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Investigating the Factor Structure of Vocabulary Knowledge

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INVESTIGATING THE FACTOR STRUCTURE OF VOCABULARY KNOWLEDGE

By

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ABSTRACT

The present study examined four kinds of vocabulary knowledge: Definitional knowledge, using vocabulary in context, relational knowledge, and morphological knowledge. A measure was developed that assessed all four kinds of vocabulary knowledge using the same 23 vocabulary words, which allowed within- and between-word variance to be modeled. Confirmatory factor analysis was used to test three alternative models of vocabulary knowledge: (1) a four-factor model that specified four related yet distinct dimensions of vocabulary knowledge, (2) a two-factor model that considered vocabulary knowledge and morphological knowledge to be two separate but potentially related factors, and (3) a one-factor model in which vocabulary knowledge was unidimensional. These alternative models were examined by modeling both within- and between-word variance. When controlling for extraneous word-level variance, vocabulary knowledge was found to be a relatively unidimensional construct.
INTRODUCTION

Statistics show that by the end of 8th grade only about 34% of students are reading at or above the proficient level (National Assessment of Education Progress, 2011). Reading comprehension, or the ability to gain understanding of written text through a process of extraction and construction (Research and Development Reading Study Group, 2002), has been identified as a strong predictor of future academic outcomes (Nash & Snowling, 2006; National Reading Panel, 2000). Reading comprehension abilities are required for more than language arts and are fundamental to other areas of the academic curriculum (e.g., reading texts in history and science). However, comprehension abilities are affected by a variety of knowledge and skills. Vocabulary knowledge has been identified as an important contributor to both reading and language comprehension (see Anderson & Freebody, 1981; Beck & McKeown, 1991; Beck, Perfetti, & McKeown, 1982; Carlisle, 2002; Joshi, 2005; Katz, 2004; Nagy & Anderson, 1984). Although relations between vocabulary and reading comprehension appear to be reciprocal (Stanovich, 1986; Wagner & Ridgwell, 2009; Wagner, Muse, & Tannenbaum, 2007; Walberg & Tsai, 1983), children with more limited vocabularies are more likely to be at risk of having reading comprehension difficulties, and as a result, have poorer academic outcomes than those with stronger vocabularies (Nash & Snowling, 2006).

Vocabulary acquisition begins in the early years and continues to develop as children enter school. By the time children are in the elementary grades, they are encountering and learning upwards of 3,000 words per year through both direct instruction and incidental word learning (Nagy & Anderson, 1984; Phythian-Sence & Wagner, 2007; Shu, Anderson, & Zang, 1995; Swanborn & DeGlopper, 1999; Swanborn & DeGlopper, 2002; Waring & Takaki, 2003; White, Power, & White, 1989). Children’s gains in vocabulary knowledge occur in a variety of domains, and their subsequent knowledge base contains more than the dictionary definitions of these words. Vocabulary knowledge does not consist of isolated and packaged bits of information, rather this knowledge is part of a larger network of background knowledge (Stahl, 1999), and tasks where vocabulary knowledge is highly utilized, for example during the process of reading comprehension, require skills above and beyond just knowing the definition of a word. Vocabulary knowledge represents an overall contextual understanding or the understanding that word meanings can change depending on the context in which they are found. The rapid rate which vocabulary grows makes it highly unlikely that direct vocabulary instruction or incidental word learning alone could account for such rapid growth (Jenkins & Dixon, 1983; White, Graves, & Slater, 1990). It is most likely the exposure to direct instruction and use of contextual information in conjunction with other processes, such as syntactic and semantic mapping (Carey, 1978; Johnson, Pittelman, & Heimlich, 1986), that result in the rapid acquisition of words throughout the school years.

Vocabulary knowledge in general is an umbrella term that fails to describe possible underlying factors. Knowledge of words is not restricted to the narrow contexts in which they were first encountered and are learned over multiple exposures and contexts (Kelsius & Searls, 1990; Stahl, 2003; Webb, 2007). Exposure and experience with vocabulary over time should allow for more flexibility in what children are able to do with the words they know in addition to how well they understand these words.

Most measures of vocabulary knowledge assess definitional knowledge. Definitional knowledge refers to an individual’s ability to provide a definition when presented with a word (i.e., expressive vocabulary) or pick out the correct vocabulary word when presented with a definition (i.e., receptive vocabulary). However, being able to provide definitions may not
Vocabulary knowledge is often described in terms of an individual’s breadth and depth of his or her word knowledge (Anderson & Freebody, 1981; Coyne, McCoach, Loftus, Zipoli, & Kapp, 2009; Nagy, Anderson, & Herman, 1987; Tannenbaum, Torgesen, & Wagner, 2006). Nagy and colleagues explain that these terms encompass both the number of words that an individual is familiar with (breadth) as well as how much one knows about a particular word (depth). Breadth and depth of vocabulary knowledge can vary across words. Individuals are more likely to know more simple or common definitions across several frequently encountered words than they are to know highly detailed or multiple definitions for these same words.

