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The contributions of vocabulary and letter writing automaticity to word reading and spelling for kindergartners

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Abstract In the present study we examined the relation between alphabet knowledge fluency (letter names and sounds) and letter writing automaticity, and unique relations of letter writing automaticity and semantic knowledge (i.e., vocabulary) to word reading and spelling over and above code-related skills such as phonological awareness and alphabet knowledge. These questions were addressed using data from 242 English-speaking kindergartners and employing structural equation modeling. Results showed letter writing automaticity was moderately related to and a separate construct from alphabet knowledge fluency, and marginally ($p = .06$) related to spelling after accounting for phonological awareness, alphabet knowledge fluency, and vocabulary. Furthermore, vocabulary was positively and uniquely related to word reading and spelling after accounting for phonological awareness, alphabet knowledge fluency, and letter writing automaticity.

Keywords Letter writing automaticity · Semantic (vocabulary) knowledge · Alphabet knowledge · Phonological awareness · Spelling · Word reading

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Introduction

Understanding the processes that contribute to accurate and fluent word reading and spelling are of critical importance. The past three decades of research have elucidated the role of code-related skills such as phonological awareness and alphabet knowledge in early literacy achievement (i.e., word reading and spelling; e.g., Adams, 1990; Ziegler & Goswami, 2005; National Research Council, 1998). However, it has been suggested that more nuanced and precise understanding is needed that contribute to word reading and spelling beyond knowledge of grapheme-phoneme correspondences by including semantic and syntactic knowledge in early models of reading development (Bishop & Snowling, 2004). The present study had two primary goals responding to this call. The first goal was to examine whether letter writing automaticity contributes uniquely to early literacy acquisition over and above code-related skills such as phonological awareness and alphabet knowledge. The second goal was to examine the relation of semantic knowledge with word reading and spelling over and above phonological awareness and alphabet knowledge. We addressed these research questions using data from a larger study involving 242 English-speaking kindergartners in the United States who were assessed at the end of academic year.

The role of letter writing automaticity in early literacy acquisition

Letter writing automaticity is defined as the rate at which children can access, retrieve from memory, and write alphabet letters accurately. Typically this is measured by asking children to write lower case alphabet letters within 15 s (Graham, Berninger, Abbott, & Whitaker, 1997) or 1 min (Jones & Christenson, 1999; Kim et al., 2011; Wagner et al., 2011). Letter writing automaticity, also known as handwriting fluency, has received increasing attention due to its consistent relation with written composition for students in primary to middle schools (Berninger, Whitaker, Feng, Swanson, & Abbott, 1996; Graham et al., 1997; Kim et al., 2011; Wagner et al., 2011). Researchers hypothesize that achieving letter writing automaticity frees attentional resources for higher level nonautomatic processes such as ideation during the writing process (Graham et al., 1997; Graham & Harris, 2000; McCutchen, 1988, 2000). By contrast, slow or laborious retrieval and production of letters would limit or interfere with written composition of already developed and planned ideas held in working memory (Graham et al., 1997).

However, there are at least two gaps in the literature regarding letter writing automaticity. The first gap is that the relation between letter writing automaticity and alphabet knowledge has been underexplored. Letter writing automaticity involves access to and retrieval and production of *letters*. Although letter writing automaticity involves motoric aspect that is unique, it involves both access and retrieval of letters which are commonly shared with letter naming and sound fluency tasks. Thus, children's knowledge of letter names and sounds may be related, or may be a precursor, to letter writing automaticity. In fact, it is an empirical question how highly related letter writing rates are to letter naming or sound fluency. These may represent a single construct, or letter writing rate may be a related, but dissociable construct from letter naming and sound fluency. According to a recent study, the magnitude of the relation appears moderate ($.33 \leq rs \leq .39$; Al Otaiba et al., 2010). In the present study, we investigated the relations among letter knowledge tasks such as letter naming, sound, and writing tasks, and whether these tasks are best described as a single construct or related but dissociable, or separate, constructs.

