The Relationship Between Vocabulary Knowledge and Reading Comprehension in Elementary School Children: A Cross-Lagged Study

Authors: Chen Hongjun, Zhao Ying, Wu Xinchun, Sun Peng, Xie Ruibo, Feng Jie, Wu Xinchun

Date: 2019-05-13T00:00:00+00:00

Abstract

A longitudinal study was conducted on 399 students in Grades 1, 3, and 5 of elementary school over a period of one year, using a cross-lagged model to examine the relationship between vocabulary knowledge and reading comprehension among children in lower, middle, and upper elementary grades. After controlling for phonological awareness, morphological awareness, general cognitive ability, and autoregressive effects, the results revealed: in the lower elementary grades, no significant longitudinal predictive relationship was found between vocabulary knowledge and reading comprehension; in the middle grades, there existed a significant bidirectional predictive relationship between vocabulary knowledge and reading comprehension; in the upper grades, T1 reading comprehension could significantly predict T2 vocabulary knowledge, whereas the predictive effect of T1 vocabulary knowledge on T2 reading comprehension was not significant. The findings indicate that the relationship between vocabulary knowledge and reading comprehension exhibits different patterns across different grade levels in elementary school, which supports the developmental stage theory of reading and provides some supplementation to the triangular theory of reading.

Full Text

The Relationship Between Vocabulary Knowledge and Reading Comprehension in Elementary School Children: A Cross-Lagged Study

Chen Hongjun, Zhao Ying, Wu Xinchun, Sun Peng, Xie Ruibo, Feng Jie

Research Center of Children' s Reading and Learning, Beijing Key Laboratory

of Applied Experimental Psychology, School of Psychology, Beijing Normal University, Beijing 100875, China

Abstract

This study tracked 399 students from first, third, and fifth grades over a one-year period to examine the longitudinal relationship between vocabulary knowledge and reading comprehension across low, middle, and high elementary grades using cross-lagged models. After controlling for phonological awareness, morphological awareness, general cognitive ability, and autoregressive effects, the results revealed distinct developmental patterns: no significant longitudinal predictive relationship between vocabulary knowledge and reading comprehension in the lower grades; a significant bidirectional predictive relationship in the middle grades; and in the upper grades, only Time 1 reading comprehension significantly predicted Time 2 vocabulary knowledge, while Time 1 vocabulary knowledge did not significantly predict Time 2 reading comprehension. These findings support reading stage theory and provide supplementary evidence for the reading triangle model.

Keywords: elementary school children; vocabulary knowledge; reading comprehension; cross-lagged model; longitudinal study

1 Research Questions

The elementary school period represents a critical developmental window, particularly for the growth of reading abilities. On December 27, 2016, China' s State Administration of Press, Publication, Radio, Film and Television issued the *National Reading Development Plan for the 13th Five-Year Plan Period*, emphasizing the need to strengthen research on and application of principles governing children' s reading development. Comprehension constitutes the ultimate goal and core challenge of reading. Reading comprehension involves constructing meaning from text based on existing knowledge and experience (Kintsch, 1998; Van den Broek, 2010). As a fundamental competency in individual development, reading comprehension has long been a focal point for researchers worldwide. Vocabulary knowledge refers to the understanding of word meanings employed when comprehending others' speech, expressing one' s own ideas, and interpreting written texts (Moats, 2005). Children' s vocabulary knowledge expands rapidly during elementary school, with each child acquiring thousands of new words annually (Nagy & Anderson, 1984). The Lexical Quality Hypothesis (Perfetti, 2007) posits that the quality of vocabulary knowledge determines the quality of reading comprehension. Given limited cognitive resources, readers who are familiar with words in a text can process them quickly and extract their meanings efficiently, freeing up resources for higher-level activities that facilitate comprehension. Consistent with this theory, previous research has documented strong correlations between vocabulary knowledge and reading comprehension (Cunningham & Stanovich, 1997; Koda, 1989; Tannenbaum, Torgesen, & Wagner, 2006).