**Definitional knowledge**

The first and most typical representation of vocabulary knowledge is definitional knowledge. It is the ability to generate or recognize a definition or multiple definitions of a word and can represent varying levels of understanding (i.e., fairly superficial to very comprehensive) depending on the quality and quantity of known definitions. Because of how words are usually encountered (i.e., within a context-rich environment), vocabulary knowledge rarely exists in isolation. This knowledge has the potential to vary amongst words and individuals, and classroom instruction that focuses heavily on teaching definitions may only promote superficial understandings of these words (Nagy, 1988; Nagy & Herman, 1987). Although definitions are important for comprehending text (Anderson & Freebody, 1981), emphasis on definitional learning and rote memorization of dictionary definitions is not conducive to a deeper understanding, nor does it seem to improve reading comprehension abilities (National Reading Panel, 2000; Stahl, 1983; Stahl & Fairbanks, 1986). Thus, definitional knowledge seems to be a necessary but not sufficient factor for text comprehension.

Vocabulary definitional knowledge can be displayed expressively or receptively. Expressive vocabulary is vocabulary that is either written or spoken, while receptive vocabulary consists of recognizing and attaching meanings to words that are heard or read (McKeown & Curtis, 1987; Wise et al., 2007). The number of words that can be defined expressively is usually smaller than the number of words that can be identified receptively; expressive vocabulary contains words that are more familiar to the user whereas receptive vocabulary can contain partial meanings of less familiar words (Kamil & Hiebert, 2005).

**Vocabulary usage**

The ability to use vocabulary in context (i.e., sentence generation) is a potentially second type of vocabulary knowledge. Contexts that are richer and that extend words beyond the classroom have positive effects on how quickly children are able to access word meanings, and this fluency of lexical access is critical for usage (McKeown, Beck, Omanson, & Pople, 1985; Perfetti & Hart, 2002). Even less direct methods of vocabulary instruction (e.g., through
discussions or listening to stories; Elley, 1989; Nagy, Herman, & Anderson, 1985) and engaging in casual interactions (e.g., talking to parents or peers; Farkas & Beron, 2004) can provide further understanding of known and new words as well as a better understanding of how words can and should be used. When words are spoken instead of written, usage ability can also be considered an oral language skill, which has also been linked to reading achievement (see Olofsson & Nidersoe, 1999; Scarborough, 1990; Wise et al., 2007).

Relational knowledge

A third potential type of vocabulary knowledge is knowing how words are related, as in the ability to generate synonyms and antonyms. Relational knowledge refers to knowledge of how words are related to one another and to higher-order categories (Stahl, 1983). If an individual is able to provide synonyms or antonyms for a vocabulary word, it implies understanding, even at a superficial level, of the target word as well as some definitional understanding of any correctly generated related words. Further, the individual possesses some knowledge of how these words are classified. Thus, the ability to produce synonyms or antonyms for a word suggests a greater depth of understanding (Tannenbaum, Torgesen, & Wagner, 2006).

Morphological knowledge

The final potential type of vocabulary knowledge is morphological knowledge. Morphological knowledge is knowledge about the internal structure of words and is part of the process whereby morphemes are actively manipulated to convey meaning (Carlisle, 2004; Carlisle & Fleming, 2003). Morphemes are the smallest units of meaningful language (Chung & Hu, 2007; Kuo & Anderson, 2006). Prefixes and suffixes (e.g., -er, un-, or -s) are common examples of morphemes. Morphemes can be free or bound and inflectional or derivational. Free morphemes can stand alone (i.e., actual words). Bound morphemes cannot stand alone and are bound to free morphemes. For example, -er is attached to the words write and sing to form the words writer and singer. Thus –er can mean someone who does the action described by the free morpheme. Derivational morphemes create new words from original or parent words (Ford, Davis, & Marslen-Wilson, 2010; Tyler & Nagy, 1989). For instance, un- can be attached to the word cover to produce uncover, which is a new word. Finally, inflectional morphemes are units that contain grammatical information (Bybee, 1988; Tong, Deacon, Kirby, Cain & Parrila, 2011). For example, adding an –s onto a free morpheme is indicative of plurality.

Morphological knowledge may play a fundamental role in the acquisition vocabulary knowledge (Carlisle, 2007; Nagy & Anderson, 1984; Taft & Kougious, 2004). This knowledge can be used to analyze the structure of unfamiliar words and to obtain an understanding of novel words (Freyd & Baron, 1982; Nagy & Anderson). Additionally, Carlisle, Fleming, and Gudbrandsen (2000) identify morphological knowledge as critical for incidental word learning, which is defined as a process that occurs when a reader is lacking a lexical representation of a word (i.e., it is an unfamiliar word) and he or she uses context clues to establish some kind of meaning. In addition to its contribution to vocabulary acquisition, morphological knowledge has been identified as contributing significantly to reading achievement. When definitional vocabulary knowledge is controlled, a unique portion of the variance in reading comprehension abilities can be accounted for by morphological knowledge (Carlisle, 2007; Deacon & Kirby, 2004; Kieffer & Lesaux, 2008; Nagy, Berninger, & Abbott, 2006), indicating that this knowledge provides a unique contribution to predicting reading comprehension over and above definitional
Previous Studies of the Factor Structure of Vocabulary Knowledge