If letter writing automaticity is best described as a separate construct from letter naming and sound fluency, it will be important to examine whether it is independently related to lexical level literacy skills, namely, word reading and spelling, the second gap in the literature. Just as slow letter writing is theorized to constrain writing, it seems logical to hypothesize that automatized letter writing would free cognitive and phonological resources that are necessary for successful spelling as well. In the literature, both letter writing automaticity and spelling are considered transcription skills, which is a necessary skill for writing (Berninger & Swanson, 1994; Berninger et al., 1997, 2002; Graham et al., 1997; Kim et al., 2011). However, letter writing automaticity is a sublexical level skill whereas spelling is a lexical skill and requires integration of multiple sublexical processes. Thus, similar to the hierarchical conceptualization of fluency in reading (Meyer & Felton, 1999), automaticity in writing letters might be a component skill for spelling by freeing up cognitive resources for children to attend to other multiple processes that operate for spelling such as integration of knowledge about print, grapheme–phoneme correspondence, meaning, and detailed whole word orthographic knowledge (Apel & Apel, 2011; Moats, 2005–2006). This might be particularly important for kindergarteners, who are still simultaneously developing multiple skills such as phonological awareness, letter-sound correspondences, and orthographic knowledge that contribute to early literacy skills. More efficient and automatized letter writing might allow them to more readily apply letter-sound correspondences, and attend to spelling patterns whereas slow and laborious letter writing might interfere with these processes. Previous studies have shown a weak correlation between spelling and letter writing fluency for students in primary and intermediate grades (respectively, $rs = .20$ and .32) and a moderate correlation among kindergarteners ($r = .46$; Al Otaiba et al., 2010). However, further research is warranted to examine whether letter writing automaticity make a unique and independent contribution to early literacy acquisition.

The role of semantic knowledge in early literacy acquisition

Successful reading requires linking oral to written language. Typically, however, certain language skills have been examined for certain literacy skills. Namely, phonological awareness has been extensively studied in relation to word reading and spelling whereas vocabulary has been studied in relation to reading comprehension (see National Institute of Child Health and Human Development, 2000; National Research Council, 1998 for reviews). Although these established links between different aspects of oral language to different aspects of literacy skills are clearly important, our understanding is limited about how other aspects of oral language such as vocabulary is related to lexical level literacy skills. According to some researchers, semantic knowledge would not be uniquely or directly related to word reading (or word spelling) because decontextualized word reading is "modular" (Share & Leiken, 2003, p. 90). Thus, reading words would be less dependent on semantic and syntactic information than reading in connected text (passages), which is supported by understanding the surrounding context (Perfetti, 1999; Share & Leiken, 2003; Stanovich, 1990, 2000). In this view, semantics would be more related to reading and understanding of connected text such as reading comprehension and may also influence early literacy acquisition indirectly via phonological awareness (see the lexical restructuring hypothesis, Walley, Metsala, & Garlock, 2003).

However, vocabulary knowledge may be involved in word reading and spelling directly. According to connectionist models, while both semantic and phonological pathways are involved in the computation of all words, the model tends to focus on establishing the phonological pathway (i.e., the connection between orthography and phonology) in the initial phase, but on the semantic pathway (i.e., connection between orthography and phonology via semantics) in the later phase (Harm & Seidenberg, 2004; Plaut, McClelland, Seidenberg, & Patterson, 1996). This division of labor appears to be particularly important for words that are not transparent in phonological and orthographic mappings such as irregular words in English (Harm & Seidenberg, 2004). Semantic knowledge may facilitate successful reading of irregular or exception words in English because a system of mappings between letters and sounds is not sufficient for successful reading of irregular words. As an example, understanding the word meaning may be more facilitative for reading or spelling *yacht* correctly than *yoyo*. Previous studies have provided preliminary evidence for the relation between vocabulary and word reading, both decodable and irregular words (Bishop & Snowling, 2004; Ouellette, 2006; Ricketts, Nation, & Bishop, 2007). Children's receptive vocabulary was positively related to their decoding skills after controlling for age and nonverbal IQ. In addition, both receptive and expressive vocabulary were uniquely related to reading irregular words after accounting for age, nonverbal IQ, and decoding skills (Ouellette, 2006). Similarly, children's expressive vocabulary was positively related to their exception word reading after accounting for decoding skills (Ricketts et al., 2007). In line with this emerging evidence, researchers recently called for a more comprehensive model to understand developmental dyslexia that includes semantic and syntactic influences in addition to phonological influences (Bishop & Snowling, 2004). In the present study we expand these previous studies, and investigated whether one aspect of semantic knowledge, vocabulary, matters for early literacy acquisition over and above code-related skills such as phonological awareness and alphabet knowledge.