To investigate the impact of vocabulary knowledge on reading comprehension, Seigneuric and Ehrlich (2005) conducted a three-year longitudinal study of 56 French first-graders, finding that Time 1 vocabulary knowledge did not significantly predict Time 2 reading comprehension but did predict Time 3 reading comprehension, while Time 2 vocabulary knowledge predicted Time 3 reading comprehension. Zhang et al. (2012) tracked 164 Hong Kong children aged 7-8 for one year and similarly found that Time 1 vocabulary knowledge did not significantly predict Time 2 reading comprehension. Storch and Whitehurst (2002) examined 626 American children from preschool through fourth grade, with structural equation modeling revealing that lower-grade reading comprehension was determined by foundational skills such as phonological awareness, whereas middle-grade comprehension was primarily determined by concurrent vocabulary knowledge. Shu et al. (2006) assessed 152 fifth- and sixth-grade children in Beijing, finding that vocabulary knowledge significantly predicted reading comprehension alongside morphological awareness, rapid naming, and phonological awareness. Song and colleagues (2015) conducted an eight-year longitudinal study of 264 Chinese children (ages 4-11), demonstrating that both vocabulary knowledge and its growth rate from ages 4-10 significantly predicted reading comprehension at age 11. These inconsistent findings across grade levels warrant further systematic investigation of the longitudinal relationship between vocabulary knowledge and reading comprehension in different elementary grade spans.

The Reading Triangle Theory (Perfetti, 2010) proposes that vocabulary knowledge and reading comprehension influence each other reciprocally: robust vocabulary knowledge facilitates comprehension, while reading comprehension enhances vocabulary learning. Research indicates that only about 10% of vocabulary is acquired through formal instruction during elementary school (Penno, Wilkinson, & Moore, 2002). Incidental learning during reading constitutes the primary source of vocabulary growth (Nagy, Herman, & Anderson, 1985; Wasik, Hindman, & Snell, 2016) and explains the rapid expansion of children' s vocabulary knowledge (Ku & Anderson, 2001). Cain, Oakhill, and Lemmon (2004) found that 9- to 10-year-old children can infer word meanings from context. Conversely, poor reading comprehension impedes vocabulary development (Cunningham & Stanovich, 1991; Nagy & Anderson, 1984; Nagy et al., 2000). Thus, beyond vocabulary influencing comprehension, comprehension may also affect vocabulary acquisition. However, most previous research has focused on vocabulary' s impact on comprehension while neglecting the reverse relationship.

Verhoeven and Van Leeuwe (2008) conducted a six-year longitudinal study of 2,143 Dutch children (grades 1-6) using cross-lagged models, revealing reciprocal effects: Time 1 vocabulary predicted Time 2 comprehension, Time 2 comprehension predicted Time 3 vocabulary, and this pattern continued through grade 6. Sparapani et al. (2018) assessed vocabulary knowledge and reading comprehension in 468 American children during the first and second semesters of first grade, finding longitudinal bidirectional predictions. In contrast, Quinn, Wagner, Petscher, and Lopez (2015) tracked 316 American

first-graders through fourth grade using latent growth modeling, finding that vocabulary knowledge predicted reading comprehension but not vice versa. However, Quinn et al. (2015) and Sparapani et al. (2018) controlled no variables affecting vocabulary and comprehension, while Verhoeven and Van Leeuwe (2008) overlooked phonological awareness and did not examine whether the relationship differed across grades. Numerous studies have demonstrated that phonological awareness, morphological awareness, and general cognitive ability significantly influence both vocabulary knowledge and reading comprehension (Henry & Maclean, 2003; McBride-Chang et al., 2005; Li, Rao, Dong, Zhu, & Wu, 2011; Zhao, Cheng, Wu, & Ruan, 2016). Therefore, this study controlled for phonological awareness, morphological awareness, and general cognitive ability to conduct a more rigorous examination. By tracking first-, third-, and fifth-grade children' s vocabulary knowledge and reading comprehension over one year and employing cross-lagged models, we investigated the bidirectional relationship between these constructs across different grade spans and tested the Reading Triangle Theory.