Several studies have explicitly investigated the structure of vocabulary. For instance, Tannenbaum, Torgesen, and Wagner (2006) examined the structure of vocabulary and morphological knowledge in 203 third graders. Six standardized vocabulary measures were administered, and confirmatory factor analysis (CFA) and structural equation modeling were used to test alternative models of vocabulary knowledge and relations between vocabulary knowledge and reading comprehension. The results supported a two-factor model of vocabulary knowledge consisting of a breadth factor and a combined depth/fluency factor. Although breadth was found to explain more unique variance in reading comprehension scores than was the combined depth/fluency factor, the factors were found to be highly related ($r = .87$).

Muse (2005) investigated the factor structure of vocabulary and morphological knowledge in 99 fourth-grade students. The aims of this study were (1) to discover if morphological knowledge could be further broken down into separate factors, (2) to investigate the possibility of methods effects (e.g., reading versus listening), (3) to examine how vocabulary and morphological knowledge were related, (4) and to examine the relationship between morphological knowledge and vocabulary, reading comprehension, and oral reading fluency. A battery of standardized and researcher-created assessments was administered. The results of confirmatory factor analyses were that a single-factor model provided the best fit to the data. For the first aim and third aims, this implies that vocabulary and morphology were the same general construct and that all assessments were basically measuring a single construct. There were no method effects within the data meaning that the different methods of assessment administration (e.g., oral versus written administration) did not affect the outcome. Finally the combined vocabulary and morphological knowledge factor significantly accounted a large amount of the variance in reading comprehension scores.

Kieffer and Lesaux (2012) investigated vocabulary and morphological knowledge in 90 Spanish-speaking language minority students. Data were collected longitudinally, following participants from fourth until seventh grade. Combinations of standardized and researcher-created measures were used, and data collection occurred at four time points during the winter. The study had two aims: (1) to discover the average growth for Spanish-speak language minority students from fourth to seventh grade, and (2) to investigate the ways in which growth in one skill may contribute to growth in the other. Growth curve modeling showed that vocabulary and morphological knowledge were highly related. Specifically, growth in relational morphological knowledge was found to result in similar growth in vocabulary knowledge.

Nonetheless, these studies leave several questions unanswered. Tannenbaum et al. (2006) and Muse (2005) examined vocabulary knowledge in younger populations of children (i.e., third- and fourth-graders). It is unclear whether their results would generalize to older children. Kieffer and Lesaux (2012) included a sample of older children (i.e., seventh graders); however, their study focused on language minority students. Results from other studies and national norms data supplied by standardized measures served as proxies for an English-speaking sample. No English-speaking sample was explicitly tested within their study. Whether relatively similar results would occur for children whose first language is English is uncertain.

The Present Study
Understanding the factor structure of vocabulary knowledge has implications for vocabulary assessment and potentially instruction and intervention. For example, if vocabulary knowledge consists of three separable factors, it would be reasonable to expect that vocabulary assessments should sample each of the factors. Each of the kinds of vocabulary knowledge represented by the factors may be a potential lever for improving vocabulary knowledge through instruction and intervention.

In each of the previous studies of the factor structure of vocabulary knowledge, the factor structure was characterized by either highly correlated factors (Kieffer & Lesaux, 2012; Tannenbaum et al. 2006) or a single underlying factor (Muse, 2005). An issue that was addressed in the present study was whether differential knowledge of individual vocabulary words was partly responsible for the high degree of correlation among vocabulary factors. Consider the following examples. For a relatively common word such as fast, it may be easy to provide a definition, use the word in a sentence, identify an antonym or synonym, and to generate a morphologically-related version (e.g., faster). However, for relatively uncommon words like legate, an individual is probably less likely to be able to provide a correct definition, use this word in a sentence, generate related words, or identify a morphologically related usage. Because vocabulary performance is dependent on how well an individual knows a given word (i.e., good performance for well-known words and poor performance for unknown words), this phenomenon could possibly inflate the true correlations among these potential vocabulary factors and result in a spurious one-factor model.

To address this issue, alternative models of the factor structure of vocabulary knowledge were fit to two kinds of data, made available by the fact that assessment of the different kinds of vocabulary knowledge was carried out for the same 23 words. The two kinds of data are between- and within-word covariances among multiple indicators that represented the four kinds of vocabulary knowledge. Three alternative theoretical models of the factor structure of vocabulary knowledge were examined in the present study. The first is a four-factor model in which vocabulary knowledge was represented by four distinct, yet potentially related factors of definitional knowledge, usage, relational knowledge, and morphological knowledge. The second model is a two-factor model in which vocabulary knowledge was represented by two distinct, yet potentially related factors of vocabulary knowledge, which includes definitional knowledge, usage, and relational knowledge, and morphological knowledge as a second factor. The third model is a unidimensional model in which definitional knowledge, usage, relational knowledge, and morphological knowledge all were manifestations of a single underlying factor.