The role of semantic processing, morphological awareness in particular, has received attention in relation to spelling. A considerable body of evidence confirms the relation of morphological awareness to spelling (Apel, Masterson, & Brimo, 2011; Bourassa, Treiman, & Kessler, 2006; Deacon & Bryant, 2005; Kim, 2010; Nagy, Berninger, & Abbott, 2006; Ouellette & Sénéchal, 2008). However, to our knowledge vocabulary knowledge has not been systematically examined in relation to early spelling in English. Vocabulary knowledge may be related to spelling because theoretically, the main principles of models developed for reading (e.g., connectionist models) can be extended to spelling–learning to spell also essentially involves modifying weights on the connections between orthographic units and phonological units in the words to which a child has been exposed (Treiman, 1993). In the present study, we examined this hypothesis with beginning spellers–kindergartners at the end of the school year—to investigate the relation of vocabulary knowledge with spelling after accounting for code-related skills such as phonological awareness and alphabet knowledge fluency.

Present study

In summary, the overall goal of the present study was to examine the shared and unique relations of letter writing automaticity, vocabulary knowledge, phonological awareness, and alphabet knowledge fluency, to word reading and spelling skills at the end of kindergarten. The specific research questions that guided the present study were as follows:

1. Is letter writing automaticity a dissociable construct from alphabet knowledge fluency?
2. If letter writing automaticity is a dissociable construct from alphabet knowledge fluency, are letter writing automaticity and vocabulary knowledge uniquely related to word reading and spelling after accounting for phonological awareness and alphabet knowledge fluency?

These research questions were addressed using a latent variable approach such as confirmatory factory analysis and structural equation modeling as an analytical strategy. By using multiple indicators to create latent variables, structural equation modeling reduces the effects of measurement error and method variance, and thus, can generally capture the nature of relationships with more precision.

Methods

Sample and sites

The present study was part of a larger study investigating the efficacy of core reading instruction within a response to instruction (RTI) framework (for a detailed description, see Al Otaiba et al., 2011). Although the larger study included 14 schools, 44 teachers, and 556 students, due to limited resources, we recruited roughly half of these teachers (i.e., 21 teachers) and students (i.e., 242 students) to participate in spelling assessments for the present study.[1] Within the participating schools, kindergarten programs were full-day and had an academic focus. Children were provided a minimum uninterrupted block of 90 min of instructional time for

[1] When children's treatment status was included as control variable, the results were essentially the same as those reported in the present article. Thus, for parsimony, the model without treatment status as a control variable is presented in the present article.

reading and language arts. All schools utilized the same core reading program (*Open Court,* Bereiter et al., 2002), which is an explicit and systematic curriculum that emphasizes teaching of phonological awareness and phonics as well as vocabulary and comprehension.

Within the 21 classrooms, there were a total of 242 students. Students' mean age at the time of spring testing was 5.83 ($SD = .61$). Slightly more than half of the sample was male (56.20 %). It was an ethnically diverse sample; a majority were African American (64.05 %), about one-third were Caucasian (33.06 %), <2 % were Hispanic and a similar percentage were Asian or Multi-racial. The percentage of the students who were identified as Limited English Proficient (LEP) was notably small, and ranged from <1 to 5 %.

Measures

Word reading

Children's performance on five measures, the Letter Word Identification and Word Attack subtests of the *Woodcock Johnson-third edition* (WJ-III, Woodcock, McGrew, & Mather, 2001), the Sight Word Efficiency and Phoneme Decoding Efficiency subtests of the *Test of Word Reading Efficiency* (TOWRE; Torgesen, Wagner, & Rashotte, 1999), and the Word Identification Fluency task (Fuchs, Fuchs, & Compton, 2004) served as indicators of word reading skills. The Letter Word Identification test consists of 76 increasingly difficult items beginning with identifying letters and then words. Testing is discontinued after six consecutive incorrect items. The Word Attack test consists of 32 items, requiring children to decode nonwords. Reliability estimates were reported to be .91 and .87 for the Letter Word Identification and Word Attack, respectively, for kindergartners (Woodcock et al., 2001). The TOWRE requires students to read as many words on two lists, a sight word list and a phonetic decoding list, as they can in 45 s per list. Test-rest reliability estimates were reported to be >.90 (Torgesen et al., 1999). Because the TOWRE had relatively few simple sight words, students' ability to read first grade sight words was also assessed by the Word Identification Fluency task (Fuchs et al., 2004). In this task, the student is presented with an array of 50 first grade sight words that were selected randomly from the Dolch word list of 100 frequent words and an educator's guide of 500 frequently used words in reading (Zeno, Ivens, Millard, & Duvvuri, 1995). Alternate form reliability from 2 consecutive weeks was reported to be .97 (Fuchs et al., 2004).