According to reading stage theory, lower elementary grades (grades 1-2) represent the "learning to read" stage, where children master basic word recognition and reading skills. Middle grades (grades 3-4) transition toward "reading to learn" (Chall, 1983), and upper grades (grades 5-6) use reading as the primary means of acquiring new knowledge (Chall, 1996). Additionally, vocabulary becomes increasingly abstract as children progress through school (Minskoff, 2005). Lower-grade vocabulary primarily concerns concrete, experience-based words; middle-grade children must understand all written words corresponding to oral vocabulary (Graves, Juel, Graves, & Dewitz, 2011); and upper-grade children encounter more abstract vocabulary from textbooks and classroom discussions (Minskoff, 2005). Consequently, the relationship between vocabulary knowledge and reading comprehension likely differs across grade levels. In lower grades, both constructs are more strongly influenced by foundational reading skills such as phonological and morphological awareness (Storch & Whitehurst, 2002). In middle grades, comprehension becomes influenced by vocabulary knowledge (Storch & Whitehurst, 2002), and children begin inferring word meanings from text. In upper grades, reading becomes the main source of vocabulary knowledge (Nagy, Anderson, & Herman, 1987).

Previous research indicates that lower-grade reading comprehension is primarily determined by foundational skills like phonological awareness (Storch & Whitehurst, 2002), while vocabulary knowledge derives mainly from oral language experience. In middle grades, comprehension is influenced by vocabulary knowledge (Storch & Whitehurst, 2002), and children can infer meanings of unfamiliar words through text understanding (Cain, Oakhill & Lemmon, 2004), suggesting a potential bidirectional relationship. A meta-analysis found that direct vocabulary interventions had near-zero effects on reading comprehension for upper-grade children (Wright & Cervetti, 2017), suggesting that comprehension may primarily influence vocabulary at this stage. Based on these theories and findings, we hypothesized that after controlling for foundational abilities

like phonological and morphological awareness, lower-grade children would show no significant longitudinal predictions between vocabulary knowledge and reading comprehension, middle-grade children would exhibit significant bidirectional predictions, and upper-grade children would show a predominant influence of reading comprehension on vocabulary knowledge rather than vice versa.

2.1 Participants

The study involved 399 students from first, third, and fifth grades in two ordinary primary schools in Shanxi Province, including 198 boys and 201 girls. Time 1 (T1) testing occurred during the fall semester of grades 1, 3, and 5, while Time 2 (T2) testing took place during the fall semester of grades 2, 4, and 6 one year later. A total of 436 children participated in the initial testing; due to school transfers and other reasons, 22, 13, and 2 participants were lost from the lower, middle, and upper grade cohorts respectively by T2, yielding an overall attrition rate of 8.49%. Chi-square tests and ANOVAs (controlling for grade) comparing children who remained versus those who dropped out revealed no significant differences in gender ($^2 = 2.13$, $p = 0.14$), age in months [$F(1, 433) = 1.49$, $p = 0.22$], general cognitive ability [$F(1, 427) = 0.22$, $p = 0.64$], or T1 scores on vocabulary knowledge [$F(1, 433) = 1.02$, $p = 0.31$], reading comprehension [$F(1, 433) = 0.28$, $p = 0.45$], phonological awareness [$F(1, 433) = 0.07$, $p = 0.80$], or morphological awareness [$F(1, 433) = 0.28$, $p = 0.59$], indicating random attrition. Participants who completed both assessments constituted the final sample, with demographic information presented in Table 1 .

2.2 Measures

2.2.1 Vocabulary Knowledge Test

Vocabulary knowledge was assessed using a vocabulary definition task. The examiner orally presented a two-character word and asked children to explain its meaning, recording their responses verbatim (Li, Dong, Zhu, Liu, & Wu, 2009). The test comprised 32 items arranged in order of difficulty, with administration discontinued after five consecutive incorrect or no responses. Two trained raters scored each response 0, 1, or 2 based on semantic appropriateness: 2 points for accurate, contextually appropriate, and coherent definitions; 1 point for partially accurate or imprecise but comprehensible definitions; and 0 points for completely incorrect definitions. The mean of the two raters' scores served as the item score, with a maximum total score of 64. Inter-rater reliability was 0.93 and 0.94 for T1 and T2 respectively, with internal consistency coefficients of 0.90 for both time points.