The current study seeks to answer two main questions:
1. What are the underlying dimensions of vocabulary knowledge?
2. Do differences in how well words are known spuriously reduce the number of underlying dimensions and increase their degree of correlation?
METHOD

Participants

The sample consisted of 90 English-speaking 8th grade students who were involved in a larger reading comprehension study. They were obtained from a moderately sized Southeastern school. The sample consisted of 46% males and 54% females. Overall, participants’ demographics were relatively representative of the community. Participating students were provided with a token (i.e., a bag of chips) for their participation.

Measures and Procedure

Vocabulary Tasks

Vocabulary familiarity rating scale. This measure was designed to gauge students’ perceived familiarity with twenty-three relatively common vocabulary words. The scoring system was based on a 5-point scale. The scale ranged from 1 (not at all familiar with this word) to 5 (very familiar with this word). See Appendix A for a list of words.

Vocabulary assessment. This assessment contained three parts for each of the 23 words (see Appendix B). The first part consisted of three questions that measure general definitional knowledge: 1. Tell me what the word ___ means. After an answer was generated, the students were prompted again. Tell me another definition of the word ___. Finally, if participants successfully give two definitions, they were asked to generate a third definition: What is another meaning of the word ___?

The second section focused on word usage ability. Two usage questions were administered: Give me a sentence using the word ___. They were prompted again after a response is provided: Give me another sentence that uses a different meaning of the word ___.

The final section of this task was comprised of two questions that assessed students’ word relatedness abilities (i.e., synonym and antonym generation). Here, participants were prompted: Give me words that mean the same as ___ followed by: Give me words that mean the opposite of ___.

Measure of morphological awareness. This measure had two parts that assessed students’ morphological abilities for the same 23 vocabulary words (see Appendix C). The measure assessed morphological sentence completion and morphological word generation. Students were provided with a sentence and an infinitive of each vocabulary word and were required to modify the word to accommodate the sentence. For example, for the word light, the sentence is Her mom ____ the birthday candles (the correct answer is either lit or lights). For morphological generation, participants were asked: Give me other words that you can get by changing the word light. Examples of correct responses include delight, lightly, and lighter. Each sentence and prompt was read aloud to the participants.

All participants were given feedback on their responses to a practice word before continuing on with the 23 target words. The entire assessment was conducted orally. If participants were unable to provide an answer, testers cued them further (e.g., Give me any definition you can think of.). If no answers were elicited, testers went on to the next item. Responses were recorded exactly as they were given.

Procedure
The study was approved by the Institutional Review Board approval prior to data collection. All subjects were provided with informed consent prior to participation. Trained testers administered all tasks individually. The tasks were administered over two sessions due to time constraints. During the first session, participants were given the vocabulary familiarity rating scale, the first 11 items of the vocabulary assessment, and the first 11 items of the measure of morphological awareness, which kept the same words together over the vocabulary and morphology tasks. The order of administration of tasks was held constant across all participants. Administration occurred over one week during the 2010 spring academic year.
RESULTS

Preliminary analyses were conducted to assess the overall features of the vocabulary and morphology measure, including the chosen method for handling outliers and missing data. Further analyses were carried out for both the between- and word data matrices, and both were fit to the three models of interest: the four-factor, two-factor, and one-factor models of vocabulary knowledge.

Preliminary Analyses

Using PASW Statistics 19.0, data were screened for potential outliers, missing data, and checked for violations of normality prior to conducting the factor analysis. Outliers were identified using the median plus or minus two interquartile ranges (IQR) criterion. Similar to standard deviation, the IQR describes the spread of the data. It contains the middle 50% of the data and it is obtained by calculating the difference between the 1st quartile (25th percentile) and the 3rd quartile (75th percentile). This method is preferred because the median is used as its corresponding measure of central tendency and is not affected by outliers in the same way as the mean is if the plus or minus three standard deviations method is used. Outliers identified by this criterion were first checked for data entry error. No data entry errors were found. A total of 6 outliers were found. Because the outlier scores were not particularly extreme and because we wanted to preserve the purity of the data, outliers were included in the analysis. Additionally, the averaging procedure that was used to generate the two matrices that were used in the analyses minimized any effects of outliers. There were no multivariate outliers. Partial data were included for one case that had data missing at random. Normality and linearity estimates were within acceptable ranges.