Spelling

Children's performance on spelling decodable real words, sight words, nonwords served as three indicators of a spelling latent construct using an untimed spelling task (Byrne & Fielding-Barnsley, 1993). The task includes 5 real decodable words (dog, man, plug, limp, tree), 5 sight words (one, said, blue, come, went) and 4 nonsense words (ig, sut, frot, yilt). Research assistants introduced the spelling task by pointing to the answer sheet and saying *I would like you to spell some words.*

Some are real and some are made-up words. If you don't know how to spell a word, sound it out and do your best. First I am going to say the word, then I will use it in a sentence, and then I will say the word more time. Ready, begin. Remember to write the word next to the correct number on your answer sheet. Then the research assistant read each word, read the sentence with the word, and then repeated the spelling word (e.g., *dog*. I *took my dog to the park dog*). The nonsense words were repeated three times (e.g., *Next word is ig, ig, ig*.). Cronbach's α for this sample was .86 for the decodable words, 84 for the sight words, and .83 for the pseudo-words.

The spelling rubric, adapted from Tangel and Blachman (1992) provided a developmental score, which ranged from 0 to 6 (highest). A 0 indicated a random string of letters or no response; (1) was a single phonetically related letter (e.g., for *dog* student wrote an *o* or a *g*); (2) was a correct first letter followed by other unrelated letters (e.g., *dib* or *d* followed by random letters and *g*); (3) was more than one phoneme that was phonetically correct (e.g., *do* for *dog*); (4) was all letters represented and phonetically correct (e.g., *dawg*); (5) was all letters represented and phonetically correct *and* the student made an attempt to mark a long vowel (e.g., for the word *blue* if the student wrote *blew* or *bloo*; (6) was the word was spelled correctly (e.g., *dog*). The research assistants were trained to use the rubric with a small subset of children. Once they reached 100 % agreement, each individually scored 15 % of the entire data set. The inter-rater agreement was 94.75 % and Cohen's κ was .92.

Vocabulary knowledge

Children's vocabulary knowledge was assessed by expressive and receptive tasks. The former was assessed by the Picture Vocabulary subtest of the WJ-III (Woodcock et al., 2001) and the Vocabulary subtest of the *Kaufman brief IQ test* (KBIT; Kaufman & Kaufman, 2004). In the Picture Vocabulary task, children were asked to identify pictured objects. Median reliability was estimated to be .77 (Woodcock et al., 2001). In the KBIT Vocabulary subtest, children were asked to point to a picture among several that represented the best answer to the examiner's prompt. The internal consistency was reported to be .89 and test–retest reliability to be .85 (Kaufman & Kaufman, 2004).

Phonological awareness

Children's performance on two measures, the Blending Words and Elision subtests of the *comprehensive test of phonological processing* (CTOPP; Wagner, Torgesen, & Rashotte, 1999), served as two indicators of phonological awareness. The Blending test requires children to blend separately presented sounds to form real words and the Elision test requires children to say a word after deleting a sound. Cronbach's αs were estimated to be .88 and .90 for the Blending Words and Elision subtests, respectively (Wagner et al., 1999).

Alphabet knowledge fluency

Children's performance on two measures, the letter name fluency (LNF) subtest of the *dynamic indicators of basic early literacy skills* (DIBELS; Kaminski & Good, 1996) and AIMSweb letter sound fluency (LSF; Shinn & Shinn, 2002) served as indicators of alphabet knowledge fluency. The LNF task consists of the 26 upper- and lower-case letters randomly arranged in 11 rows of 10 letters. The children were asked to name each letter and the number of correctly identified letters in a minute was calculated. Kaminski and Good reported .93 for alternate-forms reliability. In the letter sound fluency task, letters are arranged in random order and students are asked to produce letter sounds for 1 min. Reliability coefficients have been reported to range .80–.90 for alternate-forms reliability and test–retest in kindergarten and first grade (Elliott, Lee, & Tollefson, 2001; Fuchs & Fuchs, 2004; Speece & Case, 2001).

