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Multicomponent view of vocabulary acquisition: An investigation with primary grade children

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ABSTRACT

The role of working memory in vocabulary acquisition has been well established in the literature. In this study, we proposed and empirically tested the multicomponent view of vocabulary acquisition, which states that multiple language and cognitive skills are involved to facilitate phonological and semantic representations needed for vocabulary acquisition. Working memory and attention were hypothesized to be directly and indirectly related to vocabulary, whereas inference and morphosyntactic knowledge were hypothesized to be directly related to vocabulary (measured by the Picture Vocabulary Test of the Woodcock–Johnson III battery). Results from 262 kindergartners using path analysis revealed that all the multiple cognitive and language skills were directly related to vocabulary after controlling for age, gender, racial/ethnic backgrounds, socioeconomic status (as measured by free or reduced-price lunch eligibility), and each other. Furthermore, working memory and attention also made indirect contributions via inference and morphosyntactic knowledge. Total effects (beta weights), accounting for direct and indirect effects, were .33 for working memory, .23 for attention, .18 for inference, and .18 for morphosyntactic knowledge. These results indicate that although working memory is important, contributions of other language and cognitive skills should be considered in vocabulary acquisition. Theoretical and practical implications are discussed.

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Introduction

Vocabulary learning is an enormous task. According to one estimate, students are exposed to roughly 88,700 different word families in school between kindergarten and Grade 12 (Nagy & Anderson, 1984). Approximately half of these words are learned, on average, which translates to 3000–4000 new words per year, or 8–11 new words per day (Graves, 2006; Stahl & Nagy, 2006; White, Graves, & Slater, 1990). However, this estimate is an "average." Some children learn more than 3000–4000 words per year, whereas others learn fewer words. Given the importance of vocabulary in language and literacy acquisition (Kim, 2015, 2016, 2017; National Institute of Child Health and Human Development [NICHD], 2000; National Research Council, 1998), it is vital to have a clear understanding about factors involved in vocabulary acquisition.

One well-known factor for vocabulary acquisition is an environmental one, exposure frequency and quality. Vocabulary learning is essentially associative learning—associating sequences of sounds to meaning (McMurray, Horst, & Samuelson, 2012; Pressley, Mohan, Raphael, & Fingeret, 2007). Therefore, repeated and persistent stimulation is needed for the strength of association between phonological sequences and meaning. The effect of input or exposure frequency in vocabulary acquisition has been well demonstrated. For instance, Hart and Risley (1995) showed how frequency of vocabulary exposure in the home is strongly related to children's vocabulary size. This finding has been replicated in several studies (Hoff, 2003a, 2003b; Huttenlocher, Haight, Bryk, Seltzer, & Lyons, 1991; Pan, Rowe, Singer, & Snow, 2005). Of course, language acquisition does not solely depend on frequency of input. Language learning occurs with a goal of achieving communication goals in the context of social interactions (Rice, 1989; Snow, 1983). Therefore, quality of interaction, such as semantically responsive interactions where children's immediate interests are recognized and extended, is also important to vocabulary acquisition (e.g., Burchinal et al., 2008; Hirsh-Pasek et al., 2015; Hoff, 2003b).

Given these findings, it is not surprising that many vocabulary intervention studies have focused on effective ways to create opportunities for students to get systematic quality exposure to target vocabulary words (see Elleman, Lindo, Morphy, & Compton, 2009, and NICHD, 2000, for reviews). These studies have demonstrated that explicit instruction does help children to acquire vocabulary. Low-intensity instruction (e.g., providing definitions) can help children to learn approximately 22% of taught vocabulary words, whereas high-intensity instruction (e.g., in-depth discussion with various activities; Beck, Perfetti, & McKeown, 1982) can facilitate learning of 41–43% of taught words (Biemiller & Boote, 2006). However, there is one consistent and critical finding that has not received its due attention in these previous studies: large individual differences in the amount of words learned. As an example, in Jenkins, Stein, and Wysocki's (1984) study, fifth graders were exposed to target vocabulary words embedded in stories six times (i.e., incidental learning) and were asked to provide meanings of the target words. Large individual variations were observed across students' comprehension abilities, such that the standard deviation (28.9) was as large as the mean (29.4) for the low-comprehension ability group. Large variations in the amount of vocabulary learning have also been found in direct instruction of vocabulary. For instance, Coyne et al. (2010) provided direct and extended vocabulary instruction to kindergartners from high-poverty schools. In addition to the mean intervention effect, there were large variations across treatment conditions. Similar large variations around mean intervention effects have been reported in other studies (e.g., Silverman, 2007; Silverman & Hines, 2009; Townsend & Collins, 2009). Then, there are a couple of naturally rising critical questions. Why do some children learn more vocabulary words than others even when the amount of exposure is similar or the same? What child characteristics (i.e., cognitive and language factors) underpin vocabulary acquisition?