2.2.2 Reading Comprehension Test

Grade-appropriate reading comprehension tests were administered, with identical tests used at T1 and T2. For lower grades, a sentence comprehension task presented a written sentence with four pictures, requiring children to select the

picture matching the sentence content (Li et al., 2009). This task included two practice items and 20 test items, scored 1 point per correct answer, with a maximum score of 20. Internal consistency coefficients were 0.88 and 0.67 for T1 and T2 respectively.

Middle and upper grade tests were adapted from sample items of the international reading assessment PIRLS. Children read a written passage and answered comprehension questions. The middle-grade passage, "An Unbelievable Night," contained 12 items (5 open-ended) with a total score of 16. Internal consistency coefficients were 0.79 and 0.66 for T1 and T2 respectively. The upper-grade passage, "Finding Food," contained 15 items (7 open-ended) with a total score of 17. Internal consistency coefficients were 0.56 and 0.53 for T1 and T2 respectively. Multiple-choice items received 1 point for correct answers. Open-ended items were scored by two trained raters using reference answers, with scoring rubrics allowing 0-1, 0-2, or 0-3 points per item. Inter-rater reliability for open-ended items was 0.85 and 0.90 for middle grades, and 0.82 and 0.98 for upper grades at T1 and T2 respectively.

2.2.3 Phonological Awareness Test

Phonological awareness was assessed using a phoneme deletion task. The examiner orally presented a syllable, which children repeated and then responded to by stating the remaining syllable after deleting a specified phoneme (e.g., "/shen1/ without /sh/ is what? (en1)") (Li et al., 2009). Each correct answer received 1 point, with a maximum score of 12. The internal consistency coefficient was 0.86.

2.2.4 Morphological Awareness Test

Morphological awareness was measured using a compound word production task (Liu & McBride-Chang, 2010; Dong, 2013). The examiner orally presented sentences describing novel objects, and children created a new word that best represented the object. The test comprised 20 items arranged by difficulty, discontinued after five consecutive errors or no responses. Two raters scored responses 0-3 based on whether key morphemes were extracted and the accuracy and conciseness of word structure (e.g., for "What do you call a plate made of leaves?" , "leaf-plate" received 3 points, "leaf plate" or "leaf-plate-zi" received 2 points, "leaf plate-zi" received 1 point, and "plate-leaf" received 0 points). The mean of the two raters' scores served as the item score, with a maximum total of 60. Inter-rater reliability was 0.98, and internal consistency was 0.89.

2.2.5 General Cognitive Ability Test

General cognitive ability was assessed using Raven's Progressive Matrices, requiring children to select the missing portion of a figure through nonverbal reasoning (Raven, Court, & Raven, 1996; Zhang & Wang, 1989). The test contained 60

items, each scored 1 point, with a maximum of 60. Internal consistency was 0.94.

2.3 Procedure

Prior to initial testing, schools were contacted and teachers' consent obtained. Parental consent forms were sent home with students. Raven' s Progressive Matrices and reading comprehension tests were administered in group sessions, while remaining tests were administered individually. General cognitive ability, phonological awareness, morphological awareness, vocabulary knowledge, and reading comprehension were assessed during the fall semester of grades 1, 3, and 5. One year later, during the fall semester of grades 2, 4, and 6, vocabulary knowledge and reading comprehension were reassessed. The lower-grade reading comprehension test required approximately 20 minutes, while middle- and upper-grade tests required about 35 minutes, with nearly all students completing within the allotted time. Examiners were undergraduate or graduate students from Shanxi Normal University majoring in education or psychology who underwent rigorous training.

Data were analyzed using SPSS 21.0 for descriptive statistics and correlation analyses, and Mplus 7.0 for cross-lagged analyses. Data inspection revealed minimal missing data: 2 children (0.5%) missing general cognitive ability scores, 1 child (0.3%) missing T2 reading comprehension, and 1 child (0.3%) missing phonological awareness scores. Listwise deletion was used for ANOVAs and correlation analyses, while maximum likelihood estimation handled missing data in cross-lagged analyses (Little & Rubin, 2002).