Letter writing automaticity

Children's handwriting automaticity was measured by asking children's writing alphabet letters as fast and accurately within a minute. This is similar to similar to previous studies with first graders (Jones & Christensen, 1999) and first and fourth grade students (Wagner et al., 2011) although a 15 s time limit has been also used (e.g., Berninger et al., 1992; Berninger & Rutberg, 1992; Graham et al., 1997). Research assistants asked children to write all the letters in the alphabet in order, using lower case letters. The directions were: *We're going to play a game to show me how well and quickly you can write your abc's. First, you will write the lowercase of small abc's as fast and carefully as you can. Don't try to erase any of your mistakes, just cross them out and go on. When I say "ready begin", you will write the letters. Keep writing until I say stop. Ready, begin*. After 1 min, tell the students: "*Stop and put down your pencils*". Children received a score for the number of correctly written letters. The possible range of scores was 0–26; with one point awarded for each correctly formed and sequenced letter. Given that children were in kindergarten, we allowed a .5 for each poorly formed letter that could only be recognized in context or was reversed. The following responses were scored as incorrect and earned a score of zero: (a) letters written in cursive; (b) letters written out of order; or (c) uppercase letters.

Procedures

All the assessments with an exception of spelling were individually administered by trained research assistants. Spelling assessment was group-administered with three to four children per group.

Results

Descriptive and correlational analysis

Descriptive statistics (i.e., means, standard deviations, minimum and maximum scores) are presented in Table 1. Standard scores are also reported when available.

Table 1 Descriptive statistics ($N = 242$)

	M (*SD*)	Min–max
Word reading		
Letter word identification—raw score	22.44 (7.60)	4–47
Letter word identification—standard	104.93 (14.72)	61–142
Word attack—raw score	6.40 (4.26)	0–25
Word attack—standard	108.36 (13.39)	55–136
Sight word efficiency—raw score	15.87 (12.91)	0–66
Sight word efficiency—standard	98.49 (11.61)	65–140
Phonemic decoding efficiency—raw	6.40 (6.42)	0–33
Phonemic decoding efficiency—standard	101.75 (9.77)	75–130
Word identification fluency task	17.81 (19.21)	0–94
Spelling		
Decodable words	17.98 (8.41)	0–30
Sight words	16.83 (7.70)	0–30
Nonwords	13.15 (7.23)	0–24
Semantic process		
WJ-III picture vocabulary—raw score	17.85 (2.67)	9–26
WJ-III picture vocabulary—standard	99.86 (9.09)	67–126
KBIT vocabulary—raw score	14.21 (4.84)	3–29
KBIT vocabulary—standard	92.29 (14.85)	50–133
Phonological awareness		
Elision—raw score	5.73 (4.02)	0–19
Elision—standard	9.03 (2.60)	3–19
Blending—raw score	10.14 (4.10)	0–19
Blending—standard	10.43 (2.39)	4–19
Alphabet knowledge fluency		
Letter name fluency	49.70 (20.35)	0–133
Letter sound fluency	38.56 (16.95)	0–83
Letter writing fluency	10.06 (6.19)	0–26

Standard standard score, unless otherwise mentioned, the values are in raw scores

Children in the sample were in the average range in the various measures of word reading skills, the mean standard scores ranging from 98.49 to 108.93. As expected at the end of kindergarten and as shown in the minimum scores, some children were not word readers yet. There was substantial variation in all the three spelling subtests ($7.23 \leq SDs \leq 8.41$). Children's semantic knowledge was also in the average range with a mean WJ-III Picture Vocabulary standard score of 99.86 and KBIT Vocabulary standard score of 92.29. Children's performance on the phonological awareness tasks were in the average range compared to the national norms. Finally, children in the sample were able to tell, on average, 50 letter names, and 39 letter sounds correctly per minute. Children were able to write approximately 10 letters accurately, on average, per minute.

Correlations between pairs of observed variables are shown in Table 2. Word reading measures and spelling measures were moderately to fairly strongly related ($.48 \leq rs \leq .67$). Phonological awareness measures and alphabet knowledge fluency tasks tended to be moderately to fairly strongly related to word reading and spelling ($.42 \leq rs \leq .65$). Vocabulary measures were somewhat weakly related to word reading and spelling measures ($.29 \leq rs \leq .41$). Letter writing automaticity was somewhat weakly related to word reading ($.30 \leq rs \leq .35$) and moderately related to spelling measures ($.39 \leq rs \leq .46$).

MPLUS 5.1 (Muthén & Muthén, 2006) was used for confirmatory factor analysis and structural equation modeling. Preliminary analysis showed that all the measurement models were adequate. Model fits were evaluated by multiple indices including χ^2, comparative fit index (CFI), Tucker–Lewis index (TLI), root mean square error of approximation (RMSEA), and standardized root mean square residuals (SRMR). Generally, RMSEA values below .085, CFI and TLI values >.95, and SRMR below .05 indicate a good model fit (Kline, 2005; Hu & Bentler, 1999). Alternative models were compared using a χ^2 difference test between nested models (Kline, 2005; Schumacker & Lomax, 2004).

