and opaque phonological changes from stem to derivation (even if that was not a factor in the study). The opaque category often includes forms such as *generous/generosity* or *maintain/maintenance* as well as forms like *good/better* or *deep/depth*. Linguistically, the types of changes in the latter set of words are termed *suppletive forms* “which are inflected forms that have no phonological connection at all to the related forms of their paradigm” (Hayes, 2009, p. 194). More simply, suppletive forms are words that are related in meaning but have little or no phonological association. Admittedly, the distinction between suppletive and non-suppletive forms is unclear and even disputed among linguists. It is more of a spectrum than a dichotomy as can be seen from the suppletive examples given above; there is clearly more of a phonological relationship between *deep/depth* than *good/better*. However, many linguists would still dispute whether or not there is a phonological relationship that underlies the connection between *deep/depth* in the minds of speakers. In other words, linguists disagree as to whether or not it is possible to define a reasonable phonological rule or set of rules to account for the stem to derivation change. The alternative is that the pair is simply memorized as distinct phonemic forms in the mental lexicons of speakers (Hayes, 2009). This distinction could be important for students learning new words (or answering items on a morphological task), because if they do not already know that *deep* comes from *depth* or that *better* and *good* are related, they would not be able to produce the derivation based on generative morphological rules. Given this, it seems that a further distinction is warranted within the broad ‘opaque’ category: stems/derivations that are related phonologically (though not transparently related), such as *generous/generosity* or *maintain/maintenance*, and stems/derivations that, arguably, do not have a phonological relationship and are simply memorized (e.g., *deep/depth* and *good/better*). If the well-

documented effect of phonological opacity is driven primarily by suppletive items, one might question whether phonological opacity is really phonological at all.

### **Processing Skills and Morphological Tasks**

A final complication with morphological tasks is determining exactly what they are measuring. Looking only at tasks measuring syntactic knowledge of morphology, what do they require of students? Take the frequently used format described earlier: “*farm*: My uncle is a \_\_\_\_.” Students must hold the stem in memory and try to manipulate it in a way that fits the sentence semantically and syntactically. Completed correctly, *farmer* is generated. While morphological awareness is related to awareness of syntax and semantics, it is still a separate cognitive function.

Nagy (personal communication, July 2012) suggests that cognitive flexibility, or a similar aspect of executive processing, may be able to partially, or even fully, explain the relation between students’ performance on morphological tasks and reading, citing studies by Cartwright and colleagues as evidence (2002; Cartwright, Marshall, Dandy & Isaac, 2010). Cognitive flexibility, also referred to as shifting, is often considered one of the processes underlying executive functioning along with other cognitive abilities necessary for control and regulation including inhibitory control, updating/monitoring, working memory, and planning (Altemeier, Abbott, & Berninger, 2008; Hughes, 2002). Cartwright and colleagues (2010) define cognitive flexibility as “the ability to maintain simultaneously dual representations and flexibly switch between those representations when engaged in a task” (p. 62). This complex definition means that children must shift attention while mentally maintaining representations of the different aspects of the task they are completing. This is important in reading as children must simultaneously pay attention to phonology, orthography, syntax, semantics, and morphology in

order to be successful readers (Cartwright et al., 2010). Cartwright (2002) has shown that training in cognitive flexibility improves children's reading comprehension. She trained students on a reading-specific multiple classification task, which required them to sort words based on their phonological and semantic dimensions simultaneously. This reading-specific classification task made a significant and unique contribution to reading comprehension above and beyond the contributions made by children's age, a general multiple classification task, verbal ability, and decoding skill. Cartwright et al. replicated these findings in their 2010 study.

**Morphological tasks and working memory.** Research studies investigating morphological awareness also provide a rationale for including working memory and orthographic skill, in addition to vocabulary and phonological skill, in a structural equation model predicting reading skills. Researchers have recognized that working memory and/or short term memory have some overlap with morphological awareness tasks and have included measures to account for the effects of memory as it is a known predictor of reading skills (e.g., Baddeley, 2003; Cain, Oakhill, & Bryant, 2000; Gottardo, Stanovich, & Siegel, 1996; Micaela et al., 2012; Pham & Hasson, 2014; Seigneuric & Ehrlich, 2005). Baddeley (2003) states that “working memory is a temporary storage system that underpins our capacity for thinking” (p. 203) with implications for language processing, while short-term memory, part of the working memory system, has to do with the capacity to chunk information for recall. Some researchers seem to use the terms interchangeably or are not technical in their definitions and usage of the terms, so studies including measures of either will be reviewed.

There are some key issues to note with the studies reviewed here. First, there is inconsistency in the results; some studies find that both morphological skill and processing skills or working memory contribute to reading skills, while others find that only one of the two

contributes. The type of literacy skills used as outcomes (usually word reading, comprehension, or spelling), the variables used as predictors, and the age-ranges sampled vary from study to study. These issues make drawing conclusions across studies difficult and problematic and warrant further research.

***Predicting spelling.*** One study of morphological awareness that included a verbal memory task was conducted by Deacon and colleagues (2009); in this case the outcome variable was spelling rather than reading, and a measure of orthographic awareness was not included (but given that the outcome is spelling, an orthographic task, this is not surprising). In their study with 115 students, they investigated the unique contribution of morphological awareness, measured at grade 2, to general spelling at grade 4. The distinction that the authors make between general spelling and spelling morphologically complex words is important because they hypothesized that morphological awareness contributes to spelling ability in general. They designed their study in order to test whether the contribution of morphological awareness to general spelling (of 25 single-morpheme words) was robust enough to account for unique variance after controlling for phonological awareness, RAN (requiring children to name pictures of familiar objects), verbal short-term memory (assessed with a word memory span task), and general intelligence. Morphological awareness was assessed with the sentence analogy task (e.g., *Tom helps Mary: Tom helped Mary:: Tom sees Mary: \_\_\_\_\_*.) (Nunes et al., 1997).

Correlations showed that all of the grade 2 predictor variables and the grade 4 outcome were significantly correlated. Regression analyses revealed that morphological awareness made a significant unique contribution (8%) to spelling even after their stringent set of control variables. This is an important finding as it shows that morphological awareness is a robust predictor of general spelling when controlling for other variables that are known to be related to spelling.

There are some limitations to note. First, despite their stringent controls, vocabulary was not included as a predictor and it is known to be significantly related to morphological awareness. However, they measured verbal ability while many studies would use vocabulary as a substitute. Second, due in part to the age of their sample, only knowledge of past tense verbs (inflectional morphology) was assessed on the morphological awareness task. Future research should include other morphemes. However, it is important to note that this one component of morphological awareness was a unique predictor of spelling single-morpheme words. Finally, the only literacy skill involved in this study was spelling. Such stringent tests of the contribution of morphological awareness are needed for other literacy skills and with a broader age group.

***Predicting word reading.*** Chung and McBride-Chang (2011) investigated the predictors of Chinese word reading at ages 4-5 with 85 children from kindergartens in Hong Kong. They included measures of inhibitory control (based on a classic Stroop task), working memory (with a forward and backward digit recall), vocabulary (both receptive and productive), morphological awareness (involving compound words), and phonological awareness (based on the English phoneme deletion task). They found that processing skills (inhibitory control and working memory) explained significant unique variance in word reading after controlling for the other variables. They used a hierarchical regression with the processing skills as the last step, so while the contributions of the other variables were significant, it cannot be determined whether their contribution was unique. Also, the results of this study should be interpreted with caution when considering word reading in English because working memory has been shown to have language-specific effects (Cohen-Mimran, Adwan-Mansour, & Sapir, 2013; Marton, Schwartz, Farkas, & Katsnelson, 2006; Vasishth, Suckow, Lewis, & Kern, 2010)

Singson and colleagues (2000) conducted a study with 98 students in grades 3 to 6 to determine the relation between morphological awareness, vocabulary, verbal short-term memory (as measured by a digit span task), and word reading (real words and pseudowords). Their measure of morphological awareness was a multiple-choice derivational suffix task involving real words and morphologically complex pseudowords. They found significant correlations between all variables. In a multiple regression predicting word reading, morphological awareness made a significant unique contribution beyond the contribution of verbal short-term memory. The findings in Singson et al. (2000) are limited because they did not include other predictors in their regression, such as vocabulary or phonological and orthographic awareness, and the only reading outcome they used was word reading. Additionally, their sample was fairly small. However, they show that morphological awareness and short-term memory are both important for word reading and, at least in their sample, morphological awareness contributed after verbal short-term memory was controlled.

***Predicting comprehension along with other reading skills.*** Nagy and colleagues (2006), discussed previously to highlight the importance of morphological awareness beyond phonological awareness, addressed some of the limitations of Singson et al. study (2000). While this study did not include a measure of orthographic awareness, it did include a measure of short term memory. They sought to determine if morphological awareness would contribute beyond phonological abilities, including short-term memory, to literacy outcomes in their sample of 607 students from grades 4 to 9. They also investigated whether morphological awareness would have a greater contribution to literacy skills for typically-achieving students in grades 4 and above compared to the sample of at-risk students in another study (described later; Nagy et al.,

2003), and if the contribution of morphological awareness differs depending on the literacy outcome.

The first of two morphological awareness measures involved three separate tasks, all having to do with choosing the correct suffix in a syntactic context with real words, plausible nonwords, and nonwords with real suffixes. The second morphological measure was a relatedness task (e.g., *Does moth come from mother?*). The two measures of phonological abilities included a task used to assess phonological short-term memory, and a nonword decoding task. Vocabulary, reading comprehension, spelling, and decoding multi-morphemic words were also tested and used as outcomes.

Correlations among all the predictors plus vocabulary were significant for each age group. Using structural equation modeling, they found that morphological awareness made a significant and unique contribution to comprehension, spelling, and vocabulary for all age groups. Compared to at-risk grade 4 students in an earlier study by Nagy and colleagues (2003), morphological awareness made greater contributions to literacy outcomes for the students in this study (2006).

It should be noted that orthographic awareness was not included as a predictor in this study, and Nagy et al. (2003) found that it was a significant and unique predictor of word reading, decoding, and spelling for at-risk students in grades 2 and 4 as well as comprehension for the grade 2 students. Still, this study suggests that morphological awareness has very important implications for reading beyond short term memory and vocabulary.

It is important to note that not all studies have found morphological awareness to be a unique predictor of reading once measures of working memory were included. For example, Fraser and Conti-Ramsden (2008) investigated the contribution of various language skills,

including phonological awareness, morphological awareness, and working memory, to word reading, comprehension, and spelling in their sample of 71 students who were between 9 and 11 years old. Phonological awareness was assessed with a phoneme deletion task, working memory was measured with word and nonword recall, and morphological knowledge was assessed with a past tense elicitation task (testing only knowledge of verb inflections and probably not very demanding in terms of morphological knowledge). Again though, this study did not include a measure of orthographic awareness. Their results showed that morphological knowledge was significantly correlated with most of the other predictors, including both measures of working memory, phonological awareness, and vocabulary, and with the three outcomes of interest (comprehension, word reading, and spelling). Regression analyses revealed that phonological awareness, non-word recall (one of the working memory tasks), and vocabulary were the only significant unique predictors of word reading accuracy and spelling while vocabulary and recalling sentences were significant unique predictors of reading comprehension. Importantly, the sentence recall required children to recall and repeat sentences so it is not surprising that it accounted for much of the variance in reading comprehension.

While morphological knowledge was not a predictor of literacy skills in this study, it should not be dismissed. First, it was significantly correlated with the literacy outcomes and many other predictors. It is also important to note that this study included a wide range of reading abilities and the majority of the children in this study were considered by their school to have reading and/or language difficulties. This may be a reason that morphological awareness was not uniquely predictive of literacy skills as Nagy and colleagues found that morphological awareness made greater contributions to the literacy skills of typical readers (2006) than to those of at-risk readers (2003). Regarding the morphological task itself, it involved only inflectional

morphology, and it is not one of the more commonly used tasks. Another limitation is that the sample size of this study is not necessarily large enough to reasonably use so many predictors in the regression and this could have affected the results. Further research is needed with a larger sample size, typical readers, and a similar set of variables, but including orthographic awareness, in order to determine if the results would be consistent. However, this study does show that working memory is an important predictor of reading skills for this population of students and should be included in models that also include morphological awareness as a predictor of reading skills.

*Summary.* As can be seen from the studies reviewed above, results are inconsistent with regards to the contribution of morphological awareness and processing skills to literacy skills (typically word reading, comprehension, or spelling). There has not been enough consistency or replication with the literacy skills used as outcomes, the variables used as predictors (including the type of morphological awareness task used) or the populations studied. Further research is needed to identify the nature of the relation between morphological awareness tasks and processing skills and which specific processing skills are important. Additional research is also needed to determine if morphological awareness makes a unique contribution to specific literacy skills after controlling for processing skills and if this changes as children become more skilled readers.

### **Orthographic Awareness and Morphological Tasks**

As discussed earlier, phonemic knowledge is not enough to read, spell, and learn new words because of the morphophonemic nature of English orthography. In these situations, knowledge of morphology can provide the missing information, but it is also possible that knowledge of orthography can aid in these tasks. Apel et al. (2012) define orthographic

awareness as “the understanding or knowledge of the rules and patterns governing how individuals represent words in print” (p. 1285). Research has shown that orthographic awareness is also a unique predictor of reading, even when controlling for phonological awareness (e.g., Cunningham, Perry, & Stanovich, 2001; Olson, Forsberg, Wise, & Rack, 1994; Olson, Wise, Conners, Rack, & Fulker, 1989). Given that phonological, morphological, and orthographic awareness all pertain to linguistic aspects of individual words and are especially relevant in English, it is reasonable to hypothesize that they are all related and contribute to literacy skills, and some studies have found this (Nagy et al., 2003; Roman et al., 2009; Walker & Hauerwas, 2006). Morphological awareness concerns the ability to manipulate and reflect on morphemes while orthographic awareness is concerned with the legitimate combination of letters. Since morphemes are composed of legitimate combinations of letters, there is inherent overlap. The contributions of morphological awareness beyond phonological awareness and of orthographic awareness beyond phonological awareness have been established, but the question remains as to whether morphological awareness makes an independent contribution to literacy when all three are used as predictors. Studies including measures of each of these types of linguistic awareness are reviewed in this section, but there are few that include all three types of linguistic awareness and even fewer that include all three in addition to vocabulary and a memory or processing task. Similar to the studies investigating morphological awareness and processing skills or working memory, studies investigating both morphological and orthographic awareness have mixed results.