Working memory and vocabulary acquisition

Vocabulary acquisition requires storing sound sequences and mapping those to meaning. Therefore, the capacity in "encoding, maintenance, and manipulation of speech-based information," verbal working memory (also called phonological memory; Gathercole, Willis, Emslie, & Baddeley, 1992, p. 887), is essential in vocabulary acquisition. In the current study, we refer to this as the core working memory account of vocabulary acquisition. According to this view, establishing a stable long-term phonological representation of a word is a direct consequence of one's working memory capacity (the ability to construct phonological loop representations) (Gathercole, Hitch, Service, & Martin, 1994). Prior research has shown that there are large individual differences in verbal working memory in children and adults and that working memory is implicated in vocabulary acquisition (e.g., Baddeley, Gathercole, & Papagno, 1998; Engel de Abreu & Gathercole, 2012; Gathercole, 2006; Gupta & Tisdale, 2009; Kim, 2015, 2016, 2017; Verhagen & Leseman, 2016). Furthermore, a 4-year longitudinal study with children aged 4–8 years revealed that working memory at 4 years was significantly associated with vocabulary at 5 years (partial $r = .38$). In contrast, vocabulary at 4 years was weakly related to working memory at 5 years (partial $r = .14$), suggesting that the direction of relation is from working memory to vocabulary, not vice versa (Gathercole et al., 1992). Moderate bivariate correlations (e.g., $.34 \leq rs \leq .61$) have been reported between working memory and vocabulary for primary-grade children (Baddeley et al., 1998; Gathercole et al., 1992; Kim, 2016, 2017; Kim & Schatschneider, 2017).

Other language and cognitive factors associated with vocabulary

The literature also suggests that cognitive and language skills other than working memory are associated with vocabulary acquisition. Learning, even implicit learning, occurs in real-life contexts where multiple irrelevant stimuli compete for attention (Toro, Sinnett, & Soto-Faraco, 2011). Therefore, attentional control, one's ability to inhibit and not get distracted by irrelevant stimuli and to sustain attention on the selected focal stimuli, is important in learning, including vocabulary acquisition (e.g., Hoffman & Gillam, 2004; Stevens, Sanders, & Neville, 2006). In fact, attention is a prerequisite to any learning tasks according to information processing theories (e.g., Adams & Snowling, 2001; Verhoeven, Reitsma, & Siegel, 2011). Empirical evidence does lend support for the role of attention in early language acquisition. Children's joint attention measured by gestures and gesture plus speech combinations at 18 months of age predicted their vocabulary and sentence complexity at 42 months (Rowe & Goldin-Meadow, 2009). Young infants' attention to speech at 12 months of age was also positively related to their vocabulary at 18 months (Vouloumanos & Curtin, 2014). Whereas these studies have been primarily conducted with infants and toddlers, growing evidence suggests a moderate bivariate correlation ($.30 \leq rs \leq .46$) between attentional control and vocabulary for school-aged children (Kim, 2016; McClelland et al., 2007; Stephenson, Parrila, Georgiou, & Kirby, 2008).

Another potential cognitive factor for vocabulary acquisition is an inferencing skill. The vast majority of vocabulary learning occurs incidentally in the absence of direct instruction (Jenkins et al., 1984; Nagy, Herman, & Anderson, 1985; Sternberg, 1987). Therefore, children's ability to derive meaning from context using meaning cues surrounding an unknown word may be important to vocabulary learning. Although external contexts are not always ideal to derive meaning (Beck, McKeown, & Kucan, 2002), children indeed learn from context with multiple encounters (Jenkins et al., 1984; Nagy et al., 1985; Sternberg & Powell, 1983). Furthermore, a review of the literature showed that instruction on deriving meaning from context was effective in helping children to figure out meaning of words (Kuhn & Stahl, 1998). Then, individual differences in an inferencing skill may be related to vocabulary acquisition. Previous studies of incidental learning of vocabulary have acknowledged the importance of inferring meanings from context, but few studies have explicitly investigated whether an inferencing skill is related to children's vocabulary. Instead, studies have investigated differences between proficient readers and struggling readers in deriving word meanings from context (Jenkins et al., 1984; McKeown, 1985). These studies, however, do not reveal what drives the relation between children's reading ability and the ability to learn vocabulary from context. Moreover, previous studies typically examined the role of vocabulary in inference making (e.g., Calvo, 2005; Currie & Cain, 2015; Kim, 2016, 2017; Tompkins, Guo, & Justice, 2013), not the other way around. One exception is a recent study showing that an inference skill at preschool predicted vocabulary at kindergarten even after accounting for the autoregressor (Lepola, Lynch, Laakkonen, Silvén, & Niemi, 2012). Correlations between vocabulary and inference making have ranged from .36 to .60 in previous studies (Currie &