Research question 1: is letter writing automaticity a dissociable construct from alphabet knowledge fluency?

Confirmatory factory analysis was conducted to examine whether letter writing automaticity is better conceptualized as an indicator of the latent variable, alphabet knowledge fluency. The model fit in which letter writing was considered as an indicator of alphabet knowledge fluency was good: $\chi^2(79) = 175.46$, $p < .001$; CFI = .97; TLI = .96; RMSEA = .07 (confidence interval = .06–.09); and SRMR = .037. The alternative model in which letter writing was considered as a separate variable was also good: $\chi^2(75) = 160.27$, $p < .001$; CFI = .97; TLI = .96; RMSEA = .07 (confidence interval = .05–.08); and SRMR = .032. The χ^2 difference of 15.19 with a degree of freedom (4) was statistically significant ($p = .004$), suggesting that letter writing automaticity is better described as a related, but dissociable variable from alphabet knowledge fluency latent variable.

Correlations among latent variables and letter writing automaticity (observed variable) are presented in Table 3. Word reading and spelling were moderately related to vocabulary knowledge ($rs = .42$ and .49, respectively), fairly strongly to phonological awareness ($rs = .72$ and .68, respectively) and alphabet knowledge fluency ($rs = .65$ and .66, respectively), and moderately to letter writing automaticity ($rs = .37$ and .48, respectively).

Research question 2: the relations of letter writing automaticity and vocabulary knowledge to word reading and spelling

To investigate the unique relations of letter writing automaticity and vocabulary knowledge to word reading and spelling, structural equation modeling was used. Standardized coefficients are presented in Fig. 1. The model fit was excellent: $\chi^2(75) = 160.27$, $p < .001$; CFI = .97; TLI = .96; RMSEA = .07; SRMR = .03.

Table 2 Correlations between observed variables

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Letter–word identification	–													
2. Word attack	.78	–												
3. Sight word efficiency	.86	.79	–											
4. Phonemic decoding efficiency	.76	.79	.86	–										
5. Word identification fluency	.82	.74	.93	.81	–									
6. Spelling: decodable words	.67	.61	.64	.59	.58	–								
7. Spelling: real words	.65	.57	.65	.54	.59	.84	–							
8. Spelling: nonwords	.60	.56	.57	.53	.48	.79	.77	–						
9. WJ-III picture vocabulary	.41	.30	.41	.41	.36	.35	.31	.32	–					
10. KBIT vocabulary	.33	.30	.33	.29	.30	.35	.32	.37	.56	–				
11. CTOPP blending	.58	.57	.56	.58	.50	.63	.57	.57	.32	.63	–			
12. CTOPP Elision	.58	.65	.59	.64	.54	.54	.47	.54	.47	.42	.63	–		
13. Letter naming fluency	.46	.46	.53	.50	.47	.44	.42	.39	.26	.17	.40	.39	–	
14. Letter sound fluency	.55	.54	.57	.56	.51	.60	.58	.55	.27	.18	.49	.48	.71	–
15. Letter writing automaticity	.32	.35	.33	.35	.30	.46	.43	.39	.16	.16	.41	.37	.36	.50

All coefficients are statistically significant at .05 level

The model explained approximately .61 and .58 of the total variance in word reading and spelling, respectively. As expected, phonological awareness and alphabet knowledge fluency were both uniquely related to word reading and spelling (*ps* $\leq$ .002) after accounting for each other, vocabulary knowledge, and letter writing automaticity. Vocabulary knowledge was also uniquely and positively related to word reading ($\beta = .16$, $p = .04$) and spelling ($\beta = .17$, $p = .05$) once phonological awareness, alphabet knowledge fluency, and letter writing automaticity were taken into consideration. Letter writing automaticity was not related to word reading ($\beta = -.07$, $p = .28$), but marginally related to spelling ($\beta = .11$, $p = .06$).