Descriptive statistics (i.e., means, standard deviations, and correlations) are provided in Table 3. All correlations were found to be significant. Data were also checked for floor and ceiling effects to determine if tasks were too easy or too difficult for the present sample. This is important because floor or ceiling effects can result in a significant reduction of variability and cause the data to be relatively uninformative. The word familiarity rating task and definition 3 of the vocabulary assessment were dropped from further analyses because of a ceiling and floor effect, respectively. There was adequate variation among all remaining tasks included in the analyses. Skewness values were investigated for all variables. Values were within an acceptable range for all of the assessment variables. Sentence 1 and the morphological generation question had slightly skewed distributions, with values of -.66 and .77, respectively. Given that the maximum possible score for sentence 1 was 23 and the mean was 21 with a small standard deviation, there was a modest ceiling effect. Distributions were also examined with regards to kurtosis for all variables. Definition 1 and morphological sentence completion were found to have a slightly leptokurtic distribution, with values of .045 and .057, respectively.

The data were organized and analyzed in two ways. Because data were available for the same 23 words, two separate data matrices were created. The first matrix (Table 2) consisted of between-word variance. The columns in this matrix corresponded to the eight questions. The rows corresponded to the 23 vocabulary words. The entries represented the mean scores across the participants. The second matrix (Table 3) consisted of within-word variance. The entries represented the mean correlations among the 8 questions averaged across the 23 vocabulary words. Overall, correlations within this matrix were relatively low. The strongest correlation was between definition 2 and sentence 2 (r = .32) in the vocabulary assessment.
Underlying Dimensions of Vocabulary Knowledge

Controlling for Word-Level Variance

Confirmatory factor analyses of the averaged within-word correlation matrix were used to test three alternative models of vocabulary knowledge: (a) a one-factor model was specified by having observed indicators loading onto a single latent factor that represents general vocabulary knowledge; (b) a two-factor model, was specified by having definitional knowledge, usage, and relational knowledge loading on a vocabulary factor, and the two morphological questions loading on a morphological knowledge factor; and (c) four-factor model was specified with definitional knowledge, usage, relational knowledge, and morphological knowledge specified as four distinct yet possibly correlated factors.

For these models, definitional knowledge was represented by the two definition questions in the vocabulary assessment. Usage was represented by the two sentence generation questions on the measure. Relational knowledge was represented by synonym and antonym generation questions. Finally morphological knowledge was represented by the morphological sentence and morphological generation questions of the morphological assessment. The four-factor model considered definitional, usage, relational, and morphological knowledge to be four separate yet related facets of vocabulary knowledge. For, the two-factor model, vocabulary knowledge was represented by the six definition, usage, and relational questions and morphological knowledge was represented by the two morphology questions. For the one-factor model, general vocabulary knowledge was a latent construct comprised of all eight questions. The comparative fit indices for these models can be found in Table 4. All models are logically identified according to the t-rule, scale dependency, and two-indicator rule.

All models had non-significant chi-square probabilities [Four-Factor Model: $\chi^2 (14, N = 92) = 4.142, p = .995$; Two-factor Model: $\chi^2 (19, N = 92) = 11.556, p = .904$; One-Factor Model: $\chi^2 (20, N = 92) = 11.773, p = .924$]. SRMR values were .053 for the two- and one-factor models and .036 for the four-factor model, all of which indicated good fit. RMSEA values and probabilities for all models were indicative of perfect fit (Four-Factor Model RMSEA < .001, $p = .998$; Two-Factor Model RMSEA < .001, $p = .904$; One-Factor Model RMSEA < .001, $p = .924$). Values for all models were highly similar (Four-Factor Model: CFI = 1.00, TLI = 4.65; Two-Factor Model: CFI = 1.00, TLI = 3.031; One-Factor Model: CFI = 1.00, TLI = 3.132) and indicated excellent fit. The one- and two-factor models were nested within the four-factor model. Chi-square difference testing for all models resulted in non-significant chi-square values (Two-Factor Model versus One-Factor Model: $\chi^2$ difference = 0.217 with 1 degree of freedom; Two-Factor Model versus Four-Factor Model: $\chi^2$ difference = 7.414 with 5 degrees of freedom; One-Factor versus Four-Factor: $\chi^2$ difference = 7.631 with 6 degrees of freedom). However, non-significant chi-square difference testing indicated that the correlations are not significantly different from 1 for the multi-factor models. Although they fit the data as well as the one-factor model, the two- and four-factor models were not correct because they specified multiple, distinct factors and the results indicated that the factors were not distinct but rather were perfectly correlated. Therefore, the simplest (i.e., one-factor) model is preferred (see Figure 1).

Analyzing Word-Level Variance

A model that considers vocabulary knowledge and morphological knowledge to be two separate latent constructs was compared to a unidimensional model of vocabulary knowledge
and both models were compared to a four-factor model. The comparative fit indices for all models can be found in Table 5. All models are logically identified according to the t-rule, scale dependency, and two-indicator rule.