Cain, 2015; Florit, Roch, & Levorato, 2011; Florit, Roch, & Levorato, 2014; Kim, 2016, 2017; Kim & Schatschneider, 2017; Lepola et al., 2012).

For children to infer word meanings correctly in context, comprehension of meanings of the context or sentences is required. In other words, being able to accurately understand the meaning of semantic context in which an unknown word is embedded would be critical in figuring out the meaning of an unknown word. Therefore, children's ability to use morphosyntactic cues to infer and comprehend meanings would be important to vocabulary learning. The idea of using syntactic cues in word learning has been suggested by the syntactic bootstrapping hypothesis (Gillette, Gleitman, Gleitman, & Lederer, 1999; Gleitman, 1990). Syntactic bootstrapping has received particular attention in learning verbs because meanings of verbs are often guided by the syntactic structure of a sentence (Fisher, Gertner, Scott, & Yuan, 2010; Naigles, 1996; Naigles & Kako, 1993). Although syntactic bootstrapping has been primarily studied with toddlers, studies have shown that elementary-grade children and adults also use syntactic cues in their vocabulary acquisition (Gillette et al., 1999; Piccin & Waxman, 2007). Studies with children in elementary grades have shown moderate correlations (.37–.59) between vocabulary and morphosyntactic knowledge (Brimo, Apel, & Fountain, 2017; Cain, 2007; Kim, 2015, 2016, 2017).

Multicomponent view of vocabulary acquisition

The literature reviewed above suggests that working memory (e.g., the core working memory account) is a foundational capacity for vocabulary acquisition. However, the core verbal working memory account is primarily concerned about the phonological representation of words and does not account for the semantic representation. Successful vocabulary acquisition requires learning of both phonological and semantic aspects, and vocabulary without meaning representation is empty and incomplete. For the semantic representation, several theoretical models have been proposed to explain early learning of meaning, including the multi-route model (Barrett, 1986), the syntactic bootstrapping hypothesis (Gleitman, 1990), the constraints hypothesis (e.g., Golinkoff, Mervis, & Hirsh-Pasek, 1994), associative learning (McMurray et al., 2012), and hypothesis elimination (Xu & Tenenbaum, 2007). Although these models are rich and informative, their primary focus has been about accurately identifying learning *processes* involved in sound–referent mapping, particularly for very young children.

The focus of the current study was to identify capacities or skills that are necessary to enable phonological and semantic representations for vocabulary acquisition. Processes and skills are intimately related because processes are possible only when necessary capacities or skills are in place to enable the use of such processes. We hypothesized, based on the evidence reviewed above, that vocabulary acquisition relies on multiple language and cognitive skills such as working memory, attentional control, inference, and morphosyntactic knowledge. We refer to this as the multicomponent view of vocabulary acquisition. In this view, executive functions such as working memory and attentional control are foundational cognitive abilities needed for both phonological and semantic representations. In addition to its role in the phonological representation, working memory is also responsible for semantic processing because holding and updating linguistic information is necessary during the inference process. Attentional control would facilitate accurate representations of phonological and semantic information because attention to both aspects is needed to facilitate stable and long-term representation of target words. An inferencing skill and morphosyntactic knowledge, on the other hand, are hypothesized to be primarily responsible for the semantic representation because they are involved in inference of meaning.

The conceptual model of the multicomponent view is presented in Fig. 1. Note that in this model foundational cognitive capacities such as working memory and attention are hypothesized to have direct and indirect contributions to vocabulary. The indirect contributions via inference and morphosyntactic knowledge are based on the evidence that inference and morphosyntactic (grammatical) knowledge are higher-order skills built on these foundational cognitive skills (Carlson, Moses, & Breton, 2002; Gathercole & Baddeley, 1990a; Gathercole & Baddeley, 1990b; Kim, 2016, 2017; Slade & Ruffman, 2005; Verhagen & Leseman, 2016).