**Predicting spelling.** In a study that included measures of three types of linguistic awareness, Walker and Hauerwas (2006) investigated the role of phonological, morphological, and orthographic awareness on spelling inflected verbs in a sample of 103 children in grades 1,

2, and 3. Specifically, they explored the unique contributions that the different types of linguistic awareness would have on the students' written representations of inflected present progressive and past tense verbs (*-ed* and *-ing*, respectively). Spelling was assessed with inflected verbs and sentences that contained inflected verbs. Morphological awareness was orally assessed with a nonword cloze task based on the classic *wug, wugs* task by Berko (1958). Phonological awareness was assessed with a phoneme deletion task. To assess orthographic awareness, a nonword choice task was designed by the researchers and administered to students. It should be noted that unlike other orthographic choice tasks (Nagy et al., 2003, 2006; Olson et al., 1989, 1994) this task did not control for phonological awareness as some of the words were phonologically as well as orthographically impossible (e.g., *fbcz*). This confound could have affected their results.

Contrary to their hypotheses and despite significant correlations with all three types of linguistic awareness at each grade, the authors found that orthographic awareness uniquely predicted the ability to include the past tense ending (regardless of spelling) for students in grades 1 and 2 while morphological awareness uniquely predicted this ability in grade 3. One of their hypotheses regarded the ability to correctly represent the inflectional endings; correlations were significant with all three types of linguistic awareness. The regression showed that this ability was uniquely predicted by orthographic awareness for first grade and morphological awareness for third grade. Finally, all three types of linguistic awareness were significantly related to the application of orthographic patterns for inflectional morphemic units and regressions showed that this ability was uniquely predicted by phonological awareness and orthographic awareness for first grade, orthographic awareness for second grade, and morphological awareness for third grade. These findings indicate a unique earlier role for

phonological and orthographic awareness and a unique later role for morphological awareness when spelling inflected endings, again seeming to suggest that phonological and orthographic awareness develop first, and through those skills, morphological awareness develops a little later. Another important finding is the continued importance of orthographic awareness, which suggests that it is necessary to include along with measures of phonological and morphological awareness when investigating literacy skills, in this case spelling.

Some limitations of this study by Walker and Hauerwas (2006) should be noted. The confounds present in the orthographic awareness task pose a possible issue. Awareness of phonology could have been used to answer some of the items, which may be a reason why phonological awareness did not uniquely predict more of the spelling components. The authors did not report correlations among the predictor variables so there is no way of determining how much overlap may have been present between the phonological and orthographic awareness tasks. Also, while the authors assessed vocabulary in order to report the general characteristics of their sample, they did not include it in any of their analyses. This is noteworthy because vocabulary is often strongly correlated with linguistic skills, especially morphological awareness (as seen in many studies reviewed in this paper); this study would have been strengthened by the inclusion of vocabulary, along with a measure of working memory, in the analyses. Finally, while this study does show strong correlations between three types of linguistic awareness and spelling, they only assessed spelling of two inflectional morphemes. Nevertheless, this study demonstrates that multiple aspects of linguistic awareness should be considered.

**Predicting word reading.** Roman et al. (2009) also investigated the contributions of the three types of linguistic awareness of interest and used real word and pseudoword reading as outcomes. This is one of the few studies that included measures of phonological, morphological,

and orthographic awareness, along with RAN, as simultaneous predictors for word reading. Participants were 92 students in grades 4, 6, and 8. Their main aim was to investigate which skills the children in the study use when they read. To assess morphological awareness, a production task and a word analogy task were administered and orthographic awareness was assessed with an orthographic choice task, based on a measure developed by Olson and colleagues (1989; 1994), and required students to select from a pair the word with the correct orthography (e.g., *hert* vs. *hurt*). To complete the battery, students were assessed on a phoneme deletion task, RAN with digits and letters, and real word and pseudoword reading.

For both real word reading and pseudoword reading, Roman et al. (2009) found that phonological, morphological, and orthographic awareness each made significant unique contributions after controlling for age. Despite significant correlations, RAN was not a unique predictor of real word reading or pseudoword reading. Further investigation revealed that the effect of RAN on real word reading disappeared when orthographic awareness was entered into the equation. The authors assert that this indicates that RAN might be mediated by orthographic awareness; this shows, once again, the importance of orthographic awareness.

The results of this study are important because they demonstrate that phonological, morphological, and orthographic awareness are all unique contributors to word reading in intermediate and middle grades. However, despite these significant findings, there are still some limitations and questions. First, the authors did not control for general verbal ability, which is often measured through a vocabulary task, nor was a measure of working memory included. Research has shown that vocabulary and morphological awareness are related (e.g., Nagy et al., 2003, 2006; Nunes & Bryant, 2006) and this relation could affect the contribution of morphological awareness to word reading. Second, the only reading outcomes used in this study

were word reading and pseudoword reading. Results could look different for other literacy skills, such as comprehension and further research is needed.

**Predicting comprehension along with other reading skills.** In order to investigate the contribution of morphological, phonological, and orthographic awareness, to reading skills, Nagy and colleagues (2003) used structural equation modeling with their sample of 195 students in grades 2 and 4, all of whom were at risk for passing the state reading and writing tests respectively. The researchers' goal was to determine whether vocabulary and morphological, phonological, and orthographic awareness were related to reading and writing skills at grades 2 and 4.

The battery of tests given to the students to assess reading skills and linguistic awareness included a phonological awareness task (syllable and phoneme deletion), two orthographic awareness tasks (a receptive coding task and a word choice task), and three morphological awareness tasks (a suffix choice task, a relatedness task, and a task evaluating students' knowledge of compound words). Vocabulary was measured with an oral task that required students to explain the meaning of words. Measures of word reading accuracy and efficiency, decoding, spelling, and reading comprehension were also administered to students and were used as outcome variables.

The tested SEM model specified direct paths of vocabulary and phonological, orthographic, and morphological awareness on each of the outcome variables. For grade 2 the following paths reached statistical significance: the morphological awareness factor to comprehension, the phonological factor to word reading efficiency, the orthographic factor to all outcomes except for the paths to two decoding measures, and vocabulary to word reading accuracy. For grade four, phonological awareness had significant paths to two measures of

decoding. Orthographic awareness continued to have the highest number of significant paths including to word reading, several decoding outcomes, and spelling. Even though morphological awareness did not uniquely contribute directly to more outcomes, there are some important points from this study. First, it did contribute uniquely to comprehension for students in grade 2. Additionally, Nagy and colleagues (2003) concluded that morphological awareness indirectly influenced word reading through vocabulary. Although no paths from morphological awareness were significant for grade 4, it was strongly correlated with almost all the outcomes and was strongly intercorrelated with the orthographic awareness factor, which was not seen with grade 2 students. The authors highlight the fact that orthographic awareness uniquely contributed to word reading, decoding, and spelling and assert that this indicates that “morphology is an emerging knowledge source in word reading and decoding for these at-risk writers who are still learning to coordinate morphology with the orthographic and phonological cues in written words” (p. 740). This seems to suggest that morphological awareness develops later and perhaps through orthographic awareness and phonological awareness. Regarding limitations, the findings of this study are generalizable only to students in similar grades who are also at risk for reading or writing. Further research is needed to extend the models and conclusions of Nagy et al. (2003) to typical readers and writers.

Apel and colleagues (2012) addressed some of the limitations noted in the reviews of the other studies in this section. They examined the predictive ability of morphological, orthographic, and phonological awareness, vocabulary, and RAN on spelling, word recognition, and comprehension with 56 students in grades 2 and 3. They assessed morphological awareness with a production task and phonological awareness was assessed with a phoneme counting task. Orthographic awareness was measured by a task that required participants to choose a word that

most resembled a real word from 15 pairs of nonwords (e.g., *zeg* and *zzeg*). Receptive vocabulary, RAN with letters, word recognition, reading comprehension, and spelling were all assessed with standardized tests.

Apel and colleagues (2012) found that morphological awareness was the only unique predictor of spelling despite significant correlations with orthographic awareness, vocabulary, and RAN. When the outcome was word recognition, only morphological and orthographic awareness were uniquely predictive. For the regression on reading comprehension, only age, vocabulary, and morphological awareness were entered as predictors. Despite jointly accounting for 11% of the variance (after age) on reading comprehension, neither vocabulary nor morphological awareness were unique predictors.

It is important to note that phonological awareness was not included as a predictor in any of the regressions because it was not significantly correlated with any of the outcomes (or the other predictors). This is one of the limitations of this study. While the researchers assert that the phoneme counting task they used is more demanding than other phonemic awareness tasks, it is not as common as phoneme blending or elision tasks. Furthermore, it was not significantly correlated with any of their other measures. This could be an issue with the task or an anomaly of their sample as phonological awareness is usually significantly correlated with reading skills and other linguistic variables. Also, the number of participants in this study was fairly small, especially when you consider the number of students in each grade. Despite its limitations, this study demonstrates that morphological awareness, along with orthographic awareness and vocabulary, are correlated with reading skill and sometimes uniquely predictive (in this case, morphological awareness was uniquely predictive of spelling and word recognition while orthographic awareness was uniquely predictive of word recognition). This study again shows

the importance of including both a morphological and orthographic task in studies investigating reading skill, but would have been strengthened by the use of a different phonological task and the inclusion of a working memory task.

**Summary.** Some of the studies reviewed here seem to suggest that phonological and orthographic awareness develop in early elementary while morphological awareness develops a little later (i.e. Nagy et al., 2003; Walker and Hauerwas, 2006). A growth curve analysis conducted by Berninger, Abbot, Nagy, and Carlisle (2010) supports this conclusion. In a longitudinal study with students in grades 1 through 6, they found that students in the younger cohort (grades 1 to 4) showed greater growth in measures of phonological and orthographic awareness than the older cohort (grades 4-6). They found that growth was greater for morphological awareness in younger grades for three types of morphological tasks: a relational task, a suffix choice task (involving both derivational and inflectional suffixes), and a decomposition task (providing the base when given a derivation). Importantly, they found that growth on a morphological derivation task (their version of a morphological production task) was greatest in the older grades showing that the type of morphological skill being assessed by this task, generating morphological derivations, “does not show its primary growth during the early grades and continues to develop beyond grade 4” (Berninger et al., 2010; p. 154). The results of the study are important for two main reasons. First, they again show that results can vary based on the type of morphological task used and it is important to consider the task in relation to the sample of students and the outcome variables or goals of the study. Second, the results suggest that knowledge of derivational morphology continues to develop in the later elementary years, while phonological and orthographic awareness show the greatest growth in the early elementary years.

## **Implications**

It is clear from the studies reviewed that processing skills, phonological, morphological, and orthographic awareness, are all important factors in literacy skills. However, it remains unclear if they are each unique predictors and which literacy skills they may each predict. It appears that the unique contribution of each depends on the skill and age of the students, specifically that phonological and orthographic awareness develop first with morphological awareness developing in later elementary, but there are not enough studies including all three of these as predictors to make that determination with certainty. Attending simply to the number of outcomes uniquely predicted, orthographic awareness tallied the most, nearly twice that of morphological awareness and four times that of phonological awareness. Further, orthographic awareness consistently predicted word reading across all studies that included it as an outcome. Neither morphological awareness nor phonological awareness consistently predicted the same skill (word reading, comprehension, or spelling) across all studies. This suggests that a measure of orthographic awareness is very important to include in a model involving any type of linguistic awareness and predicting reading skill. Due to the small number of studies that include all three types of linguistic awareness (phonological, orthographic, and morphological) there is not enough replication or consistency to form any firm conclusions and further research is needed.

Thus, given all the concerns described in interpreting the results of the previous research, it is necessary that research be undertaken in order to determine if task demands account for the contribution of morphological tasks to reading skills and if the contribution of morphological skill to reading skills remains significant after controlling for various related skills with a large sample of typical elementary students. The results from the studies reviewed here provide the

rationale for the development of a task parallel to a morphological production task in Study 1. This review also provides a basis for the proposed structural equation models for Study 2 predicting reading comprehension which include vocabulary, orthographic awareness, phonological skill, and working memory as well as the morphological and orthographic production tasks. Although somewhat inconsistent across studies, there is still enough evidence to justify the hypothesized significant direct path of morphological awareness to reading comprehension.

## CHAPTER 3: Study 1

### Overview

The primary research question of Study 1 was whether a measure of morphological awareness, a morphological production task, would explain unique variance in reading comprehension and word reading when accounting for vocabulary, decoding, and processing artifacts using linear regressions. Within this main research question were several goals. The first goal of Study 1 was to develop and administer a task parallel to the morphological production task. Such a task would require the same type of flexible processing skills but not morphology in order to parse out the processing artifacts from the morphological production task in the linear regression. The second goal was to examine the developmental nature of both morphological awareness, as measured by the morphological production task, and the task designed to measure the processing demands, termed the orthographic production task. The third goal of Study 1 was to examine the relation between morphological awareness and reading comprehension, after accounting for processing artifacts, in upper-elementary students. Within this third goal was a secondary objective of more closely analyzing the morphological production task in order to investigate issues of phonological transparency and opacity within the morphological items and how they may or may not affect the connection between the morphological task and reading skills. Students in upper elementary, grade 5 and grade 8, were the focus of this study because it is during this time period that students encounter more and more words that are morphologically complex and knowledge of derivational morphology becomes increasingly important (Nagy & Anderson, 1984).