Chi-square values closer to zero with probability values greater than .05 indicate good fit. All models had significant chi-square probabilities [Four-Factor Model: $\chi^2$(14, N = 92) = 28.204, $p = .013$; Two-factor Model: $\chi^2$(19, N = 92) = 40.718, $p = .003$; One-Factor Model: $\chi^2$(20, N = 92) = 40.725, $p = .004$]. SRMR values represent the difference between the observed and expected correlations, with values closer to zero implying better fit. SRMR values were .121 for the four-factor model and .141 for the two- and one-factor models. RMSEA values closer to 0 and less than .05 are desired, and their associative probability values are, again, desired to be higher than .05. RMSEA values and probabilities for both models were indicative of less-than-good fit (Four-Factor Model RMSEA = .21, $p = .021$; Two-Factor Model RMSEA = .223, $p = .005$; One-Factor Model RMSEA = .212, $p = .008$). CFI and TLI values above .95 indicate excellent model fit. Values for all models were somewhat similar (Four-Factor Model: CFI = .80 and TLI = .59; Two-Factor Model: CFI = .69, TLI = .54; One-Factor Model: CFI = .70, TLI = .58) and indicated poor to moderate fit. These values indicated that the four-factor model provided the best fit to the data. The one-factor model was nested within the two-factor model and the one- and two-factor models are nested within the four-factor model. Chi-square difference testing was used to compare all models. Difference testing resulted in a significant chi-square value for the two- versus four-factor model ($\chi^2$ difference = 12.521 with 6 degrees of freedom). The four-factor model fit the data the best. Because the chi-square value was significant for these two models, the model with the smaller chi-square was preferred. Chi-square difference testing for the two- versus one-factor model ($\chi^2$ difference = 0.007 with 1 degree of freedom) and the one- versus four-factor models ($\chi^2$ difference = 12.514 with 6 degrees of freedom) resulted in non-significant chi-square values, suggesting that the more parsimonious model would be preferred in this case. However, overall analyses show that based on the between-word data matrix, the four-factor model provided the overall best fit (see Figure 2). Yet, it is important to note that even the best fitting model did not provide a close fit to the data.

**Influence of Differential Knowledge of Vocabulary Words**

Model results were influenced by the data matrices used. When investigating model fit for the within-word variance matrix, the one-factor model was preferred over the two- and four-factor models. However, when fitting the between-word variance matrix to these same models, he four-factor model had the best overall fit to the data when compared to the one- and two-factor models. Differential knowledge was not found to spuriously result the number of underlying dimensions. Fit indices for both models are provided in Figures 1 and 2. The implications of these findings are discussed below.
DISCUSSION

The purpose of the current study was to investigate the factor structure of vocabulary and morphology. There were two main goals. One goal was to investigate the underlying dimensions of vocabulary knowledge. Because the same 23 words were administered over the same four sections of the vocabulary assessment, both between- and within-word variance could be modeled. The current design allowed for a second question to be answered: whether or not potential differences in how well words are known spuriously reduce the number of underlying dimensions and increase their degree of correlation.

Both data matrices were fit to a four-factor model that considered vocabulary knowledge to be comprised of four distinct yet related factors; a two-factor model, which separated vocabulary and morphological knowledge into two separate factors; and a one-factor model that considered vocabulary knowledge to be a unidimensional factor.

First, within-word variance was investigated. The results supported a one-factor model is preferred due to the non-significant differences between the three models and the selection of the most parsimonious model to describe the present data. This result implies each of the areas of vocabulary knowledge examined – definitional knowledge, usage, relational knowledge, and morphological knowledge – actually represent a single construct of vocabulary knowledge.

When data were modeled using the between-word variance matrices, the four-factor model was the best fitting model according to the data. In other words, vocabulary knowledge is best represented by the separate yet interdependent components of definitional knowledge, usage, relational knowledge, and morphological knowledge when the variance between words was considered.

With regards to the second goal of the present study, results showed that differences in how well words are known to do not spuriously reduce the number of underlying dimensions or increase their degree of correlation. This conclusion is based on the fact that vocabulary knowledge was unidimensional when analyzed at the within-word level, and the fact that vocabulary knowledge at the between-word level, which represents differences in how well words are known, yielded a four-factor solution. Confirmatory factor analyses support the conclusion that vocabulary knowledge appears to be a relatively unidimensional construct.
Table 1

*Correlations, Means, and Standard Deviations for the Complete Vocabulary Task (N = 92)*

<table>
<thead>
<tr>
<th>Question</th>
<th>1</th>
<th>2</th>
<th>3</th>
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*p < .05, ** p < .01
Table 2

*Data Matrix for Between-Word Variance*

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*Correlation Data Matrix for Within-Word Variance*

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Table 4

*Fit Indices for Vocabulary and Morphological Knowledge (2-Factor), General Knowledge (1-Factor), and Four-Distinct Factors of Vocabulary Knowledge (4-Factor) models accounting for within-word variance*

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Table 5

Fit Indices for Vocabulary and Morphological Knowledge (2-Factor), General Knowledge (1-Factor Model), and Four-Distinct Factors of Vocabulary Knowledge (4-Factor) models accounting for between-word variance

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Figure 1. Fit Indices for the One-Factor Model for Within-Word Variance
Figure 2. Fit Indices for the Four-Factor Model for Between-Word Variance
# APPENDIX A

## LIST OF WORDS USED IN THE VOCABULARY AND MORPHOLOGICAL ASSESSMENT

1. Run (*Example*)
2. Cover
3. Clear
4. Light
5. Catch
6. Part
7. Clean
8. Drop
9. Store
10. Rough
11. Stable
12. Tangle
13. Treat
14. Stand
15. Wake
16. Note
17. Still
18. Found
19. Store
20. Resign
21. Suspend
22. Honor
23. Support
24. Consume
APPENDIX B

VOCABULARY ASSESSMENT ITEMS

Materials: This response booklet.
Notes: Record answers verbatim for later scoring. Give feedback and additional examples for first item—run—only.
Directions: I am going to ask you questions about some words. Ready?