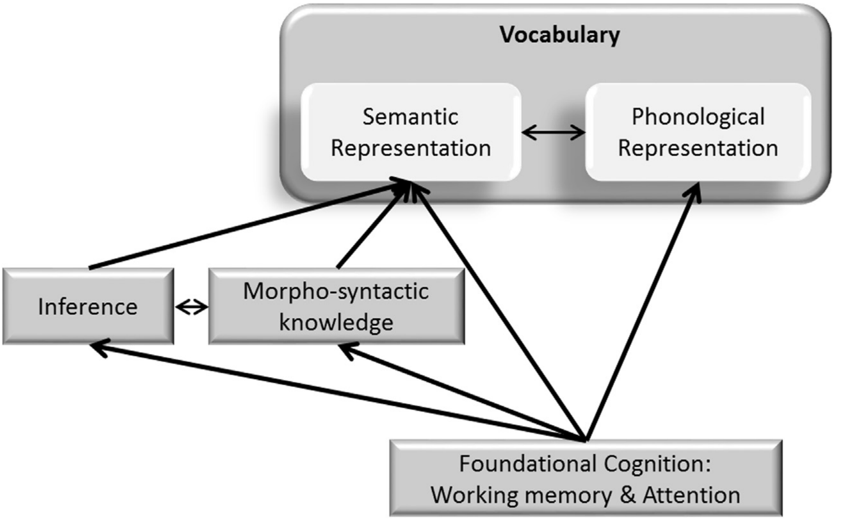

Fig. 1. Conceptual representation of the multicomponent view of vocabulary acquisition.

The current study

The primary goal of the current study was to empirically investigate the multicomponent view of vocabulary acquisition—whether multiple language and cognitive factors (i.e., attentional control, inference, and morphosyntactic knowledge), in addition to working memory, make contributions to vocabulary knowledge for primary-grade children (i.e., kindergartners). Although previous studies have suggested bivariate correlations between the language and cognitive skills and vocabulary, these have not been jointly and systematically examined as predictors of vocabulary. To this end, we tested two alternative models.[1] The first model is a direct and indirect relations model (see Fig. 2A) where, as depicted in Fig. 1, working memory and attention were directly related to vocabulary as well as indirectly via inference and morphosyntactic knowledge. In the second model (indirect relations model; Fig. 2B), working memory and attention were hypothesized to be only indirectly related to vocabulary via inference and morphosyntactic knowledge. Children's demographic backgrounds such as age, gender, race/ethnicity, and socioeconomic status (SES; as measured by eligibility for free or reduced-price lunch) were included as control variables in these models.

Method

Participants and sites

Participants included 262 kindergartners (55% boys; mean age = 5.33 years, *SD* = 0.45) from 31 classrooms and seven schools in the United States. Schools and classrooms (or teachers) were recruited, and all children in participating classes were invited via content letters to parents and guardians. The sample was composed of Caucasians (53%) and African Americans (34%), with 3% Hispanic and 5% mixed race. Approximately 69% of the children were eligible for free or reduced-priced lunch. Only 1% of children were English language learners. Approximately 11% of the children were identified

[1] A model where working memory and attention have direct relations only was not included as a third alternative model for two reasons. First, as noted above, evidence indicates that inference and morphosyntactic knowledge are higher-order skills predicted by working memory and attention. Second, model fit would be identical between this model and Model 1 mathematically unless covariances are fixed to be zero between working memory and attention and between inference and morphosyntactic knowledge. However, lack of relations among these is not reasonable given previous evidence.

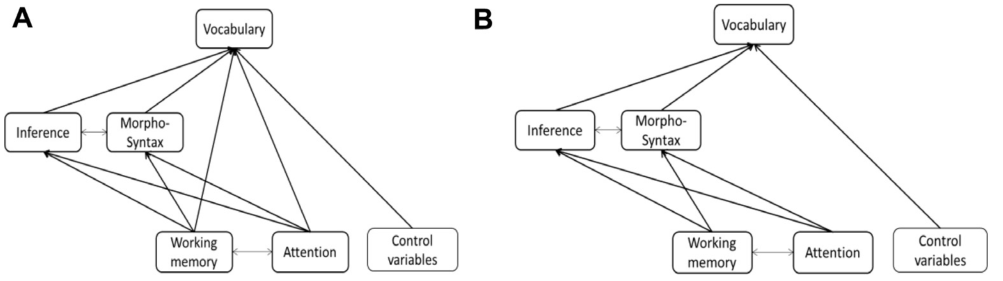

Fig. 2. Two alternative models for the multicomponent view of vocabulary. (A) Working memory and attention have direct and indirect relations to vocabulary (direct and indirect relations model). (B) Working memory and attention have only indirect relations (indirect relations model). Correlations among predictors are allowed but not shown.

as having learning disabilities, and the vast majority of them received services related to speech impairment.