A morphological awareness task tapping syntactic knowledge, the understanding that derivational suffixes convey which syntactic category words belong to, was used for several

reasons. First, as mentioned previously, this is one of the more common types of morphological awareness tasks used in the literature (e.g., “farm: My uncle is a \_\_\_\_.”) (Carlisle, 1995, 2000; Carlisle & Nomanbhoy, 1993; Casalis, Col’è, & Sopo, 2004; Fowler & Liberman, 1995; McCutchen et al., 2008, 2009). Second, within an age range similar to that examined here, McCutchen et al. (2008) did not find significant differences in performance between syntactic and distributional tasks, but did find that tasks on relational knowledge did not differentiate between students as much as tasks on syntactic knowledge. Finally, one aim was to develop and include a parallel task measuring processing demands of the task, but not morphology, and the syntactic task lent itself to this goal. The task included items that were phonologically transparent and opaque, and further distinction was made between opaque items, characterizing some as “shift” and others as more authentically “opaque.” In this design, shift items did not completely maintain their phonology between the stem and the derivation but had definite phonological connection (e.g., *maintain/maintenance*). Opaque items were those whose phonological connection was questionable, including suppletive forms (e.g., *deep/depth*). Because of the relations among morphological awareness, phonological awareness, vocabulary, and processing skills, measures of all these skills were included in the design of Study 1. Since students were in upper elementary, a measure of decoding (real word reading) was used as a proxy for phonological awareness. Phonological awareness and word reading are generally very highly correlated and word reading was a more appropriate measure for this sample.

As determined from the discussion of cognitive flexibility, working memory, and processing skills in the previous chapter, executive processing demanded by the task could explain much of the relationship between students’ performance on morphological awareness tasks and their literacy skills. In other words, the link between literacy skills and morphological

awareness may reflect some type of executive processing rather than the specific morphological aspect of print. Nagy (personal communication, July 2012) suggested the development of a parallel task that does not involve morphology. This task was then designed to maintain the inclusion of phonological, semantic, syntactic and orthographic elements. The following is an example which requires students to change one letter in the prompt word: *point*: The artists' clothes were covered with \_\_\_\_\_. The goal in developing and employing such a task was to separate what is uniquely morphological from processing artifacts of the morphological production task. The literature reviewed in the previous chapter also provides a strong argument for including a task that is parallel to the morphological production task, but requires orthographic manipulation. Again, orthographic awareness consistently and uniquely predicted outcomes in all of the studies that included it as a predictor. Therefore, this specific parallel task was chosen as it allowed accounting for task demands/processing artifacts and included orthographic manipulation. Will morphological awareness still make a unique contribution to both reading comprehension and word reading after taking into account the processing artifacts inherent in the task?

The primary research question was whether the measure of morphological skill would explain unique variance in reading comprehension and word reading when accounting for vocabulary, decoding, and processing artifacts (via the orthographic production task) using linear regressions. It was hypothesized that morphological awareness would make a unique contribution to both reading comprehension and word reading though it was expected to be correlated with the other predictors. As previous studies have found, it was also hypothesized that grade 8 students would perform significantly better than grade 5 students on the morphological awareness task with the greatest difference showing in the shift and opaque

categories. Additionally, it was hypothesized that grade 8 students would perform significantly better than grade 5 students on the orthographic production task (described below). This would be consistent with Cartwright's (2000) findings that older students perform better on tasks requiring executive processing. While the orthographic production task was not the focus of this study, further examination of the results was warranted since it was developed for the purposes of this study.

## **Study 1: Methods**

### **Participants**

One hundred sixteen students from three schools in a large metropolitan area participated in the study. There were 68 students in grade 5 and 48 students in grade 8. Grade 5 students were 51.5% male with ages ranging from 9 years 11 months to 11 years 7 months. The students in grade 8 were 58.3% male with ages ranging from 12 years 5 months to 14 years 7 months. Overall, 59% of the students reported European American as their racial category, 19% Asian American, 5% African American, 2% Native American, 1% Pacific Islander, 13% as more than one race, and 1% as other. Fifteen percent reported having Hispanic heritage. In order to accurately represent mainstream classrooms as they exist in schools, students who qualified for special education services and those classified as English-language learners were included in the sample. Seven students in the sample qualified for special education services and five were classified as English-language learners.

### **Materials and Procedures**

Students were tested in one group session (in their regular classroom) and one individual session by trained graduate students for a total testing time of about 1.5 hours per student.

Participants completed several standardized literacy measures as well as researcher-developed morphological and orthographic production tasks.

**Standardized assessments.** Students completed a battery of standardized literacy measures including several subtests from the Woodcock-Johnson III Tests of Achievement (WJ-III; Woodcock, McGrew, & Mather, 2001). All tests were individually administered and followed standard administration procedures.

**Word reading.** The Letter-Word Identification subtest (Word ID) from the WJ-III is a measure of real word reading in which students must read aloud a list of words with correct pronunciation. The technical manual reports a split-half reliability of 0.94.

**Reading comprehension.** The Passage Comprehension subtest is an oral cloze task in which students read a short passage and supply the missing key word. The WJ-III Technical Manual reports a split-half reliability of 0.88.

**Vocabulary.** In the Picture Vocabulary subtest from the WJ-III, students must orally supply the correct word for the objects pictured. The test manual reports a split-half reliability of 0.81.

**Morphological Production Task.** Students also completed a morphological production task which was modeled after many sentence-completion tasks used to assess a construct that is commonly referred to as morphological awareness in the literature (e.g., Carlisle, 2000; McCutchen et al., 2009). As with previous tasks, students were presented with a stem word followed by an incomplete sentence. Students were given examples and were instructed to complete the sentence by changing the underlined (prompt) word (e.g., destroy: The storms were very \_\_\_\_\_.). In similar tasks, a distinction is usually made between phonologically opaque and transparent changes from stem to derivation. In a previous study, McCutchen et al. (2008) found

that only phonologically opaque items significantly differentiated between skilled and less skilled readers; however McCutchen and colleagues included suppletive forms within their phonologically opaque category, without differentiating them, which prompted the further distinction into three categories (phonologically transparent, phonologically shifted, and phonologically opaque) in the current study. Consequently, the current morphological production task was made to include three categories of changes: opaque, shift, and transparent (see Table 3.1). Previously, ‘opaque’ has been used to describe a morphological change that does not maintain the orthography and/or phonology of the stem. In the current study, a further distinction was made into ‘opaque’ and ‘shift’ categories. In the opaque category, the change from stem to derivation is atypical (e.g., *deep* to *depth* instead of the more common *-ness*). In the shift category, there is both an orthographic and phonological shift to the stem when the derivational suffix is attached (e.g., *generous* to *generosity*). The transparent category contains words that maintain both their orthography and phonology when the derivational suffix is added (e.g., *forget* to *forgetful*).

Table 3.1.

*Morphological Production Task: Mean Frequencies and Examples*

<b>Opaque</b> (atypical change from stem to derivation) ( $M=50.05$ , $SD=7.23$ )	<b>Shift</b> (shift to stem in orthography and/or phonology) ( $M=48.2$ , $SD=3.52$ )	<b>Transparent</b> (stem maintains orthography and phonology) ( $M=47.52$ , $SD=7.06$ )
deep → depth	generous → generosity	forget → forgetful
brief → brevity	destroy → destructive	achieve → achievement

In order to control the relative level of difficulty between the three categories of items within the morphological production task, the mean standard frequency index (SFI; Zeno, Ivens, Millard & Duvvuri, 1995) was used to determine the frequency of each target word. This resulted in a mean SFI for each of the categories (means and standard deviations are given in

Table 3.1). The SFI is a widely used index in the literature for controlling task difficulty (McCutchen et al., 2008) and this specific corpora was created from samples of text books, literature, fiction, and non-fiction totaling more than 60,000 (Zeno et al., 1995) making it appropriate for literacy research with students. A one-way analysis of variance (ANOVA) was conducted with type of phonological change as the between groups factor, using the Statistical Package for the Social Sciences (SPSS), to compare the SFI of each category and there was no evidence of differences between them:  $F(2, 27) = .449, p = .643$ .

**Scoring.** In the morphological production task, participants received one point for every word for which they generated an appropriate morphological change fitting the sentence context. This task was scored three ways, giving each participant three total scores: strict scoring, which required correct spelling and typically accepted morphological forms; less strict scoring, which allowed phonological spellings (e.g., *matinence* instead of *maintenance* and *generosity* instead of *generosity*); and a lax scoring, which allowed phonological spellings and regularized morphological forms (e.g., *deepness* instead of *depth* and *broadness* instead of *breadth*, which are included as entries in current dictionaries but are far less frequent in print than the corresponding suppletive forms; Zeno et al., 1995). The task was scored by trained research staff on an electronic database to ensure that the same answers from different students (including those spelled slightly different but phonologically consistent for all but the strict scoring) received the same score. Answers that required some subjectivity were flagged, and a consensus was reached by the research staff. Internal reliability using Cronbach's alpha was assessed for the morphological production task; the value was .89 indicating very high internal reliability (the value was .88 when allowing phonological spellings and .90 when allowing regularized forms). See Appendix A for the complete list of items from the morphological production task.

**Orthographic Production Task.** As part of the test battery, students also completed what was termed the orthographic production task. This task was developed to require the same processes as the morphological production task but involved no morphological manipulation. The purpose was to separate possible effects of working memory and processing from morphological awareness. Thus, in both tasks students had to alter a prompt word in order to correctly complete a sentence which involves syntax, semantics, phonology, and orthography. In the morphology production task, students were adding or altering morphemes whereas in the orthographic production task, students were adding a letter (e.g., pear: One old hunting tool is a \_\_\_\_\_.) or changing a letter (e.g., shone: Who answered the \_\_\_\_\_?). It was also important that this task reflect the different types of changes in the morphological production task as closely as possible, so half of the items were phonologically transparent, meaning no sounds change between the prompt and target words, and half were phonologically opaque, meaning that the added or changed letter affects the pronunciation of another letter(s) in the prompt word (see Table 3.2 for examples of the prompt and target words). There is only one category of phonological change (phonologically opaque) in this task, in addition to phonologically transparent, because suppletive forms are fundamentally morphological and could not be replicated in this orthographic task and still have it be absent of morphology.

As with the morphological production task, SFIs were determined for each target word in the orthographic production task and means were computed for each of the four categories: add and change crossed with opaque and transparent (see Table 3.2 for means and standard deviations). A 2x2 factorial analysis of variance was conducted comparing opaque and transparent items as well as add and change items, and there was no evidence of differences in SFI (the measure of word difficulty) between them as neither main effect was significant: type of

phonological change (opaque versus transparent),  $F(1, 24) = .067, p = .798$ ; type of item (add versus change),  $F(1, 24) = .022, p = .884$ .

Table 3.2.

*Orthographic Production Task: Mean Frequencies and Examples*

	<b>Opaque</b> (added or changed letter affects pronunciation of other letter[s]) ( $M=49.04, SD=7.71$ )	<b>Transparent</b> (no sounds change between the prompt and target) ( $M=49.73, SD=5.74$ )
<b>Add a Letter</b> (e.g., <u>band</u> : The food tasted _____.) ( $M=49.19, SD=5.62$ )	paid → plaid pear → spear ( $M=49.09, SD=6.25$ )	witch → twitch bar → bark ( $M=49.29, SD=5.41$ )
<b>Change a Letter</b> (e.g., <u>shone</u> : Who answered the _____.) ( $M=49.58, SD=7.81$ )	shout → stout birth → birch ( $M=48.99, SD=9.48$ )	strike → stride indent → invent ( $M=50.17, SD=6.45$ )

**Scoring.** In the orthographic production task, participants received one point for each word they correctly manipulated the spelling to fit the sentence context. This task was scored two ways: strictly, which required correct spelling, and less strict scoring which allowed phonological spellings (e.g., *twich* instead of *twitch* or *neet* instead of *neat*). As with the morphological production task, the orthographic production task was scored by trained research staff on an electronic database to ensure that the same answers from different students received the same score. Answers that required some subjectivity were flagged, and a consensus was reached by the research staff. The orthographic production task also had a high internal reliability, with Cronbach's alpha equaling .82 for both scoring methods. See Appendix A for the complete list of items from the orthographic production task.

Because the goal in developing the orthographic production task was to use it to parse out possible variation due to processing skills from the morphological production task, it was necessary to control for the relative levels of difficulty of the tasks. One-way ANOVAs were conducted on the target word SFIs comparing the morphological and orthographic production

tasks and also comparing the opaque and transparent categories across the tasks (shift and opaque categories in the morphological production task were combined for the purposes of this particular analysis). The results showed no evidence of differences in SFI of the target words between the tasks or between opaque and transparent items across the tasks: morphological ( $M=48.59$ ,  $SD=6.09$ ) and orthographic ( $M=49.38$ ,  $SD=6.68$ ),  $F(1,56) = .224$ ,  $p = .638$ ; opaque ( $M=49.09$ ,  $SD=6.45$ ) and transparent ( $M=48.89$ ,  $SD=6.27$ ),  $F(1,56) = .027$ ,  $p = .870$ .

### **Study 1: Results**

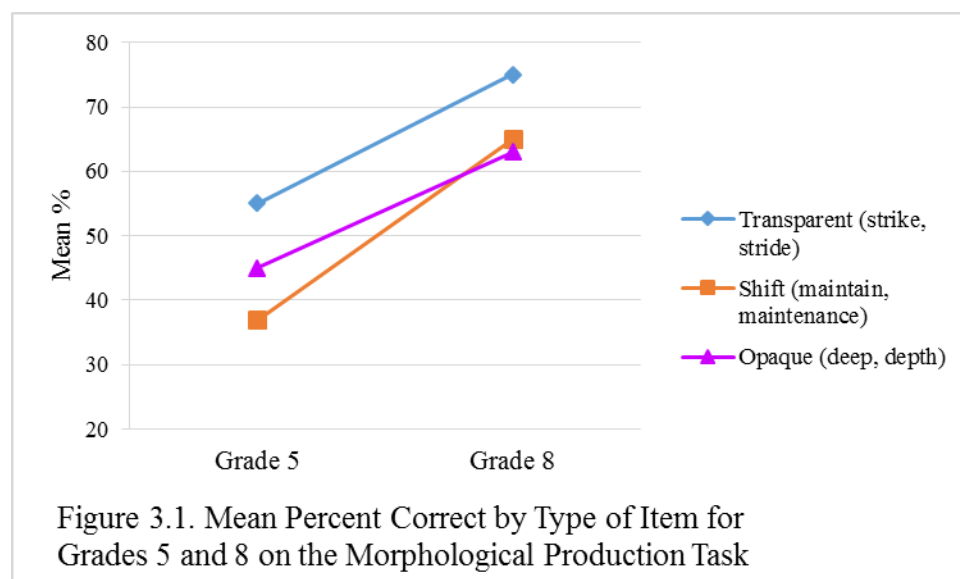
#### **Study Goal: Examine the Developmental Nature of Production Tasks**

**Morphological production task.** In order to test the developmental nature of morphological skill a 2 x 3 one-way repeated measures analysis of variance (ANOVA) was conducted on students' accuracy (percentage correct) on the morphological production task. The less strict scoring was used, which allowed phonological spellings, since this task is often administered orally where spelling accuracy could not be assessed; results were generally consistent when conducting the analysis with the other scoring methods which will be discussed later in this chapter. Type of morphological change (opaque, shift, transparent) was the within-subjects factor and grade was the between-subjects factor.