What does the word run mean?
(Give feedback and correct answer if incorrect)

Tell me another meaning of run.
(Give feedback and correct answer if incorrect)

Use run in a sentence.
(Give feedback and correct answer if incorrect)

Give me another sentence that uses a different meaning of run.
(Give feedback and correct answer if incorrect)

Give me examples of any other meanings of run you can think of.
(additional examples to provide if not provided by student: run a business; a dog run; a run of bad luck; going out for a training run; water will run downhill; a clock will run until the battery is drained)

What words mean the same as run?
(Give feedback and correct answer if incorrect. Examples include sprint, pen—as in dog pen; manage—as in manage a business; operate—as in a clock will operate until the battery is drained)

What words mean the opposite of run?
(Give feedback and correct answer if incorrect: walk; stop)
What does the word **cover** mean?

Tell me another meaning of **cover**.

Use **cover** in a sentence.

Give me another sentence that uses a different meaning of **cover**.

Give me examples of any other meanings of **cover** you can think of.

What words mean the same as **cover**?

What words mean the opposite of **cover**?
Materials: This response sheet.
Ceiling: Give all items.
Notes. When you see a blank ______, say the word blank and write in the word the student provides.

“Some complex words can be gotten by changing simple words. For example, the simple word ‘strict’ can be changed into the related words ‘restrict,’ stricter, ‘strictly, restrict, restriction, restricted, and so on.’

I am going to give you a simple word. Then I will read a sentence and I want you to tell me what related word goes in the blank. Then, I want you to tell me any other related words you know. Let’s try an example:

The simple work is ‘tire.’ Listen to this sentence: After staying up all night, Jim was BLANK the next day at school. What word belongs in the sentence?

If correct: Yes, ‘tired’ is correct. Jim was tired the next day at school.
If incorrect. The word that goes in the blank is tired.

Now, tell me other words related words you can get by changing the word “tire.”

(reinforce correct answers and give these additional examples if they are not provided by the student: tires, tired, tiring, retire, retires, retired, retirement)

Any questions?

Let’s try another one.

The word is think.

Because Sara was sick, she ________ she should stay home.

If correct: Yes, “thought” is correct. Because Sara was sick, she thought she should stay home.
If incorrect. The word that goes in the blank is thought. Because Sara was sick, she thought she should stay home.

What other related words can you get by changing ‘think?’
(reinforce correct answers and give these additional examples if they are not provided by the student: thinks, thought, thoughtful, thinker, unthinkable, rethink)
Any questions? OK, let’s try some more.
1. The simple word is ‘cover.’
She _________ her head to keep the sun out of her eyes.
What other related words can you get by changing ‘cover?’

2. The simple word is ‘clear.’
The pilot received __________ to land.
What other related words can you get by changing ‘clear?’

3. The simple word is ‘light.’
The mother _________ the birthday candles.
What other related words can you get by changing ‘light?’

4. The simple word is ‘catch.’
Justin _____ a cold yesterday.
What other related words can you get by changing ‘catch?’

5. The simple word is ‘part.’
She was __________ to blame for her poor grade.
What other related words can you get by changing ‘part?’
APPENDIX D

HUMAN SUBJECTS APPROVAL LETTER

Office of the Vice President For Research Human Subjects Committee
Tallahassee, Florida 32306-2742
(850) 644-8673 · FAX (850) 644-4392

APPROVAL MEMORANDUM

Date: 11/16/2010
To: Richard Wagner
Address: 4301
Dept.: PSYCHOLOGY DEPARTMENT
From: Thomas L. Jacobson, Chair
Re: Use of Human Subjects in Research
Assessing Reading for Understanding: A Theory-Based, Developmental Approach

The application that you submitted to this office in regard to the use of human subjects in the research proposal referenced above has been reviewed by the Human Subjects Committee at its meeting on 11/10/2010. Your project was approved by the Committee.

The Human Subjects Committee has not evaluated your proposal for scientific merit, except to weigh the risk to the human participants and the aspects of the proposal related to potential risk and benefit. This approval does not replace any departmental or other approvals, which may be required.

If you submitted a proposed consent form with your application, the approved stamped consent form is attached to this approval notice. Only the stamped version of the consent form may be used in recruiting research subjects.

If the project has not been completed by 11/9/2011 you must request a renewal of approval for continuation of the project. As a courtesy, a renewal notice will be sent to you prior to your expiration date; however, it is your responsibility as the Principal Investigator to timely request renewal of your approval from the Committee.