Measures

Vocabulary

Children's vocabulary was assessed by the Picture Vocabulary Test of the Woodcock–Johnson III battery (Woodcock, McGrew, & Mather, 2001). In this task, children were asked to identify pictured objects. Following the protocol, test administration was discontinued after six consecutive incorrect items on a page. Cronbach's alpha was estimated to be .70.

Attention

Children's attentional control was measured by the first nine items of the Strengths and Weaknesses of ADHD (attention deficit/hyperactivity disorder) Symptoms and Normal Behavior Scale (i.e., SWAN; Swanson et al., 2006). SWAN is a behavioral checklist that teachers completed in the current study. The SWAN task includes 30 items, 9 of which are related to sustaining attention on tasks (e.g., "Engages in tasks that require sustained mental effort"); the other items assess hyperactivity and aggression. Each item is rated on a 7-point scale ranging from 1 (*far below average*) to 7 (*far above average*) to allow for ratings of relative strengths (above average) as well as weaknesses (below average). A recent study showed that the 9 items related to attention indeed capture respondents' ability to regulate attention (Sáez, Folsom, Al Otaiba, & Schatschneider, 2012). Higher scores represent greater attentional control. Cronbach's alpha across these 9 items was .97.

Working memory

Working memory was measured by a listening span task (Florit, Roch, Altoè, & Levorato, 2009; Kim, 2015, 2016). In this task, children heard a sentence (e.g., "Apples are blue") and were asked to identify whether the heard sentence was correct or not. After hearing sentences, children were asked to recall the last words in each sentence in the order they were presented. Testing was discontinued after three consecutive incorrect responses. Accuracy of yes/no responses regarding the veracity of the statements was not scored. Instead, children's responses on the last words in correct order were given a score of 2, and correct responses in incorrect order were given 1 point. There were four practice items, and 14 test items were included for a total possible maximum score of 28. Cronbach's alpha was estimated to be .89.

Inference

Knowledge-based inferencing skill was measured by the Inference task of Comprehensive Assessment of Spoken Language (CASL; Carrow-Woolfolk, 1999). Because this task is normed for children aged 7 years and older, easy items were developed (modeling after the CASL items), piloted, and used in the first few test items, followed by the items in the CASL. In this task, children heard two- or three-sentence stories and were asked a question that required inference using background knowledge (e.g., "Mother calls to 4-year-old Sandra and says, 'Be sure to bring your bathing suit. And don't forget your shovel and bucket.' Where are they going?"). There were two practice items, and test administration was discontinued after five consecutive incorrect items, following the CASL protocol. Cronbach's alpha was .75.

Morphosyntactic knowledge

Morphosyntactic knowledge was measured by the Grammaticality Judgment task of CASL (Carrow-Woolfolk, 1999). The Grammaticality Judgment task was normed for children aged 7 years and older; thus, we developed a few easy items (modeling after the items in the CASL) and piloted. The experimental items were used in the first few test items, followed by the CASL items. In this task, children heard a sentence (e.g., "They is happy") and were asked whether the sentence was grammatically correct. If it was incorrect, children were asked to correct the sentence. There were three practice items, and testing was discontinued after five consecutive incorrect items. A total of 2 points were possible for grammatically incorrect items (1 point for identifying grammatical inaccuracy and 1 point for accurately correcting the sentence). Cronbach's alpha was .94.

Procedures

Children were assessed during the fall semester by rigorously trained research assistants in a quiet space in the school. The assessment battery was administered in sessions of 30–40 min.

Data analysis

Path analysis was employed as the primary data analytic strategy to examine the direct and indirect relations hypothesized in the multicomponent view. Path analysis is superior to conventional multiple regression models because it allows fitting direct and indirect relations in a single model simultaneously and allows estimates of direct and indirect effects. Multiple regression models show independent or unique contributions of predictors and mask their indirect contributions. Age and demographic variables (i.e., gender, free or reduced-price lunch status, race/ethnicity) were included as control variables. Race, gender, and free or reduced-price lunch status were dichotomous (e.g., for race/ethnicity, Caucasians = 1 and others = 0). Model fits were evaluated by chi-square statistics, comparative fit index (CFI), Tucker–Lewis index (TLI), root mean square error of approximation (RMSEA), and standardized root mean square residuals (SRMR). Typical fit guidelines for model fit are as follows: RMSEA values below .08, CFI and TLI values equal to or greater than .95, and SRMR values equal to or less than .05 indicate an excellent model fit, and TLI and CFI values greater than .90 are considered to be acceptable (Kline, 2005). Differences in model fits between competing models were examined using a chi-square test.