Discussion

Although critical roles of phonological awareness and alphabet knowledge skills in word reading and spelling are well-established in the literature, less is known about independent contributions of vocabulary and letter writing automaticity to word reading and spelling, over and above phonological awareness and alphabet

Table 3 Correlations among latent variables: vocabulary, phonological awareness, alphabet knowledge fluency, letter writing automaticity, word reading, and spelling

	Vocabulary	Phonological awareness	Alphabet knowledge fluency	Letter writing automaticity	Word reading
Phonological awareness	.58	–			
Alphabet knowledge fluency	.34	.63	–		
Letter writing automaticity	.21	.48	.53	–	
Word reading	.42	.72	.65	.37	–
Spelling	.49	.68	.66	.48	.74

All the coefficients are statistically significant at .01 level

knowledge. Thus, the present study addressed two main questions using data from beginning readers and spellers in kindergarten in English: (1) the nature of relation between letter writing automaticity, and letter naming and sound fluency tasks; (2) the unique contribution of letter writing automaticity and vocabulary knowledge to word reading and spelling.

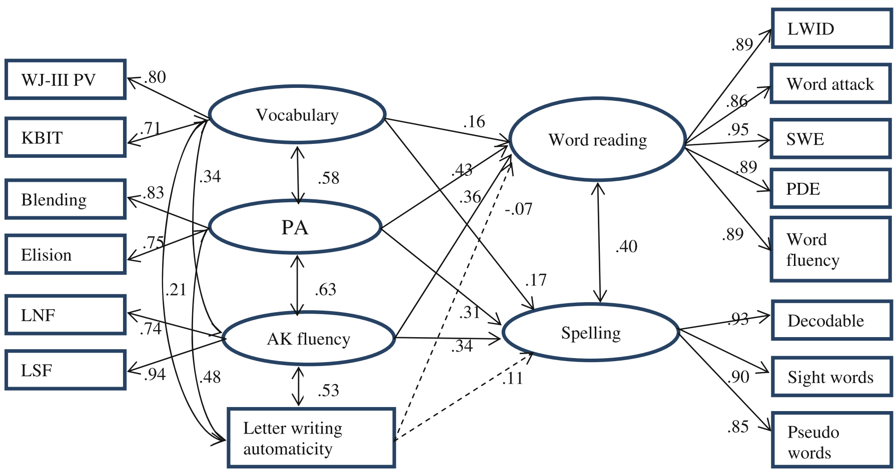

Fig. 1 Standardized structural regression weights for semantic knowledge, phonological awareness, alphabet knowledge fluency (AK fluency), letter writing automaticity, word reading, and spelling ($N = 242$). *Solid lines* represent statistically significant relations whereas *dashed lines* represent statistically nonsignificant relations. *WJ-III* Woodcock Johnson picture vocabulary, *KBIT* vocabulary subtest of the Kaufman brief IQ test, *Blending* comprehensive test of phonological processing (CTOPP) blending task, *Elision* CTOPP Elision task, *LNF* dynamic indicators of basic early literacy skills (DIBELS) letter-naming fluency task, *LSF* AIMSweb letter sound fluency task, *LWID* Woodcock Johnson-III letter word identification, *SWE* sight word efficiency, *PDE* phonemic decoding efficiency, *Word ID fluency* word identification fluency task, *Decodable* decodable real words, *Sight* sight words

Findings revealed that letter writing automaticity is moderately related to alphabet knowledge fluency composed of letter naming and sound fluency tasks ($r = .53$), but that it is a separate construct from alphabetic knowledge fluency, at least during the beginning phrase of literacy development. These results suggest that while both alphabet knowledge fluency and letter writing automaticity involve alphabet knowledge, there appears to be some unique aspects of the letter writing automaticity task. As theorized in the literature, the letter writing automaticity task is purported to measure children's ability to access, retrieve, and write letter forms (Berninger et al., 1996; Graham et al., 1997; Graham & Harris, 2000). While the accessing aspect might be largely shared among the letter writing automaticity task and alphabet knowledge fluency tasks (e.g., letter naming and sound tasks), the retrieval process is somewhat different from letter naming and sound tasks. In the latter tasks children are to recognize letters and retrieve their names and sounds whereas in the letter writing task, children have to retrieve shapes and order of alphabet letters and to produce the letters. Thus, this motoric aspect of writing letters is unique to the letter writing automaticity task (Berninger et al., 1992).