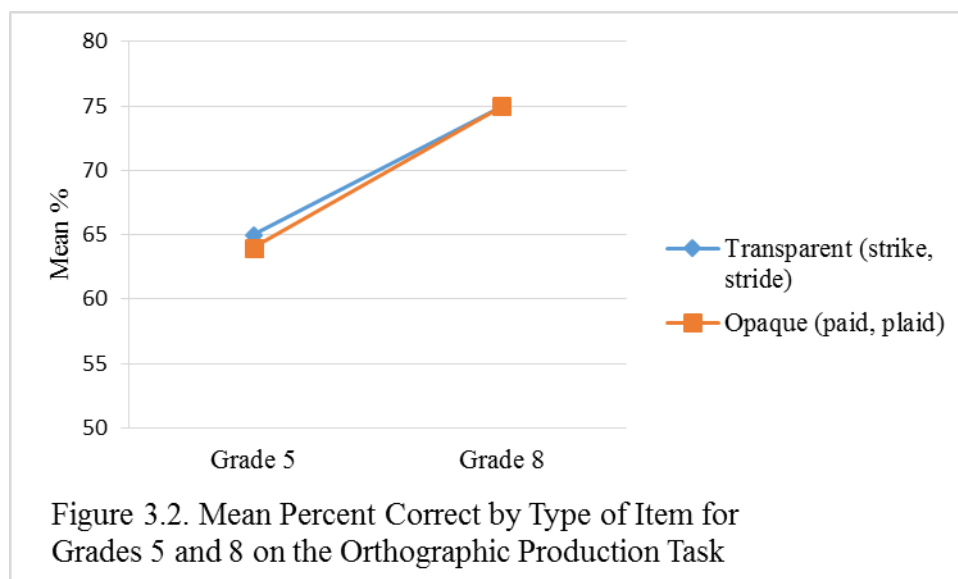
Results for tests of within-subject effects showed a significant main effect for type of morphological change  $F(2, 228) = 34.00$ ,  $p < .001$ , and a significant interaction between type of morphological change and grade,  $F(2, 228) = 4.80$ ,  $p < .01$ . The effect of grade, the between-subjects factor, was also significant:  $F(1, 114) = 48.65$ ,  $p < .001$ . As predicted, and as illustrated in Figure 3.1, students from both grades performed better on phonologically transparent items (see Table 3.3 for means and SDs) than on either type of item requiring a phonological change. Post hoc tests using Tukey's HSD at the  $p < .05$  level revealed that the main effect of type of

Table 3.3  
Means and SDs by Type of Item in Production Tasks

Measure	5th Grade $n = 68$		8th Grade $n = 48$		Total $n = 116$	
	$M\%$	$SD$	$M\%$	$SD$	$M\%$	$SD$
<i>Morphological</i>						
<i>Production Task</i>						
Opaque	0.453	0.184	0.634	0.144	0.528	0.190
Shift	0.366	0.229	0.652	0.218	0.485	0.265
Transparent	0.546	0.217	0.752	0.196	0.631	0.232
<i>Orthographic</i>						
<i>Production Task</i>						
Opaque	0.641	0.205	0.746	0.175	0.684	0.018
Transparent	0.649	0.153	0.750	0.132	0.691	0.152



morphological change was significant between shift and opaque items as well as between opaque and transparent items. Tukey's HSD at the  $p < .05$  level was also used to further investigate the interaction. As Figure 3.1 illustrates, the significant interaction is due to the fact that the difference between shift and opaque items was significant for students in grade 5, but this difference was not significant for students in grade 8. To summarize, grade 8 students performed better than grade 5 students and both grades performed better on transparent items compared to the items with the other two types of phonological change.



**Orthographic production task.** In order to test the developmental nature of the skill set measured by the orthographic production task (some type of executive processing), a similar ANOVA was conducted on the orthographic task (using the less strict scoring which allowed phonological spellings; other scoring method summarized later in this section). It was predicted that, as on its morphological counterpart, grade 8 students would perform significantly better than grade 5 students. A 2 x 2 one-way repeated measures ANOVA was conducted on students' accuracy (percentage correct) on the orthographic production task with grade as the between-subjects variable and type of phonological change (transparent and opaque) as the within-subjects variable. Again, only one type of phonological change could be included as suppletive forms are inherently morphological and could not be replicated in this orthographic task; this is also the reason both tasks could not be analyzed in the same ANOVA. Neither the main effect of phonological change in the orthographic production task nor the interaction were significant:  $F(1, 114) = 0.22, p > .05$  and  $F(1, 114) = 0.02, p > .05$  respectively. Tests of between-subjects effects revealed a significant effect of grade:  $F(1, 114) = 12.54, p < .001$ . See Figure 3.2 for a visual representation of results and Table 3.3 for means and standard deviations of the orthographic

production task. In sum, grade 8 students performed better than grade 5 students on the orthographic production task, but there was no difference in performance on transparent versus opaque items.

### **Study Goal: Examine the Contribution of Morphological Production to Reading Skills**

In order to determine if the morphological production task made a unique contribution to Word ID and reading comprehension, correlations and regressions were conducted. Preliminary examination of the zero-order correlations for both models revealed significant correlations between all predictors and outcomes (see Table 3.4).

Table 3.4.  
*Correlations*

	<i>M</i>	<i>SD</i>	1.	2.	3.	4.	5.	6.	7.	8.	9.
1. Word ID <sup>a</sup>	60.86	5.72	--								
2. Comprehension <sup>a</sup>	32.70	3.64	.73	--							
3. Picture Vocabulary <sup>a</sup>	27.91	3.87	.44	.49	--						
4. Age (in months)	143.13	18.16	.41	.41	.31	--					
5. Orthographic Production <sup>b</sup>	0.65	0.16	.73	.72	.54	.30	--				
6. Morphological Production <sup>b</sup>	0.54	0.20	.81	.76	.50	.53	.73	--			
7. Morph: Opaque <sup>b</sup>	0.53	0.19	.72	.65	.42	.43	.62	.84	--		
8. Morph: Shift <sup>b</sup>	0.48	0.26	.74	.66	.58	.51	.62	.88	.63	--	
9. Morph: Transparent <sup>b</sup>	0.63	0.23	.74	.68	.41	.42	.69	.88	.68	.72	--

*Note.*  $N=116$ . <sup>a</sup>Values given in raw scores. <sup>b</sup>Values given in percent correct.

\* all correlations significant at  $p < .001$ .

Two multiple linear regression models were performed, one predicting Word ID and the other predicting reading comprehension. Results of the multiple linear regression models showed that morphological production and orthographic production were unique predictors of both outcomes. The first model sought to determine if Word ID (a raw score out of 76) could be predicted by picture vocabulary, age, orthographic production, and morphological production (using the less strict scoring for both which allowed phonological spellings; results for other

Table 3.5.  
Multiple Linear Regression: Word Identification

	Standard Regression						
	$R^2_{total}$	$R^2_{Adj}$	$F_{total}$	$b$	(SE)	$t$	$\beta$
Word ID	.70	.69	64.61(4,111)***				
Intercept				60.77	(2.84)	21.43 ***	
Age (in months)				0.001	(0.02)	0.03	0.002
Picture Vocabulary				-0.10	(0.36)	-0.28	-0.02
Orthographic Production				1.66	(0.47)	3.57 ***	0.29
Morphological Production				3.48	(0.50)	6.98 ***	0.61

Note.  $N=116$ .

\*  $p < .05$ , \*\*  $p < .01$ , \*\*\*  $p < .001$ .

Table 3.6.  
Multiple Linear Regression: Reading Comprehension

	Standard Regression						
	$R^2_{total}$	$R^2_{Adj}$	$F_{total}$	$b$	(SE)	$t$	$\beta$
Comprehension	.65	.64	41.04(5,110)***				
Intercept				31.26	(1.95)	16.01 ***	
Age (in months)				0.01	(0.01)	0.74	0.05
Picture Vocabulary				0.23	(0.25)	0.94	0.06
Word ID				0.82	(0.37)	2.20 *	0.23
Orthographic Production				0.98	(0.34)	2.91 **	0.27
Morphological Production				1.15	(0.41)	2.80 **	0.32

Note.  $N=116$ .

\*  $p < .05$ , \*\*  $p < .01$ , \*\*\*  $p < .001$ .

scoring methods summarized later in this section). The four predictors (measures standardized by converting to  $z$ -scores across grades with age controlled by entering age in months as a predictor) accounted for a significant amount of variance in Word ID,  $R^2_{total} = .70$ ,  $F(4, 111) = 64.61$ ,  $p < .001$  (see Table 3.5). Morphological production had a unique positive effect on Word ID, ( $b=3.48$ ,  $SE = 0.50$ ),  $t(111) = 6.98$ ,  $p < .001$ ,  $\Delta R^2 = .132$ . Specifically, there is an estimated mean increase of 3.48 points on Word ID for each standard deviation increase on morphological production, holding the remaining predictors constant. Orthographic production also had a

unique positive effect on Word ID, ( $b=1.66$ ,  $SE =0.47$ ),  $t(111) = 3.57$ ,  $p < .01$ ,  $\Delta R^2 = .035$ .

Specifically, there is an estimated mean increase of 1.66 points on Word ID for each standard deviation increase on orthographic production, holding all other predictors constant. On the other hand, picture vocabulary and age were not uniquely predictive of Word ID despite significant zero-order correlations: picture vocabulary, ( $b= -0.10$ ,  $SE =0.36$ ),  $t(111) = -0.28$ ,  $p > .05$ ; age, ( $b=0.01$ ,  $SE =0.36$ ),  $t(111) = 0.03$ ,  $p > .05$ .

The second model sought to determine if reading comprehension (a raw score out of 47) could be predicted by Word ID and the same four predictors from the first model: picture vocabulary, age, orthographic production, and morphological production (using the less strict scoring for both which allowed phonological spellings). The predictors (measures standardized by converting to  $z$ -scores across grades with age controlled by entering age in months as a predictor) accounted for a significant amount of variance in reading comprehension,  $R^2_{\text{total}} = .65$ ,  $F(5, 110) = 41.04$ ,  $p < .001$  (see Table 3.6). Morphological production had a unique positive effect on reading comprehension, ( $b=1.15$ ,  $SE =0.41$ ),  $t(110) = 2.80$ ,  $p < .01$ ,  $\Delta R^2 = .025$ . Specifically, there is an estimated mean increase of 1.15 points on reading comprehension for each standard deviation increase on morphological production, holding all other predictors constant. Orthographic production also had a unique positive effect on reading comprehension, ( $b=0.98$ ,  $SE =0.34$ ),  $t(110) = 2.91$ ,  $p < .01$ ,  $\Delta R^2 = .027$ . Specifically, there is an estimated mean increase of .98 points on reading comprehension for each standard deviation increase on orthographic production, holding the remaining predictors constant. Additionally, Word ID had a unique positive effect on reading comprehension, ( $b=0.82$ ,  $SE =0.37$ ),  $t(110) = 2.20$ ,  $p < .05$ ,  $\Delta R^2 = .015$ . Specifically, there is an estimated mean increase of .82 points on reading comprehension for each standard deviation increase on Word ID, holding the other four predictors constant.

Even though the zero-order correlations were significant, picture vocabulary and age were not uniquely predictive of reading comprehension: picture vocabulary, ( $b=0.23$ ,  $SE=0.25$ ),  $t(110) = 0.94$ ,  $p > .05$ ; age, ( $b=0.18$ ,  $SE=0.25$ ),  $t(110) = 0.74$ ,  $p > .05$ .

**Analysis with type of phonological change.** Since the morphological production task uniquely and significantly predicted both Word ID and reading comprehension, two more linear regressions were conducted to determine if one type of morphological change carried the majority of the predictive value. Since there were no significant differences on the orthographic production task between the opaque and transparent items in the ANOVA that was reported earlier, the total score was still used. Keeping all other predictors the same, one model sought to determine if Word ID (a raw score out of 76) could be predicted by age, picture vocabulary, orthographic production, and morphological production separated into opaque, shift, and transparent (measures used as predictors were standardized by converting to  $z$ -scores across grades with age controlled by entering age in months as a predictor). The orthographic production task remained significant, and all three types of morphological change on the morphological production task were also significant (see Table 3.7). The other model sought to determine if reading comprehension (a raw score out of 47) could be predicted by age, Word ID, picture vocabulary, orthographic production, and morphological production separated into opaque, shift, and transparent (measures used as predictors were standardized by converting to  $z$ -scores across grades with age controlled by entering age in months as a predictor). Word ID and orthographic production remained significant, but none of the morphological predictors uniquely predicted comprehension (see Table 3.8).