Results

Descriptive statistics and preliminary analysis

There were no missing data in the vocabulary task, but 2 children (1%) had missing data on the working memory, morphosyntactic knowledge, and inference tasks and 9 children (3%) had missing data on the SWAN attention measure. Little's test of missing completely at random was not statistically significant, $\chi^2(5) = 3.17$, $p = .67$, indicating that the null hypothesis of missing completely at random cannot be rejected.

Descriptive statistics and partial correlations after controlling for age are presented in Table 1. The mean standard score of vocabulary for the sample was in the solid average range ($M = 99.23$, $SD = 9.50$). Standard scores were not available for the other measures, including morphosyntactic knowledge and inference, because those were available only for children aged 7 years and older. All

Table 1
Descriptive statistics and partial correlations controlling for age.

	Picture Vocabulary	Working memory	SWAN attention	Grammaticality Judgment	Inference
Picture Vocabulary	–				
Working memory	.43	–			
SWAN attention	.38	.45	–		
Grammaticality	.41	.39	.39	–	
Inference	.39	.35	.39	.35	–
Cronbach's alpha	.70	.89	.97	.94	.75
Mean (*SD*), raw	16.60 (2.78)	6.87 (5.93)	35.81 (11.00)	11.09 (9.49)	3.20 (3.59)
Min–Max	6–26	0–23	10–63	0–43	0–20
Skewness	−0.20	0.50	0.11	1.07	1.69
Kurtosis	1.30	−0.84	−0.16	0.54	3.20

Note. Grammaticality = Grammaticality Judgment. All the correlation coefficients were statistically significant at the .001 level.

distributional properties (i.e., skewness and kurtosis) were within acceptable ranges. Raw scores were used in the subsequent analysis.

Correlations were in the expected range. Working memory, attentional control, morphosyntactic knowledge, and inference all were moderately related with vocabulary ($.38 \leq rs \leq .43$). The predictors were also moderately related to each other ($.35 \leq rs \leq .45$).

Given that children were nested within classrooms, a preliminary analysis was conducted to estimate variance attributable to classroom differences. Results revealed that a minimal (1%) amount of variance was due to classroom difference; therefore, results were essentially identical with and without accounting for classroom differences.

Path analysis

Two alternative models shown in Fig. 2A and B were fitted to the data. Model fit for the direct and indirect relations model (Fig. 2A) was excellent, $\chi^2(3) = 2.46$, $p = .48$, CFI = 1.00, TLI = 1.00, RMSEA = .00, SRMR = .01. The indirect relations model (Fig. 2B) had a poor fit, $\chi^2(5) = 27.38$, $p < .001$, CFI = .91, TLI = .64, RMSEA = .13, SRMR = .036. A chi-square difference test showed that the direct and indirect model was superior: $\Delta\chi^2 = 24.92$, $\Delta df = 2$, $p < .001$. Standardized path coefficients for the direct and indirect model are shown in Fig. 3. Note that all the covariances between control variables and predictors (e.g., gender and attention, gender and working memory) were allowed, but only statistically significant ones were retained in the final model. Working memory ($\gamma = .22$, $p < .001$), attention ($\gamma = .14$, $p = .03$), inference ($\beta = .18$, $p = .001$), and morphosyntactic knowledge ($\beta = .18$, $p = .002$) all were directly related to vocabulary after accounting for each other and demographic variables. In addition, working memory predicted inference ($\gamma = .28$, $p < .001$) and morphosyntactic knowledge ($\gamma = .30$, $p < .001$), and so did attention ($\gamma = .25$, $p < .001$ for inference; $\gamma = .25$, $p < .001$ for morphosyntactic knowledge). The total effect of working memory, accounting for its indirect effect via inference and morphosyntactic knowledge, was .33 (.22 for direct effect and .10 for indirect effect; the difference between the total and its parts is due to rounding). The total effect for attention was .23 (.14 for direct effect and .09 for indirect effect). Total effects (direct effects only) for inference and morphosyntactic knowledge were .18 and .18, respectively.

Discussion

Vocabulary is one of the core skills in language and literacy development. In the current study, we investigated the roles of multiple cognitive and language factors (i.e., working memory, attentional control, inference, and morphosyntactic knowledge) in vocabulary using data from kindergartners.