When examined in relation to word reading and spelling, letter writing automaticity was more strongly related to spelling ($r = .48$) than to word reading ($r = .37$). This is also confirmed in the structural equation modeling in which letter writing automaticity was not uniquely related to word reading ($p = .28$), but was marginally related to spelling ($p = .06$), even after accounting for a comprehensive set of predictors in the model. The trend for spelling, but not for word reading, may not be surprising, given that spelling and letter writing automaticity are production tasks whereas word reading is a recognition task. Although the relation is relatively weak ($\beta = .11$) and barely missed the conventional significance level, these results suggest that letter writing fluency merits attention as a predictor of spelling skill, and may have to be considered in early literacy assessment. Children whose letter writing is efficient and automatized may attend to integration of multiple processes in spelling (e.g., see Apel, Masterson, & Hart, 2004 for contribution of multiple skills to spelling), whereas those who lack automaticity may have to switch attention and juggle with multiple processes such as letter production, figuring out sounds represented in the words, and representing letter-sound correspondences and orthographic units. Thus, in addition to phonological awareness, alphabet knowledge fluency, and vocabulary knowledge, individual differences in how many alphabet letters children can accurately write within a specified time may help us predict their spelling performance.

The present study also revealed that children's semantic knowledge (i.e., vocabulary) was uniquely associated with word reading and spelling after accounting for phonological awareness, alphabet knowledge fluency, and letter writing automaticity. These results add to the growing evidence that children's semantic knowledge is positively associated with early literacy acquisition, word reading in particular (Nation & Snowling, 2004; Outllette, 2006; Ricketts et al., 2007). Although kindergarten is typically considered an early phase of literacy acquisition even for the lexical level skills such as word reading and spelling and connectionist models hypothesize the semantic pathway (i.e., connection between orthography and phonology via semantics) in the later phrase (Harm & Seidenberg, 2004), the findings of the present study suggest that children at the end of kindergarten might utilize semantic pathway in their word reading and spelling. Word reading or spelling is considered a relatively "modular" or decontextualized component of reading compared to connected text reading (Share & Leiken, 2003). However, words in the context-free format still do contain a semantic aspect and therefore, children's knowledge of word's meaning appear to facilitate word reading and spelling over and above phonological awareness, alphabet knowledge fluency, and letter writing automaticity. The result for spelling is somewhat divergent from a previous study in which vocabulary was not related to children's invented spelling once phonological awareness was taken into consideration for kindergartners (Ouellette & Sénéchal, 2008). The differences may be due to different measures and/or analytical strategies; multiple regression was used in Ouellette and Senechal's (2008) study whereas structural equation modeling in which measurement error is reduced was used in the present study. Overall, the unique role of vocabulary to word reading and spelling suggests a need for attending to oral language skills such as vocabulary in early literacy instruction in addition to code-related skills such as phonological awareness and alphabet knowledge (e.g., NELP, 2009). Future investigations are necessary to further clarify a potential, unique role of vocabulary knowledge in spelling development and to concurrently explore the roles of other linguistic skills including syntactic and morphological awareness.

The present study included only measures of vocabulary *breadth*, but not depth. Some previous studies suggested that various aspects of semantic knowledge may be differentially related with various literacy skills (Ouellette, 2006). Specifically, depth and breadth of vocabulary, although highly correlated, may have differential relations with various aspect of word reading (i.e., word decoding vs. sight word reading) (Ouellette, 2006). Furthermore, it has been suggested that another aspect of semantic knowledge such as morphological awareness may contribute to children's spelling even at an early developmental phase. For example, kindergartners' spelling reflected that kindergartners use morphological knowledge in their spelling (Bourassa et al., 2006; Treiman & Cassar, 1996; Treiman, Cassar, & Zukowski, 1994). However, the relation between morphological awareness and early spelling tended to be limited particularly when other code-related skills were considered (Kuo & Anderson, 2006; McBride-Chang et al., 2005) in contrast to a more robust unique role of morphological awareness in spelling over and above phonological decoding for older children (Nagy, Berninger, & Abbott, 2006). Given these previous results, a future study should further investigate a potential unique contribution of various aspects of semantic knowledge including vocabulary breadth and depth, and morphological awareness to spelling, particularly with a longitudinal design in order to clarify the nature of a developmental relation between semantic knowledge and spelling.

Conclusion

Overall, the present study confirmed that phonological awareness and alphabet knowledge are foundational skills for early literacy acquisition. Importantly, however, the results of the present study preliminarily indicate that children might benefit from more attention to achieving lettering writing automaticity and vocabulary even for lexical level literacy skills such as word reading and spelling, not just for reading comprehension. After all, children read and write for meaning even in the very early stage of literacy development. These suggest that in addition to code-related instruction such as phonological awareness and letter-sound correspondences, early literacy instruction should attend to vocabulary.

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