Table 3.7.  
*Multiple Linear Regression: Word Identification (With MPT Item Types)*

	<i>Standard Regression</i>						
	$R^2_{total}$	$R^2_{Adj}$	$F_{total}$	$b$	(SE)	$t$	$\beta$
<i>Word ID</i>	.72	.71	47.46(6,109)***				
Intercept				60.86	(2.71)	22.42 ***	
Age (in months)				0.000	(0.02)	0.00	0.000
Picture Vocabulary				-0.45	(0.38)	-1.19	-0.08
Orthographic Production				1.69	(0.45)	3.76 ***	0.30
MPT: Opaque				1.46	(0.42)	3.43 ***	0.25
MPT: Shift				1.80	(0.49)	3.65 ***	0.31
MPT: Transparent				0.98	(0.49)	1.98 *	0.17

Note.  $N=116$ . MPT = Morphological Production Task  
 \*  $p < .05$ , \*\*  $p < .01$ , \*\*\*  $p < .001$ .

Table 3.8.  
*Multiple Linear Regression: Reading Comprehension (With MPT Item Types)*

	<i>Standard Regression</i>						
	$R^2_{total}$	$R^2_{Adj}$	$F_{total}$	$b$	(SE)	$t$	$\beta$
<i>Comprehension</i>	.65	.62	28.01(7,108)***				
Intercept				30.70	(1.96)	15.63 ***	
Age (in months)				0.01	(0.01)	1.02	0.07
Picture Vocabulary				0.20	(0.27)	0.72	0.05
Word ID				0.85	(0.40)	2.13 *	0.23
Orthographic Production				1.06	(0.35)	3.08 **	0.29
MPT: Opaque				0.40	(0.32)	1.24	0.11
MPT: Shift				0.34	(0.38)	0.89	0.09
MPT: Transparent				0.41	(0.36)	1.14	0.11

Note.  $N=116$ . MPT = Morphological Production Task  
 \*  $p < .05$ , \*\*  $p < .01$ , \*\*\*  $p < .001$ .

To summarize, items with one type of phonological change are not carrying the predictive value; either items with all types of phonological change remain significant, as was the case with Word ID, or none of the three types of phonological change are significantly predictive, as with reading comprehension.

**Analysis with alternative scoring.** Interestingly, when the same regressions that were described in full above (using the total score on the morphological production task) were

conducted using the strictly-scored total from the morphological production task (correct spelling required), morphological production made a unique contribution in the model predicting Word ID but not in the model predicting reading comprehension. However, when the same regressions were conducted using the totals computed from the lax scoring of the morphological production task (regularized forms such as *deepness* allowed), morphological production still made a significant unique contribution in the models predicting both Word ID and reading comprehension. The results did not differ based on whether the strict or less-strict totals were used from the orthographic production task.

### **Study 1: Discussion**

The results from this study have implications for theory and future research surrounding the connection between morphological awareness and reading. First, the hypothesis regarding the developmental nature of morphological skill was confirmed. Eighth-grade students performed better on the morphological measure than fifth grade students. This finding lends further support to previous research which shows that morphological awareness increases over time and continues to develop across the ages examined in this study (Kuo & Anderson, 2006; McCutchen et al., 2008, 2009; Nagy et al., 2006; Nunes, Bryant & Bindman, 1997; Singson et al., 2000). Additionally, the results from the task measuring processing demands, the orthographic production task, also show a developmental trend which is consistent with findings reported by Cartwright and colleagues (2002, 2010). Since the design is cross-sectional and not longitudinal, the results should be interpreted accordingly: This study sampled a group of grade 5 and grade 8 students simultaneously, so individual student growth cannot be claimed; however, the significant difference in performance between grade 5 and 8 students on both the morphological

and orthographic production tasks lends support to the claim that these are measuring developmental skills.

As hypothesized, the morphological production task made a significant and unique contribution to Word ID, beyond vocabulary and the orthographic production task (task processing artifacts), and to reading comprehension, beyond decoding, vocabulary, and the orthographic production task. The significant finding for reading comprehension is a particularly robust finding considering that both vocabulary and decoding (Word ID) are themselves strong predictors of comprehension and the effect of morphological production remained after accounting for those variables. Thus, the findings from this study lend credence to the claim that the traditional morphological production tasks are in fact tapping morphological awareness. Surprisingly, the orthographic production task also made a unique contribution to the prediction of reading comprehension, almost equal in magnitude to that of the morphological production task. Because the orthographic production task had been designed to include all the process demands of the morphological production task but without the morphological demands, it was not expected to account for variance in comprehension once the morphological production task was included in the model. Since both morphological and orthographic production were significant and unique predictors of comprehension, further research is needed to clarify how the processes tapped in both relate to comprehension.

The claim that morphological production tasks are tapping morphological awareness, is further strengthened by the ANOVA findings related to the three types of morphological change (opaque, shift, and transparent). Across grade 5 and grade 8 students, both shift and opaque items were responded to less accurately than transparent items. Consistent with that result, the regressions showed that it is not one item type that was making a unique contribution to reading.

For reading comprehension, opaque, shift, and transparent items were not uniquely predictive (though they were significantly correlated), most likely because they shared too much variance and the magnitude of the effect was smaller than that for Word ID, though still highly predictive. In the case of word reading, opaque, shift, and transparent items all uniquely and significantly predicted Word ID, revealing that they are all equally important for this outcome. If, for example, the opaque (in linguistic terms, suppletive) items had been the only significant and unique predictor of the three, it might be due more to vocabulary knowledge than to morphological knowledge, since there is no obvious generative morphological connection between the root and the derived form. In other words, if students do not already know that *depth* comes from *deep* or that *wisdom* comes from *wise*, they would not be able to generate the derived forms based on generative morphological rules. Lending additional support to the claim that the morphological production task is tapping morphological awareness was the lack of effect of phonological transparency in the orthographic production task.

While all students responded to transparent items more accurately than shift or opaque items in the morphological production task, there was no difference in students' responses to transparent and opaque items in the orthographic production task. Even though there was always a phonological change to target words in the orthographic production task, items that were phonologically transparent remained the same except for the letter that was changed or added (e.g., *dog* to *dig*) while in the opaque items, changing or adding one letter affected the phonology of other letters in the word (e.g., *paid* to *plaid*). This is similar to the morphological production task where the roots of transparent items remain phonologically the same with the added suffix, while deriving shift and transparent items changes the pronunciation of the root. This implies that the effect of transparency found in the morphological production task is an artifact of the

interaction of the phonology with the morphology, not simply the phonological transparency making the item easier. Perhaps correct responses to the phonologically transparent items in the morphological production task are more easily retrieved from the mental lexicon because the morphological link between the root (which the students see on their paper) and the derived forms are phonologically transparent. Conversely, the link between the root and derived forms in the shift and opaque categories are not as readily activated in the mental lexicon because the morphological link is partially obscured by a phonological change. This suggestion is consistent with results from morphological studies where differences have been found in performance based on the type of phonological relationship. McCutchen et al. (2008) found that students in grades 4 and 6 performed similarly on phonologically transparent items on morphological tasks, but 6<sup>th</sup> graders performed significantly better than 4<sup>th</sup> graders on phonologically opaque items. In another study, McCutchen et al. (2009) found that students in grades 5 and 8 were faster to respond to words that had a phonologically transparent relationship with the prime (compared to a phonologically opaque relationship).

A related argument may explain why the morphological production task was not a significant unique predictor of comprehension when using the strict scoring rules that required correct spelling. The number of participants receiving credit for correctly answering an item increased when phonological spelling was allowed, that is, when the task was more comparable to an oral production task (which by definition does not involve spelling). Thus, requiring correct spelling could be more of a vocabulary measure and a measure tapping orthographic awareness (comprised of words that students already know and know how to spell) than a measure of morphological awareness (where they can generate phonological approximations of morphological changes that fit the sentence context). The final finding that strengthens this point

is that the morphological production task was still a significant and unique predictor of both reading comprehension and word reading when using the scoring that allowed regularized forms. *Wideness, briefness, broadness, and wiseness* were fairly common answers given by students. It is unlikely that students have seen these forms before as they are less frequent than the suppletive forms *width, brevity, breadth, and wisdom* (Zeno et al., 1995). Consequently, it is more likely that students are using the productivity of *-ness* (Hayes, 2009) and generating the forms based on their knowledge of morphology. In conclusion, the findings from this study lend great credence to the claim that the traditional morphological production tasks are really tapping morphological awareness.

## CHAPTER 4: Study 2

### Overview

The primary research question of Study 2 was whether the morphological production task and the orthographic production task (from Study 1) would continue to have a significant unique effect on reading comprehension after accounting for more variables that address other linguistic skills and processing skills more precisely. Within the research question were two goals. The first goal was to determine if morphological skill would continue to have a unique effect on reading comprehension after including measures of orthographic skill, vocabulary, phonological word skill, and working memory (a measure of processing skill) in a structural equation model using factors versus single measures when possible. The second goal of Study 2 was to further examine the nature of the relationship between reading comprehension and the parallel processing task, the orthographic production task that was developed in Study 1, by including it in a structural equation model along with measures of orthographic skill, vocabulary, phonological word skill, and working memory.

It is unclear how the processes tapped in both the morphological and orthographic production task relate to reading comprehension and further research is needed. Study 2 seeks to clarify the nature of the relationship between both tasks and reading comprehension with two separate structural equation models. The findings from Study 1 show that the morphological production task remained a significant and unique predictor of reading comprehension after accounting for the parallel orthographic production task, vocabulary, and decoding. These findings suggest that one traditional type of task used to measure knowledge of morphology is not simply another way to measure processing skills (required by the task) or even vocabulary. This strengthens the claim that this type of task, a task in which students must produce a

derivation of a root to fit a syntactic context, is tapping a construct that can more confidently be characterized as morphological in nature. Based on the findings from Study 1 and the literature reviewed previously, it was hypothesized that the morphological production task would continue to have a unique effect on reading comprehension. The additional finding from Study 1, that the orthographic production task significantly and uniquely predicted reading comprehension after accounting for vocabulary, decoding, and the morphological production task, raises the question as to what the orthographic production task is measuring. With the inclusion of the additional measures in the structural equation model, the prediction for Study 2 was that the orthographic production task would share much variance with orthographic skill, working memory, phonological word skill, and vocabulary. Therefore, it was hypothesized that the orthographic production task would not have a unique effect on reading comprehension, but would be significantly correlated with reading comprehension and with the other predictors.

An orthographic skill factor, measured with an orthographic choice task (Olson et al., 1989, 1994) and a spelling task, was included in the structural equation models because it was hypothesized that the orthographic production task was in large part a measure of orthographic skill and that the measures would significantly overlap. Additionally, given the literature reviewed previously, it was important to include an orthographic factor in the model involving the morphological production task because of the number of studies that found orthographic skill to be significantly related to morphological skill and to reading skill. To address the known relationships among phonological skill, morphological skill, and reading comprehension, a phonological/word skill factor was included in the models with Word ID and Word Attack (a pseudoword reading task) from the WJ-III as indicators. Again, given the age of the participants, measures of word decoding skill were more appropriate and were used as a proxy for

phonological awareness. To account for processing skills in both the morphological and orthographic production tasks, a measure of verbal working memory was included in the structural equation models. Finally, to address the known relationships among vocabulary, morphological skill, orthographic skill, and reading comprehension, a measure of vocabulary was included in the models.

## **Study 2: Methods**

### **Participants**

This study was part of a larger intervention study with participating teachers implementing lessons on teaching academic language via morphological word families. The pretest data was used for the analyses in this study. Three hundred seven students in grades 4 and 5 from seven schools in a large metropolitan area participated in the study. There were 111 students in grade 4 and 196 students in grade 5. Grade 4 students were 49.5% male and ranged in age from 9 years 1 month to 10 years 7 months. Grade 5 students were 47.4% male and ranged from 10 years 1 month to 11 years 5 months. Overall, 75.9% of the students reported European American as their racial category, 7.2% Asian American, 4.2% African American, 1.3% Native American, 1% Pacific Islander, 7.5% as more than one race, and 2.9% as other. Seven and a half percent reported having Hispanic heritage. In order to accurately represent mainstream classrooms as they exist in schools, students who qualified for special education services and those classified as English-language learners were included in the sample. Twenty six students in the sample qualified for special education services (12 in grade 4) and 6 were classified as English-language learners (3 in each grade level).

## Materials and Procedures

Students were tested at their schools by trained research assistants in one individual session and two group sessions for a total of about two hours of testing. Participants completed several standardized literacy measures as well as researcher-developed morphological and orthographic production tasks. Because of the relationships between vocabulary, morphological, orthographic, phonological, and processing skills, as discussed previously in the review of research, measures of these were included.

**Standardized assessments.** Students completed a battery of standardized literacy measures including measures of reading comprehension, phonological skill, working memory, vocabulary, and orthographic skill. All tests were administered following standard administration procedures.

**Reading Comprehension.** Used as the outcome measure, the Passage Comprehension subtest from the WJ-III (Woodcock et al., 2001) is an oral cloze task in which students must supply the missing key word in context. Raw scores were transformed to standard scores (with a mean of 100 and standard deviation of 15) using age norms provided in the test manual. The technical manual reports a split-half reliability of 0.88.

**Decoding skill.** Two subtests from the WJ-III (Woodcock et al., 2001) were used to measure decoding skill. In the Word Attack subtest, students decode a list of increasingly difficult pseudowords. The Letter-Word Identification (Word ID) subtest was also administered. Raw scores were also transformed to standard scores for these two subtests. The technical manual reports split-half reliabilities of 0.87 and 0.94 respectively.

**Vocabulary.** Students also completed the vocabulary subtest for grade 5, Form S, of the Gates-MacGinitie Reading Tests, Fourth Edition (MacGinitie, MacGinitie, Maria, Dreyer &

Hughes, 2002). This vocabulary test presents each test word with minimal context, and students must select the word, out of five choices, that most closely matches in meaning. Raw scores were converted to extended scale scores (ESSs), the normed scores for this test. ESSs were developed by the publisher using the Rasch model according to item response theory. The ESSs is a continuous scaled score that can be used to track results across grades. (MacGinitie et al., 2002). According to the Gates Technical Report, the Kuder-Richardson Formula 20 (KR-20) reliability coefficient is 0.91.