At its core, vocabulary acquisition requires storing sound sequences and mapping them to meaning. Thus, one's ability to store and manipulate information, working memory, has been hypothesized

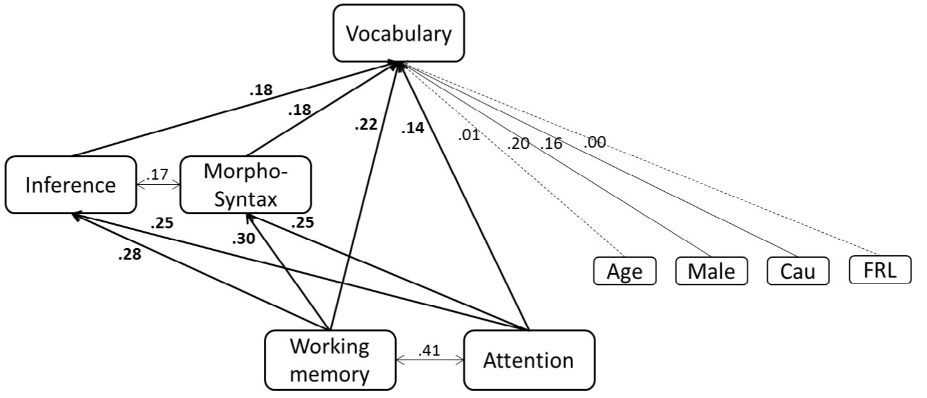

Fig. 3. Standardized path coefficients for the relations of working memory, attention, inference, and morphosyntactic knowledge (Morpho-syntax) to vocabulary when controlling for age, gender (male), race (Cau, Caucasian), and SES (FRL, free or reduced-price lunch eligibility). Solid lines represent statistically significant relations, whereas dashed lines represent nonsignificant relations. Covariances between predictors were allowed but are not shown so as to reduce visual complexity.

to be foundational and has been studied extensively (Engel de Abreu & Gathercole, 2012; Gathercole & Baddeley, 1990a, 1990b; Gathercole, Service, Hitch, Adams, & Martin, 1999; Jarrold, Baddeley, Hewes, Leeke, & Phillips, 2004; Verhagen & Leseman, 2016). However, we hypothesized that language and cognitive factors beyond memory capacity would contribute to vocabulary acquisition. Vocabulary learning occurs through interactions in real life where many stimuli compete for attention and new words are introduced and embedded in context. Therefore, individual differences in maintaining and regulating attention (i.e., attentional control) and in deriving meanings of words in the context of other words (i.e., inference and morphosyntactic knowledge) would make contributions to vocabulary. As noted above, the theoretical model on verbal working memory has primarily focused on the phonological aspect of vocabulary learning, whereas evidence on other language and cognitive factors has not been systematically integrated into a theoretical model. In the current study, we hypothesized and tested the multicomponent view of vocabulary acquisition, namely that multiple language and cognitive skills are needed to facilitate both phonological and semantic representations needed for vocabulary acquisition.

Overall, the results supported the multicomponent view of vocabulary acquisition. All the included language and cognitive factors, including working memory, attention, inference, and morphosyntactic knowledge, were moderately related to vocabulary in a bivariate examination (see Table 1). Furthermore, when investigated jointly, individual differences in working memory, attentional control, inference, and morphosyntactic knowledge all were uniquely and directly related to vocabulary after accounting for demographic control variables and each other. In addition to direct contributions, working memory and attention made indirect contributions via inference and morphosyntactic knowledge. The total effects were as follows: .18 for inference, .18 for morphosyntactic knowledge, .33 for working memory, and .23 for attention.

These results extend our understanding about vocabulary learning in a couple of important ways. First and foremost, vocabulary development is likely to depend on multiple language and cognitive skills. As shown in Fig. 1, we hypothesized that the included language and cognitive factors are important to different aspects of vocabulary acquisition and phonological and semantic representations, such that foundational cognitive abilities (working memory and attention) are necessary for representations of both phonological and semantic information, whereas inference and morphosyntactic knowledge are necessary for the semantic representation. Although examining the hypothesis of differential contributions of each component skill to phonological versus semantic representation was beyond the scope of the current study, our findings did show that all the included language and cognitive skills indeed made direct contributions to vocabulary. Another important aspect of the multicomponent view of vocabulary acquisition is a specification of direct and indirect contributions of component skills. In particular, foundational cognitive skills such as working memory and attentional control were hypothesized to make indirect contributions via inference and morphosyntactic knowledge in addition to their direct contributions (see Fig. 1). Accounting for indirect effects is important to unpacking the nature of relations and to revealing total effects of component skills. In the current study, total effects of working memory and attention, accounting for both direct *and* indirect effects, were sizable.