You are advised that any change in protocol for this project must be reviewed and approved by the Committee prior to implementation of the proposed change in the protocol. A protocol change/amendment form is required to be submitted for approval by the Committee. In addition, federal regulations require that the Principal Investigator promptly report, in writing any unanticipated problems or adverse events involving risks to research subjects or others.

By copy of this memorandum, the Chair of your department and/or your major professor is reminded that he/she is responsible for being informed concerning research projects involving
human subjects in the department, and should review protocols as often as needed to insure that the project is being conducted in compliance with our institution and with DHHS regulations.

This institution has an Assurance on file with the Office for Human Research Protection. The Assurance Number is IRB00000446.

Cc: Janet Kistner, Chair
HSC No. 2010.5256

Richard K. Wagner
Robert O. Lawton Distinguished Professor of Psychology
W. Russell and Eugenia Morcom Chair
Department of Psychology, Room A205
Florida State University
1107 W. Call St.
P.O. Box 3064301
Tallahassee, FL 32306-4301

(850) 644-1033
(850) 644-7739 (FAX)
rkwagner@psy.fsu.edu
APPENDIX E

PARENTAL CONSENT FORM

Dear Parent,

I am a professor in the Florida Center for Reading Research at Florida State University. We are doing a study on vocabulary and listening comprehension. These two skills are important for understanding what you read. We hope to include all students in your child’s class in the study.

Your child’s participation will involve taking several tasks that measure vocabulary knowledge, listening comprehension, memory, and reading. Most children find these tasks to be enjoyable. The tasks will be given in two different sessions, on two separate days. Each session will last approximately 45 minutes; the total time involved will be about 90 minutes. Your child will be given the tasks individually in an open area at your child’s school. We would also like to include your children FCAT scores in our study. With your permission we would get your child’s FCAT scores from the school.

Your child’s participation in this study is voluntary. Your consent may be withdrawn at any time, and there will be no penalty and it will not affect your child’s grade. Your child can also choose not to participate without penalty.

The results of the study may be published, but your child’s name will not be used. Confidentiality of records will be maintained to the full extent allowed by Florida law. Possible benefits of your child’s participation include learning more about reading for understanding. What we learn may help students who have trouble understanding what they read.

If you have any questions concerning this study or your child’s participation, please contact our lab at READ@psy.fsu.edu or at 850-645-7428.

Sincerely,

Richard K. Wagner
Robert O. Lawton Distinguished Professor of Psychology
W. Russell and Eugenia Morcom Chair

I GIVE permission for my child, _________________________ to participate in the above study and for my child’s FCAT scores to be provided to the researchers of this study.

Parent’s Name: _____________________________ Signature ________________________ Date: __________

Your Mailing Address: ___________________________________________________________________  ___________________________________________________________________

I DO NOT GIVE permission for my child, _________________________ to participate in the above study and for my child’s FCAT scores to be provided to the researchers of this study.

Parent’s Name: _____________________________ Signature ________________________ Date: __________

If you have any questions about your child’s rights as a participant in this research, or if you feel you have been placed at risk, you can contact the Chair of the Human Subject’s Committee, Institutional Review Board, through the Vice President for the Office of Research at (850) 644-8633.
APPENDIX F

CHILD ASSENT FORM

Before testing begins, student assent will be obtained by saying to him/her:

Hello _________ (Subject’s name), my name is ____________________ (your name). How are you doing today? Your family has agreed to help us with a study we are doing. Your parents have given permission for you to talk with me and do some reading and language activities, but I want to be sure it’s OK with you. Some of the activities may be easy. Some are for older kids and it may be harder or you may not know the answer. That is OK. I just want you to try your best.

If you want to stop at any time, that is OK. You won’t get in any trouble and no one will be mad at you.

Do you have any questions? Is it OK if we start now?

(If child does not want to start, assure them that it is perfectly OK to stop. No testing will take place).

Did subject give Assent for testing? _____ Yes _____ No
(if no, you must end the conversation with the child)

Record Subject’s Consent Verbatim: __________________________________________________________
____________________________________________________________________________________
____________________________________________________________________________________

Date Assent Completed: ___________________________________________________

Tester Printed Name: ______________________________________________________

Tester Signature: _________________________________________________________
REFERENCES


BIOGRAPHICAL SKETCH

Mercedes Spencer was born in New Jersey in 1988. She attended Cameron University, where she majored in psychology and minored in English. She worked as an undergraduate research assistant to Dr. Mary Dzindolet. In 2009, she graduated Magna Cum Laude with a Bachelor of Science degree.

In 2010, Mercedes was admitted to the developmental psychology graduate program. Dr. Richard Wagner is her advisor, and her main research interests are in the area of reading comprehension and vocabulary knowledge, mainly morphological awareness. After satisfying the requirements for a Master of Science degree, Mercedes will continue to pursue her graduate studies in the developmental psychology doctoral program at Florida State University.