**Working memory.** Verbal working memory was measured with the Working Memory, Sentences: Listening (WMSL) subtest from the Process Assessment of the Learner – Second Edition: Diagnostic Assessment for Reading and Writing (PAL-II; Berninger, 2007). This is an oral task in which students are read increasingly long items (from one to four sentences), then answer a question about what they heard. After answering the question, they are required to repeat verbatim the original sentence or sentences. Students receive one point for correctly answered questions and 0-2 points per sentence (up to 8 points per item) based on the accuracy of their repetition. Raw scores were used because published norms resulted in a loss of variation in scores; the standard score has a mean of 10 with a range of 1-19 and standard deviation of 3, but the raw scores ranged from 7 to 58. The raw scores were grade-corrected by creating  $z$  scores for students based on the mean and standard deviation of their grade level.

**Spelling.** Assessed with the spelling subtest from the Wechsler Individual Achievement Test, Third Edition (WIAT-III; Pearson, 2010), spelling was one of the two indicators of orthographic skill. Adapted for group administration and scored following standard procedures, students were read a list of increasingly difficult words and instructed to write them with correct spelling. Raw scores were transformed to standard scores (with a mean of 100 and standard

deviation of 15) using age norms provided in the test manual. The technical manual reports a test-retest median reliability of 0.85.

**Orthographic choice.** In addition to the spelling task, an orthographic choice task, based on a measure developed by Olson and colleagues (1989, 1994), was as a measure of orthographic skill. This task required students to select the correctly spelled word in a pair (e.g., *hert* vs. *hurt*). Students had 60 seconds to complete as many pairs of words as possible. Students' scores were the number answered correctly with the number answered incorrectly subtracted in order to account for guessing. The orthographic choice task had a high internal reliability, with Cronbach's alpha equaling .92. See Appendix B for the directions and items from the orthographic choice task.

**Morphological production task.** Students also completed a 40-item morphological production task. While the format was the same as the morphological production task used in Study 1, many of the words used in this task were different because the data collected for Study 2 was part of an intervention study which necessitated the inclusion of some words from the intervention. However, the mean standard frequency index (SFI; Zeno et al., 1995) was again used to determine the frequency of each target word, and the mean frequencies of the task from Study 1 and Study 2 were compared; they were not statistically different. Because it was determined in Study 1 that one type of phonological change (opaque, shift, transparent) was not carrying the unique contribution of the morphological production task to reading comprehension, in this version of the task, half the items were phonologically transparent, and half were in the shift category, where the phonology and orthography both shift from the base/root to the target word (see Table 4.1); the mean SFIs of the shift and transparent categories were not statistically different. Participants received one point for each root word they changed to correctly fit the

context, and phonological spellings were allowed (e.g., *memorable* instead of *memorable* and *explotion* instead of *explosion*). This maintained consistency with previous studies where this type of task was given orally and spelling was not an additional requirement. As with Study 1, this task was scored by the same research staff on an electronic database so that the same answers from different students received the same score (including those spelled slightly different but phonologically consistent). Answers that required some subjectivity were flagged, and a consensus was reached by the research staff. Internal reliability (Cronbach's alpha) was .92 indicating high internal reliability. See Appendix B for a complete list of items from the morphological production task.

Table 4.1.

*Morphological Production Task: Mean Frequencies and Examples*

<b>Shift</b> (shift to stem in orthography and phonology) ( $M=48.72$ , $SD=4.26$ )	<b>Transparent</b> (stem maintains orthography and phonology) ( $M=47.73$ , $SD=4.86$ )
mystery → mysterious	construct → constructive
explode → explosion	secret → secretly

**Orthographic production task.** As part of the test battery, students also completed a similar version of the orthographic production task that was developed and used in Study 1. Due to testing constraints, the task was shortened to 20 items and the prompts simplified, but the task maintained the inclusion of half add-a-letter items and half change-a-letter items crossed with half opaque items and half transparent (with no statistical difference between the mean SFIs). The mean SFIs of items in the orthographic production task and morphological production task used in this study were not statistically different. The orthographic production task was again scored by the same research staff as Study 1 on an electronic database to maintain consistency with scoring. Answers that required some subjectivity were again flagged, and a consensus was

reached by the research staff. The orthographic production task also had a good internal reliability with this sample of students, with Cronbach's alpha equaling .78. See Appendix B for the complete list of items from the orthographic production task.

## **Study 2: Results**

### **Data Analysis**

The first goal of this study was to determine if the morphological production task would significantly and uniquely predict reading comprehension in a structural equation model. The second goal was to examine the contribution of the orthographic production task to reading comprehension in a separate structural equation model. For the morphological production task, Model 1, the hypothesis was that it would be significantly correlated with the other factors (vocabulary, working memory, orthographic skill, and decoding skill) and that it would have a significant unique effect on reading comprehension. For the orthographic production task, Model 2, the same significant correlations were hypothesized, but it was hypothesized that the orthographic production task would not have a significant unique effect on reading comprehension. Instead, it was predicted that the orthographic production task would have indirect effects on reading comprehension through strong correlations with the other predictors and comprehension.

Structural equation modeling of covariance structures was conducted in which spelling and orthographic choice were used to model the latent factor underlying orthographic skill and Word ID and Word Attack were used to model the latent factor underlying decoding skill. Those two latent constructs along with working memory, vocabulary, and either the morphological production task (Model 1) or the orthographic production task (Model 2) were used as predictors for reading comprehension. The approach allowed evaluation of whether the contribution of

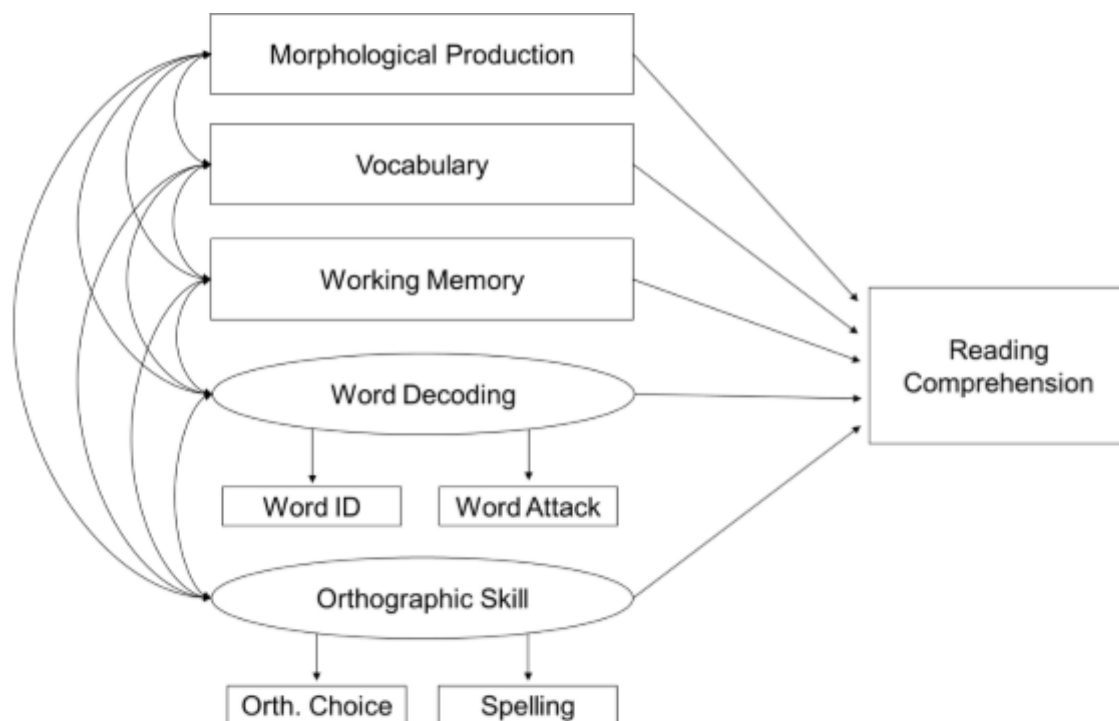


Figure 4.1. Model 1, with the morphological production task, vocabulary, working memory, word decoding, and orthographic skill predicting Reading Comprehension

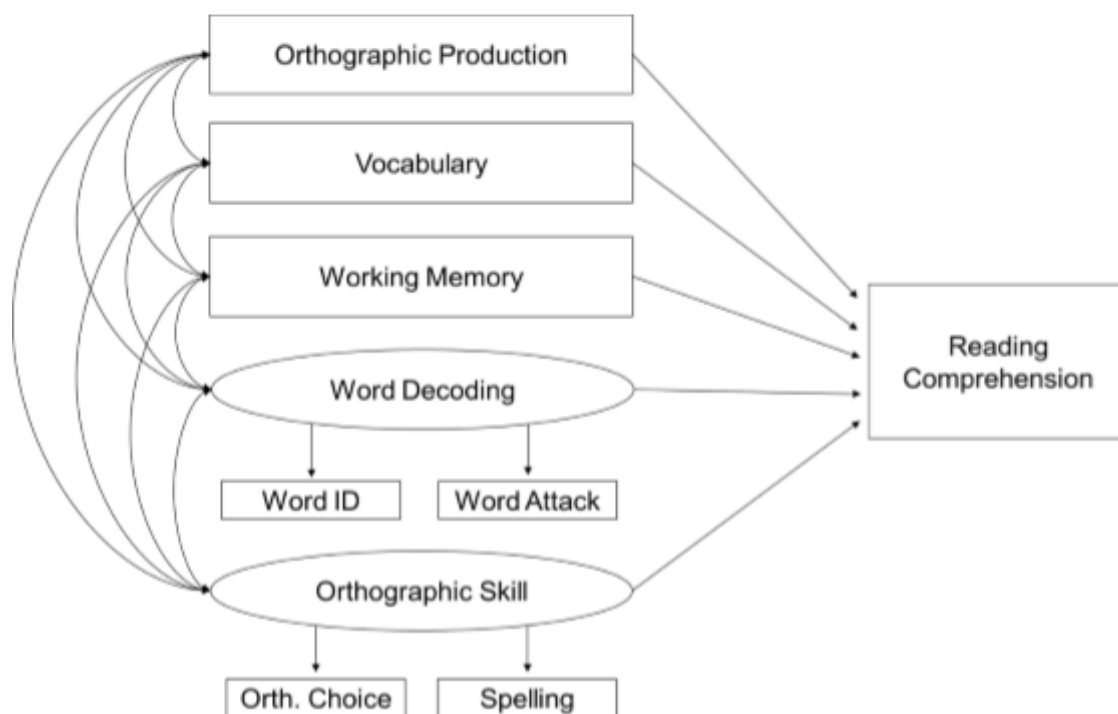


Figure 4.2. Model 2, with the orthographic production task, vocabulary, working memory, word decoding, and orthographic skill predicting reading comprehension

morphological production, in Model 1, and orthographic production, in Model 2, are unique, that is, independent of the contribution of the other factors when the shared variance among them is statistically controlled.

These analyses were based on the models depicted in Figure 4.1 (Model 1 with the morphological production task) and Figure 4.2 (Model 2 with the orthographic production task). In Model 1, it is assumed that morphological production, vocabulary, working memory, word skill, and orthographic skill each contribute to reading comprehension. Word skill is a latent variable based on two measures, Word ID and Word Attack, and orthographic skill is also a latent variable based on two measures, orthographic choice and spelling. Morphological production, vocabulary, and working memory are each represented by one measure. In Model 2, it is assumed that orthographic production, vocabulary, working memory, word skill, and orthographic skill each contribute to reading comprehension. The same configuration of latent variables and measures as Model 1 is used in Model 2, with orthographic production (represented with one measure) replacing morphological production.

Table 4.2  
*Means and Standard Deviations by Grade Level*

Measure	4th Grade $n = 111$		5th Grade $n = 196$		Total $n = 307$	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
<i>Reading Comprehension</i> <sup>a</sup>	102.64	9.15	101.98	11.23	102.22	10.51
<i>Morphological Production Task</i> <sup>b</sup>	20.46	8.15	24.70	8.08	23.17	8.35
<i>Orthographic Production Task</i> <sup>b</sup>	10.01	4.01	11.79	3.87	11.15	4.01
<i>Vocabulary</i> <sup>c</sup>	516.90	31.85	529.58	32.80	524.99	32.98
<i>Working Memory</i> <sup>b</sup>	40.62	7.29	39.71	9.62	40.04	8.85
<i>Word ID</i> <sup>a</sup>	110.19	9.16	107.44	10.39	108.44	10.03
<i>Word Attack</i> <sup>a</sup>	106.99	10.59	104.89	10.39	105.65	10.49
<i>Orthographic Choice</i> <sup>b</sup>	24.03	6.40	27.67	6.61	26.35	6.75
<i>Spelling</i> <sup>a</sup>	104.74	14.51	105.91	12.64	105.49	13.33

<sup>a</sup> Standard score ( $M = 100, SD = 15$ )

<sup>b</sup> Raw score, but analyses used grade-corrected  $z$  score based on mean for each grade level

<sup>c</sup> Scale score

## Means and Correlations

Means and standard deviations are reported in Table 4.2 for each measure. Zero-order correlations are presented in Table 4.3 among all measures that were used in the analyses. All measures are significantly correlated with the exception of orthographic choice and working memory. Correlations involving the morphological production task are higher than those involving the orthographic production task, but both tasks were highly correlated with each other and all other measures. The highest correlations are between the morphological production task and vocabulary and between Word Attack and Word ID. Table 4.4 contains correlations involving the predictor variables (with latent factors for decoding skill, based on Word ID and Word Attack, and for orthographic skill, based on orthographic choice and spelling). The morphological production task was highly correlated with the decoding skill factor and the orthographic skill factor. In fact, three of the four highest correlations involve the morphological production task and another predictor: vocabulary, decoding skill, and orthographic skill.

Table 4.3.  
*Correlations Among Measures*

	1.	2.	3.	4.	5.	6.	7.	8.	9.
1. Comprehension	--								
2. MPT	.64 ***	--							
3. OPT	.58 ***	.64 ***	--						
4. Vocabulary	.63 ***	.72 ***	.60 ***	--					
5. Working Memory	.45 ***	.43 ***	.38 ***	.41 ***	--				
6. Word ID	.64 ***	.67 ***	.53 ***	.55 ***	.31 ***	--			
7. Word Attack	.53 ***	.54 ***	.40 ***	.46 ***	.25 ***	.71 ***	--		
8. Orth. Choice	.33 ***	.45 ***	.38 ***	.34 ***	.10	.44 ***	.34 ***	--	
9. Spelling	.55 ***	.65 ***	.56 ***	.54 ***	.25 ***	.73 ***	.61 ***	.57 ***	--

Note.  $N=307$ . MPT = Morphological Production Task; OPT = Orthographic Production Task

\*\*\*  $p < .001$ .