The current study is an extension of a long and rich line of work on vocabulary acquisition. Because it was a very first attempt in examining the multicomponent view, the current findings require replication and extension in future studies. One important way to extend the current work is to examine codevelopment of the multiple language and cognitive skills. Evidence indicates that the skills examined in the multicomponent view of vocabulary continue to develop well into adolescence (e.g., working memory and inference; Scott, 1988; Swanson, 1999); thus, codevelopment among the component skills and their relations to vocabulary development would be revealing. Particularly relevant is bidirectional relations. Evidence indicates a possibility of reciprocal relations between vocabulary and inference; vocabulary predicted an inferencing skill (Currie & Cain, 2015; Kim, 2016, 2017; Tompkins et al., 2013), and inference predicted vocabulary in the current study as well as in Lepola et al. (2012). Another potential skill that might have a bidirectional relation with vocabulary is morphological awareness. Although not included in the study due to resource constraints, morphological awareness has been shown to be closely related to vocabulary (Baumann et al., 2002; Kieffer & Lesaux, 2012; Kuo & Anderson, 2006; Wysocki & Jenkins, 1987) and to have a reciprocal relation with vocabulary (e.g., McBride-Chang et al., 2008). It will be highly illuminating to investigate potential bidirectional or bootstrapping relations among vocabulary, morphosyntactic knowledge, and inference.

Although not the primary question, it is of note that SES was nonsignificant after accounting for the multiple language and cognitive skills. In a preliminary analysis where only demographic variables were included in the path analysis, children from lower socioeconomic backgrounds had lower vocabulary (see Appendix), which is convergent with previous studies (Arriaga, Fenson, Cronan, & Pethick, 1998; Feldman et al., 2000; Hart & Risley, 1995; Hoff, 2003b; Rescorla & Alley, 2001). However, after accounting for the effects of the included language and cognitive skills, differences due to SES were no longer meaningful, suggesting that the effect of SES on vocabulary is likely attributable to these language and cognitive skills. A post hoc analysis revealed that the SES effect became nonsignificant once working memory was in the model and that a standardized mean difference of .27 in working memory between children who are eligible for free or reduced-price lunch and those who are not. This difference in working memory as a function of SES is in line with extant evidence (Noble, McCandliss, & Farah, 2007). It is important to note, however, that working memory might not be biologically determined. Instead, development of working memory might be a product of interaction between biology and environment, with recent studies demonstrating that working memory can be improved with training (i.e., malleable) even for elementary-grade children (Karbach, Strobach, & Schubert, 2015; Loosli, Buschkuehl, Perrig, & Jaeggi, 2012; Studer-Luethi, Bauer, & Perrig, 2016). Therefore, working memory differences as a function of children's SES likely reflect not only biological differences but also environmental (i.e., caregiver support) differences. Studies have shown that the relation of SES to vocabulary is primarily mediated by oral language interactions in the home (Hoff, 2003b). The current findings, in conjunction with evidence from multiple lines of work on the relations of working memory and SES to vocabulary, a difference in working memory as a function of SES, and malleability of working memory, suggest a need for further systematic investigations to expand theoretical models of vocabulary learning. Specifically, an important future direction is an investigation of the mediating and moderating nature of these multiple factors to vocabulary acquisition.

Findings from the current study indicate the importance of considering language and cognitive factors in vocabulary instruction. Research on vocabulary instruction to date has focused on effective ways of providing frequent and quality exposure. Although these studies are critical and have shown that direct vocabulary instruction does improve children's vocabulary, the current findings also suggest that effective vocabulary instruction may need to consider child factors, such as those included in the current study, and how they interact with environment (exposure). Then, an important direction of future studies is to investigate whether incorporating these factors (e.g., explicit training on working memory and inferencing) into direct vocabulary instruction has an added value to the current dominant approach that focuses exclusively on environmental exposure.

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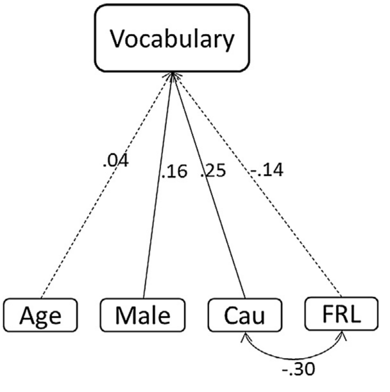
Appendix A

Standardized path coefficients for the relations of control variables (age, gender [male], race [Cau, Caucasian], and SES [FRL, free or reduced-price lunch eligibility]) to vocabulary.



Note. Solid lines represent statistically significant relations, whereas dashed lines represent non-significant relations.

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