Table 4.4.  
*Model Correlations Among Predictors*

	1.	2.	3.	4.	5.	6.
1. MPT	--					
2. OPT	.64 ***	--				
3. Vocabulary	.72 ***	.60 ***	--			
4. Working Memory	.43 ***	.38 ***	.41 ***	--		
5. Decoding Skill	.72 ***	.56 ***	.59 ***	.33 ***	--	
6. Orthographic Skill	.68 ***	.59 ***	.57 ***	.26 ***	.82 ***	--

*Note.*  $N=307$ . MPT = Morphological Production Task; OPT = Orthographic Production Task. \*\*\*  $p < .001$ .

### Structural Equation Modeling

Structural equation modeling, using EQS (Bentler, 2006), was used to examine the contribution of the morphological production task (in Model 1) and the orthographic production task (in Model 2), along with vocabulary, working memory, decoding skill, and orthographic skill (in both models) to reading comprehension. A significant path from a predictor to the outcome, comprehension, indicates that a predictor accounts for unique variance in explaining comprehension beyond that predictor's shared covariance with the other predictors. A nonsignificant path from a predictor to comprehension does not mean that the predictor is unrelated to comprehension (every predictor was significantly correlated with comprehension), but that significant correlations between that predictor and other predictors in the model reduced its unique contribution to the prediction of comprehension. Results for the structural equation models are displayed in Table 4.5. For each predictor variable, the following numbers are given: the simple correlation between the predictor variable and reading comprehension; the path weight (the standardized estimate for the factor loading) reflecting the strength of the unique contribution made by that predictor variable to reading comprehension; and a  $Z$  value associated with the unstandardized weight.  $Z$  values greater than 1.96 are significant at the .05 level (Bentler, 2006).

Table 4.5.  
*Structrual Equation Models Predicting Reading Comprehension*

Predictor Variable	Model 1			Model 2		Model 3	
	Correlation	Path	Z	Path	Z	Path	Z
Morphological Production	.64***	.07	1.04	--	--	.04	0.51
Orthographic Production	.58***	--	--	.16	2.96**	.15	2.82**
Vocabulary	.63***	.26	4.57***	.24	4.20***	.23	3.93***
Working Memory	.45***	.17	4.01***	.16	3.77***	.16	3.61***
Decoding Skill	.69***	.47	4.54***	.47	4.88***	.47	4.52***
Orthographic Skill	.57***	-.05	-0.56	-.08	-0.88	-.10	-1.00

\*\*  $p < .01$ , \*\*\*  $p < .001$ .

**Model 1.** Two fit indices were used to assess the goodness of fit; the comparative fit index (CFI) and root-mean-square error of approximation (RMSEA) show that the model fit this data well: CFI = .998, RMSEA = .031 with the chi-square statistic equaling 11.66 based on 9 degrees of freedom. As shown in Table 4.5, the paths from vocabulary, working memory, and decoding skill to reading comprehension were statistically significant. Contrary to the hypothesis, the morphological production task did not have a unique direct effect on reading comprehension, but it was significantly correlated with the outcome and highly correlated with all of the other predictors.

**Model 2.** The fit indices show that this model also fit the data very well: CFI = .999, RMSEA = .025 and the chi-square statistic equaling 10.77 based on 9 degrees of freedom. Table 4.5 shows that all factor loadings and factor correlations were significant with the exception of the path from orthographic skill to comprehension. Also contrary to the initial hypothesis, orthographic production did have a unique direct effect on reading comprehension even after accounting for vocabulary, working memory, decoding skill, and orthographic skill. This was true even though morphological production, which was not uniquely predictive in Model 1, had a higher correlation with comprehension than orthographic production, probably due to the fact

that orthographic production also had lower correlations with the other predictors (though they were still significantly correlated).

**Additional analysis.** Because one of the goals of this study was investigating what the orthographic production task was measuring, an additional model was analyzed with both the morphological and orthographic production tasks in the same model. The hypothesis regarding Model 2 was that the orthographic production task would not have a unique effect on reading comprehension because it was predicted that it was tapping a construct that could be characterized as the intersection of vocabulary, working memory (to capture processing skills involved in the task), decoding skill, and orthographic skill. Even with significant correlations with these other skills and all of them entered as predictors in Model 2 (with three of them having their own unique effect on comprehension), the orthographic production task continued to have a unique effect on reading comprehension. In an attempt to further understand the orthographic production task, a third model, Model 3, predicting comprehension was conducted involving all the predictors from Models 1 and 2. The rationale for Model 3 was the possibility that the working memory task was not fully capturing the processing demands involved in the orthographic production task (discussed in the review of literature and in the rationale for Study 1). Since the orthographic production task was designed to involve the same processing demands as the morphological production task, including both production tasks in Model 3 could account for the possibility of task processing demands being the portion of the orthographic production task making a unique contribution to reading comprehension.

Model 3 also fit the data very well as shown by the fit indices: CFI = .998, RMSEA = .027 and the chi-square statistic equaling 13.38 based on 11 degrees of freedom. As shown in Table 4.5, the standardized path weights and *Z* values for Model 3 are very similar to those for

Model 2, with only slightly lower values. Interestingly, the orthographic production task continued to have a unique direct effect on reading comprehension in Model 3.

### **Study 2: Discussion**

Though the results from this study are somewhat surprising, they have interesting implications for theory and future research. The primary research question was whether the morphological and orthographic production tasks would have a significant unique effect on reading comprehension after accounting for other linguistic and processing skills. First, it was hypothesized that the morphological production task would continue to make a significant unique contribution to reading comprehension after accounting for vocabulary, working memory, word decoding, and orthographic skill, but this hypothesis was not confirmed with this sample of students. However, there were very strong correlations between the morphological production task and reading comprehension as well as between morphological production and all the other predictors. Given the degree of overlap between the morphological production task and vocabulary alone, it is not surprising that a significant unique contribution of morphological production was not found.

The second hypothesis was that the orthographic production task would be significantly correlated with reading comprehension, but that it would not have a significant unique effect on the outcome. It was predicted that high correlations between orthographic production and the other predictors would result in no unique contribution of orthographic production. This hypothesis was also rejected, as there was a significant unique effect of orthographic production on reading comprehension in addition to significant correlations with the other predictors.

Given that the correlations among morphological production and all the other measures were higher than those correlations involving orthographic production, morphological production

has more overlap with the other skills assessed, including with reading comprehension. This includes predictors that were expected to share much variance with orthographic production, namely orthographic skill and working memory. It is due to this significant overlap, especially with vocabulary, that the morphological production task did not have a unique direct effect on comprehension.

Also considering the age of the participants in this study, students in grades 4 and 5, and the number of related skills used as predictors in the structural equation model, it is not that surprising that the morphological production task did not have a unique effect on reading comprehension; several studies reviewed previously found similar results. Nagy and colleagues (2003) found that their morphological awareness factor was significantly correlated with all other measures, but that it was not a unique predictor of reading skill; the researchers concluded that morphological awareness made an indirect contribution to reading skills through vocabulary. The same is true of the results from the current study: a high correlation between vocabulary and morphological production account for the direct effects, but morphological production is still highly related to comprehension. Similarly, Fraser and Conti-Ramsden (2008) found morphological awareness to be significantly correlated with phonological awareness, morphological awareness, working memory, word reading, comprehension, and spelling, but not uniquely predictive of reading skills (word reading, comprehension, and spelling). In their longitudinal growth-curve study, Berninger et al. (2010) found that growth in derivational morphologic was greater for grades 4-6 than for 1-4. It is important to note that the sample for the current study falls at the beginning of what Berninger and colleagues found to be period of greater growth in knowledge of derivational morphology.

Unlike the morphological production task, the orthographic production task did make a significant unique contribution to reading comprehension. It was predicted that this task was measuring a construct that falls at the intersection of vocabulary, word decoding, and working memory/processing skills, but clearly there is something more that this task is tapping that makes a unique contribution to comprehension. Because of the possibility that the working memory task used in this study was not fully capturing the processing skills involved in the orthographic production task, the morphological and orthographic production tasks were included in the same model; the orthographic production task persisted in its unique contribution to reading comprehension even after the inclusion of several linguistic and processing skills that are known to be related to and often predictive of reading comprehension (vocabulary, working memory, word decoding, orthographic skill, and morphological production). The results from this study leave unanswered the question as to what the orthographic production task is measuring. Further research surrounding this task is needed because it is not an insignificant finding that it still makes a unique contribution to reading comprehension after accounting for morphological production, word decoding, vocabulary, orthographic skills, and working memory in the structural equation model.

## CHAPTER 5: Discussion and Conclusions

The results from the two studies reported here have implications for theory and future research surrounding the contribution of morphological skill to reading skills and regarding the contribution of the orthographic production task to reading skills.

### **Morphological Production Task**

Study 1 validated the use of a traditional morphological production task in research involving morphological skill and literacy skills. In Study 1, the morphological production task made a significant unique contribution to both word reading and comprehension, and the contribution could not be attributed to one type of phonological change (opaque, shift, transparent). Furthermore, the contributions to these reading skills remained when answers with less frequent, generative morphological forms were allowed, but the contributions were reduced, the morphological production task uniquely predicted word reading but not comprehension, when only typical derivations with correct spelling were accepted. These findings suggest that a traditional morphological production task is tapping a construct that is morphological in nature and not merely vocabulary for two reasons: the phonologically irregular, suppletive forms were not carrying the contributions to literacy skills; and it is unlikely that the regularized, generative morphological forms could be memorized due to their low frequency. It was also shown through Study 1 that the morphological production task is not simply a measure of processing skills through the development and inclusion of the orthographic production task in the regression models; the morphological production task continued to make a unique contribution to both word reading and comprehension when this task with parallel processing demands was included in the regression. This finding led to the more complex statistical model in Study 2 which included more measures of linguistic and processing skills. Despite the lack of a significant direct path

from the morphological production task to reading comprehension in Study 2, the relationship between the two should not be dismissed. First, the morphological production task was highly correlated with reading comprehension and the other predictors. As discussed in the review of the literature, there is inherent overlap between morphological skill and the other factors that were included in the model, but this does not indicate that the morphological production task is another way to measure orthographic skill or vocabulary. As the review of literature also showed, the age and skill of the sample and the type of morphological task used greatly affect the outcome of the study. As indicated in the discussion of Study 2, the age of the students, grades 4 and 5, is at the earlier end of when knowledge of derivational morphology has its greatest growth (Berninger et al., 2010). Perhaps different results would be seen in Study 2 with the same age of students from Study 1, grades 5 and 8, once that growth has had more time to crystalize.

### **Orthographic Production Task**

An additional finding from Study 1 was the unique contribution of the orthographic production task to both word reading and reading comprehension. This surprise finding led to the inclusion of the orthographic production task in a structural equation model in Study 2 in an attempt to determine what it is measuring. Interestingly, the orthographic production task continued to make a significant unique contribution to reading comprehension after accounting for vocabulary, working memory, word decoding (measured by Word ID and Word Attack), orthographic skill (measured by spelling and orthographic choice), and the morphological production task (to further account for processing skills involved in the task). The orthographic production task was initially designed for Study 1 to account for possible processing artifacts in the morphological production task and was not expected to make a contribution to comprehension; to find that the orthographic production task continued to make a unique

contribution to reading comprehension after accounting for its shared contribution with vocabulary, working memory, word decoding, and orthographic skill in Study 2 was a surprise finding. It was hypothesized that the orthographic production task is measuring a combination of working memory (processing skill), orthographic skill, vocabulary, and decoding. It was expected to have enough significant overlap with the other skills that it would not contribute uniquely to reading comprehension. Clearly, the orthographic production task is measuring a construct that is independent from the other factors as it relates to reading comprehension.

In the studies by Cartwright and colleagues (2002, 2010) involving the reading-specific multiple classification task (sorting simultaneously by initial phoneme and word meaning) they found that the task made a unique contribution to reading comprehension beyond a general multiple classification task (sorting simultaneously by color and shape), verbal ability, and decoding skill. While the Cartwright studies did not include a working memory task, it is still significant that the reading-specific multiple classification task uniquely contributed to comprehension beyond the other measures. It seems there could be some similarities between what is required in the reading-specific multiple classification task and the orthographic production task. Both involve aspects of linguistic skill. In the reading-specific multiple classification task participants have to pay attention to the phonology and semantics of the words in order to complete the task; in the orthographic production task, participants have to pay attention to the orthography of the prompt and the syntax of the sentence stem, while inhibiting responses to the semantic aspects of the prompt. As stated in the literature review, Cartwright et al. (2010) define the cognitive flexibility required by their task as “the ability to maintain simultaneously dual representations and flexibly switch between those representations when engaged in a task” (p. 62). This definition seems to fit the orthographic production task with the

added challenge of having to inhibit the meaning of the prompt word (in contrast with the morphological production task where the prompt word, the root, is inherently semantically related to the answer). While Study 2 accounted for working memory, one part of executive functioning, it is still possible that another aspect of executive functioning could explain the relationship between the orthographic production task and reading comprehension.

Subsequently, inhibition, or inhibitory control, may be able to help explain the unique contribution of the orthographic production task to comprehension. This skill involves inhibiting automatic responses to stimuli in order to engage with it strategically. Consider two examples from the orthographic production task: adding a letter, “pear: One old hunting tool is a \_\_\_\_.” and changing a letter “shone: Who answered the \_\_\_\_?” Students must think about how to complete the sentence semantically and syntactically with a word similar in orthography to the prompt, but they must inhibit their attention to the meaning of the prompt. In other words, students must strategically think of a word similar in orthography to the prompt while inhibiting the more automatic response of thinking about the meaning of the prompt. As can be seen, this is a complex task involving layers of linguistic and processing skills, one aspect of which may be inhibition. This is also an important difference between the morphological production task, where the prompt and answer are inherently related due to morphology, and the orthographic production task.

Inhibition is often considered one part of executive functioning that facilitates development of other executive functions (such as shifting, and monitoring; Altemeier et al., 2008). Altemeier and colleagues (2008) write that “in order to engage in conscious, reflective problem solving, one first needs to inhibit automatic responses in order to engage strategic processes” (p. 588). This seems to fit what is required by the orthographic production task.

Studies have found inhibition to be a unique predictor of reading skills in elementary students (Altemeier et al., 2008; Chung & McBride-Chang, 2011; Kieffer, Vukovic, & Berry, 2013) while accounting for various other predictors including other executive functions (Altemeier et al., 2008), working memory, processing speed, and phonological awareness (Kieffer et al., 2013). In a study described in the literature review, Chung and McBride-Chang (2011) found that measures of inhibitory control (based on a classic Stroop task) and working memory uniquely predicted Chinese word reading after accounting for vocabulary, morphological awareness, and phonological awareness, showing that inhibition can be a strong predictor of one type of reading skill. Usually studies involving inhibition are investigating the contribution of various executive functions to literacy skills. Even though the measures typically used to assess inhibition are much less complex than the orthographic production task, there may still be a relationship between the two, and it may have been informative to include a measure like the Stroop task in Study 2.

### **Limitations and Future Research**

One of the main limitations for this study is that the sample was selected and data were collected for a different purpose, a larger intervention study. While the sample and data did not drastically effect the goals of this study, it did place time constraints on the testing and limited the age range of the sample selection for Study 2. Grades four and five were appropriate for the goals of the intervention study, as this is when students begin to rapidly acquire knowledge of derivational morphology (Berninger et al., 2010), but a developmental comparison across grades for Study 2, as in Study 1, would have been beneficial. It is possible that the structural equation model for the morphological production task would have had different results with an older group of students as there is estimated to be an increased exposure to new words with

derivational morphemes from ages 11 to 14 (Nagy and Anderson, 1984). The older students in Study 2, the fifth graders, ranged from 10 years one month to 11 years 5 months, whereas the older students in Study 1, the eighth graders, ranged from 12 years 5 months to 14 years 7 months. Thus most of the students in Study 1 were tested during or after the estimated increase in exposure to derivational morphemes, while in Study 2, testing occurred when nearly all of the students were younger than age at which the increase in exposure is estimated to occur.

Because of the limitation on testing time, the structural equation models in Study 2 could only include two latent factors (word decoding and orthographic skill), with the remaining factors and outcome only having one measure as an indicator. Future research should include models with more latent factors. This reduces measurement error which allows a theoretical construct to be more accurately assessed. It would be especially beneficial to include more measures of morphological skill to more accurately capture the different types of morphological knowledge (relational, syntactic, and distributional; Tyler & Nagy, 1989) and implicit versus explicit knowledge of morphology (Goodwin et al., 2017).

More research is also needed into what the orthographic production task is measuring. The possibility of relationships between the orthographic production task and inhibition and Cartwright's reading-specific multiple classification task (2002, 2010) should both be investigated. A study involving similar factors to those used in the structural equation models in the current study, plus measures of inhibition and additional measures of morphological skill, could offer interesting results and provide insight into the production tasks used in this study as well as into the factors that predict students' reading comprehension.

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## Appendix A: Researcher Developed Measures for Study 1

### Morphological Production Task

**Directions:** Below you will find underlined words followed by a sentence. You should change the underlined word to fit in the blank and complete the sentence in a way that makes sense.

Write the changed word in the blank space at the end of the sentence.

**Example:**     give: It was only a very small gift.  
                   farm: My uncle raises cows and is a farmer.

1. broad: Amy's project had good content and good \_\_\_\_\_.
2. cover: The paint had good \_\_\_\_\_.
3. probable: It's not a sure thing but it's a high \_\_\_\_\_.
4. sell: The department store is having a \_\_\_\_\_.
5. child: Up until age ten, Eric had a happy \_\_\_\_\_.
6. maintain: It costs a lot of money for the car's \_\_\_\_\_.
7. forget: When you are tired, you can become \_\_\_\_\_.
8. wise: With age, people usually acquire \_\_\_\_\_.
9. secret: The club members must swear to \_\_\_\_\_.
10. believe: All the people share the same \_\_\_\_\_.
11. sail: the boy grew up to be a \_\_\_\_\_.
12. thief: Once caught, the robber apologized for the \_\_\_\_\_.
13. mix: She was very careful when she created the \_\_\_\_\_.
14. destroy: The storms were very \_\_\_\_\_.
15. achieve: The blue ribbon was a great \_\_\_\_\_.
16. generous: Juan thanked the donors for their \_\_\_\_\_.
17. wide: Before buying the bed, we checked its \_\_\_\_\_.
18. miracle: their survival after the accident was \_\_\_\_\_.
19. brief: The speech was convincing despite its \_\_\_\_\_.
20. problem: The child's behavior was very \_\_\_\_\_.
21. intelligent: She wondered about the dog's \_\_\_\_\_.
22. represent: To complain about congress he called his \_\_\_\_\_.
23. view: The boy wore glasses to help with his \_\_\_\_\_.
24. lose: This game was a terrible \_\_\_\_\_.
25. receive: We sent the package and confirmed its \_\_\_\_\_.
26. bold: She is very outgoing and is known for her \_\_\_\_\_.
27. president: Mr. Anderson changed much during his \_\_\_\_\_.
28. deep: The We were unsure about the water's \_\_\_\_\_.
29. merchant: The store offers a variety of \_\_\_\_\_.
30. deliver: The driver scheduled the \_\_\_\_\_.

### **Orthographic Production Task**

**Directions:** Below you will find underlined words followed by a sentence. In this section, you will need to change one letter in the underlined word to a different letter to make it fit the sentence. Write the changed word in the blank space at the end of the sentence.

#### **Change a letter to find the right word to fit the blank:**

**Example:**        pan: I like to write with a pen.  
                       chip: They sailed across the ocean on a ship.

1. dog: In the yard, the boy began to \_\_\_\_\_.
2. point: The boy's clothes were covered with \_\_\_\_\_.
3. indent: What kind of machine did you \_\_\_\_\_?
4. shout: The short, wide man could also be called \_\_\_\_\_.
5. knob: I wish he wasn't such a \_\_\_\_\_.
6. commuter: The woman bought a new \_\_\_\_\_.
7. polite: In the small town, the people trust the \_\_\_\_\_.
8. birth: This type of tree is a \_\_\_\_\_.
9. strike: He took the new challenge in \_\_\_\_\_.
10. timber: The gymnast was very \_\_\_\_\_.
11. snout: The pig made a funny \_\_\_\_\_.
12. shone: Who answered the \_\_\_\_\_.
13. jingle: Many animals live in the \_\_\_\_\_.
14. clever: The girl knew a trick that was very \_\_\_\_\_.

**Directions:** In the section below, you will need to add one letter to the underlined word to make it fit the sentence. Again, you will write your changed word in the blank space at the end of the sentence.

#### **Add a letter to find the right word to fit the blank:**

**Example:**        rod: My mom drove her car down the road. (vowel added)  
                       top: A red light means you have to stop. (consonant added)

15. end: Put the photos in a thick envelope so they don't \_\_\_\_\_.
16. net: The classroom always looks \_\_\_\_\_.
17. old: The food we forgot to put away is now covered with \_\_\_\_\_.
18. witch: The girl was nervous and began to \_\_\_\_\_.
19. bar: In the distance they heard a loud \_\_\_\_\_.
20. are: The old book is hard to find because it is \_\_\_\_\_.
21. plot: We felt safe flying with the skilled \_\_\_\_\_.
22. paid: Her shirt was a bright \_\_\_\_\_.
23. host: The wood was heavy so it was difficult to \_\_\_\_\_.
24. band: The food tasted \_\_\_\_\_.

25. pear: One old hunting tool is a \_\_\_\_\_.
26. bus: The kids were watering the \_\_\_\_\_.
27. star: The difference between the light and dark colors was \_\_\_\_\_.
28. cash: The pots fell down and made a loud \_\_\_\_\_.

## Appendix B: Researcher Developed Measures for Study 2

### Morphological Production Task

**Directions:** Below you will find underlined words followed by a sentence. You should **change** the underlined word to complete the sentence in a way that makes sense. Write the new word in the blank space at the end of the sentence. Provide only one word for each answer.

**Example:**     give: It was only a very small gift.  
                   farm: My uncle raises cows and is a farmer.  
                   mix: She was careful when creating the ~~mix~~ mixture.

1. explore: He wanted to be an \_\_\_\_\_.
2. accept: The food tasted \_\_\_\_\_.
3. memory: The party was \_\_\_\_\_.
4. mystery: The house seemed \_\_\_\_\_.
5. clever: The girl is known for her \_\_\_\_\_.
6. agree: The two groups were in \_\_\_\_\_.
7. translate: He could only read a \_\_\_\_\_.
8. miracle: Their survival was \_\_\_\_\_.
9. experiment: The medicine was \_\_\_\_\_.
10. construct: The meeting was very \_\_\_\_\_.
11. imitate: The painting was an \_\_\_\_\_.
12. circle: He wanted the rumor to \_\_\_\_\_.
13. function: The room was very \_\_\_\_\_.
14. sincere: He spoke very \_\_\_\_\_.
15. advantage: The change was \_\_\_\_\_.
16. explode: They heard an \_\_\_\_\_.
17. direct: The company hired a \_\_\_\_\_.
18. visual: Some things are hard to \_\_\_\_\_.
19. describe: Her instructions were very \_\_\_\_\_.
20. clear: She asked the teacher to \_\_\_\_\_.
21. emotion: The news made her \_\_\_\_\_.
22. invent: The woman was a famous \_\_\_\_\_.
23. suspect: The open door seemed \_\_\_\_\_.
24. create: She presented a new \_\_\_\_\_.
25. adapt: Animals that survive must be \_\_\_\_\_.
26. achieve: This was her greatest \_\_\_\_\_.
27. sympathy: The teacher was \_\_\_\_\_.
28. observe: He wrote down his \_\_\_\_\_.
29. manage: The amount of work was quite \_\_\_\_\_.
30. reflect: She was feeling very \_\_\_\_\_.
31. operate: They prepared for the \_\_\_\_\_.
32. exclude: The brand of clothing was very \_\_\_\_\_.
33. vivid: She remembered her dream \_\_\_\_\_.
34. assign: She finished the \_\_\_\_\_.
35. intend: They had clear \_\_\_\_\_.
36. produce: The day had been \_\_\_\_\_.

37. secret: The group met \_\_\_\_\_.
38. depend: The car is \_\_\_\_\_.
39. finance: Her reasons for moving were all \_\_\_\_\_.
40. severe: They didn't know the problem's \_\_\_\_\_.

### **Orthographic Production Task**

**Directions:** Below you will find underlined words followed by a sentence. In this section, you will need to change one letter in the underlined word to a different letter to make it fit the sentence. Write the changed word in the blank space at the end of the sentence.

#### **Change a letter to find the right word to fit the blank:**

**Example:** Pan: I like to write with a pen.

Chip: They sailed across the ocean on a ship.

1. dog: The boy began to \_\_\_\_\_.
2. point: The boy's clothes were covered with \_\_\_\_\_.
3. indent: What kind of machine did you \_\_\_\_\_?
4. shout: The short, wide man could also be called \_\_\_\_\_.
5. knob: I wish he wasn't such a \_\_\_\_\_.
6. commuter: The woman bought a \_\_\_\_\_.
7. polite: In the small town, the people trust the \_\_\_\_\_.
8. birth: This type of tree is a \_\_\_\_\_.
9. strike: He had a long \_\_\_\_\_.
10. timber: The gymnast was very \_\_\_\_\_.

### **Add a Letter**

**Directions:** In the section below, you will need to add one letter to the underlined word to make it fit the sentence. Again, you will write your changed word in the blank space at the end of the sentence.

#### **Add a letter to find the right word to fit the blank:**

**Example:** Rod: My mom drove her car down the road. (vowel added)

Top: A red light means you have to stop. (consonant added)

11. end: Be careful that the photos don't \_\_\_\_\_.
12. net: Her bedroom was \_\_\_\_\_.
13. old: The food is covered with \_\_\_\_\_.
14. witch: The girl began to \_\_\_\_\_.
15. bar: In the distance they heard a loud \_\_\_\_\_.
16. are: The old book is \_\_\_\_\_.
17. plot: We felt safe with the skilled \_\_\_\_\_.
18. paid: Her shirt was a bright \_\_\_\_\_.
19. host: The wood was heavy so it was difficult to \_\_\_\_\_.
20. band: The food tasted \_\_\_\_\_.

**Orthographic Choice Task**

**Directions:** In this task, there are pairs of words. Both of these would sound like a real word, but only one is a real word. You should circle the real word in each pair. Try to answer as quickly as you can while making as few mistakes as possible. You will have one minute to answer as many as you can. Let's try some practice. Which one is a real word?

room	rume
snoe	snow

tertle	turtle
young	yung

Do you have any questions? Ready?

1	take	taik
2	pleese	please
3	rain	rane
4	stoar	store
5	streat	street
6	wagon	wagun
7	believe	beleave
8	choose	chooze
9	deap	deep
10	easy	eazy
11	face	fase
12	hoal	hole
13	hert	hurt
14	lurn	learn
15	roar	rore
16	scare	scair
17	sheep	sheap
18	thum	thumb
19	salmon	sammon
20	grone	grown
21	wheet	wheat

22	muscle	mussle
23	alternitive	alternative
24	condence	condense
25	dignity	digniaty
26	pavement	pavemant
27	nusance	nuisance
28	travle	travel
29	baisment	basement
30	assure	ashure
31	captain	captin
32	distence	distance
33	sudden	suddin
34	importent	important
35	backword	backward
36	explane	explain
37	demon	deamon
38	reath	wreath
39	salad	sallad
40	sensitive	sensative
41	liberty	libberty
42	culpret	culprit