3.1 Descriptive Statistics

Table 2 presents means, standard deviations, and repeated measures ANOVA results for vocabulary knowledge, reading comprehension, and control variables across grades and time points. All three grade cohorts showed significant improvements in vocabulary knowledge over time: lower grade $F(1, 126) = 135.09$, $p < 0.001$, $p^2 = 0.52$; middle grade $F(1, 128) = 143.82$, $p < 0.001$, $p^2 = 0.53$; upper grade $F(1, 142) = 49.57$, $p < 0.001$, $p^2 = 0.26$. Reading comprehension also improved significantly across all grades: lower grade $F(1, 126) = 266.03$, $p < 0.001$, $p^2 = 0.68$; middle grade $F(1, 128) = 94.13$, $p < 0.001$, $p^2 = 0.42$; upper grade $F(1, 142) = 45.71$, $p < 0.001$, $p^2 = 0.25$.

3.2 Correlation Analysis

Correlations among vocabulary knowledge, reading comprehension, and control variables at T1 and T2 were computed separately for each grade cohort, as shown in Tables 3 , 4 , and 5 . Across all grades, vocabulary knowledge and reading comprehension were significantly correlated within and across time points (ps < 0.05). Vocabulary knowledge also correlated significantly with morphological awareness and general cognitive ability (ps < 0.05). In lower and middle grades,

vocabulary knowledge and reading comprehension correlated significantly with phonological awareness (ps < 0.05), with correlation coefficients ranging from 0.18 to 0.68. In upper grades, T1 vocabulary knowledge correlated significantly with phonological awareness [r(141) = 0.18, p = 0.037], but T2 vocabulary knowledge did not [r(141) = 0.14, p = 0.089]. T1 reading comprehension did not correlate significantly with phonological awareness [r(141) = 0.11, p = 0.199], but T2 reading comprehension did [r(141) = 0.18, p = 0.035].

3.3 Cross-Lagged Analysis

Building on correlation analyses, cross-lagged models examined longitudinal relationships between vocabulary knowledge and reading comprehension. After controlling for phonological awareness, morphological awareness, and general cognitive ability, the theoretical model is depicted in Figure 1 [Figure 1: see original paper]. Models were tested separately for each grade cohort and were saturated (RMSEA = 0, SRMR = 0, CFI = 1, TLI = 1).

Lower grades. As shown in Figure 2 [Figure 2: see original paper], T1 vocabulary knowledge significantly predicted T2 vocabulary knowledge (= 0.51, p $<$ 0.001), and T1 reading comprehension significantly predicted T2 reading comprehension (= 0.30, p $<$ 0.001). Among control variables, T1 morphological awareness significantly predicted T2 vocabulary knowledge (= 0.25, p $<$ 0.001), whereas T1 phonological awareness (= -0.02, p = 0.73) and general cognitive ability (= 0.11, p = 0.12) did not. T1 phonological awareness (= 0.21, p = 0.008) and general cognitive ability (= 0.17, p = 0.04) significantly predicted T2 reading comprehension, but T1 morphological awareness did not (= 0.05, p = 0.58). After controlling for these variables and autoregressive effects, T1 vocabulary knowledge did not significantly predict T2 reading comprehension (= -0.02, p = 0.86), nor did T1 reading comprehension predict T2 vocabulary knowledge (= -0.003, p = 0.96).

Middle grades. As shown in Figure 3 [Figure 3: see original paper], T1 vocabulary knowledge significantly predicted T2 vocabulary knowledge (= 0.45, p $<$ 0.001), and T1 reading comprehension significantly predicted T2 reading comprehension (= 0.23, p = 0.002). Among control variables, T1 morphological awareness significantly predicted T2 vocabulary knowledge (= 0.16, p = 0.02), while T1 phonological awareness (= 0.08, p = 0.22) and general cognitive ability (= 0.03, p = 0.683) did not. T1 phonological awareness (= 0.19, p = 0.006) and general cognitive ability (= 0.28, p $<$ 0.001) significantly predicted T2 reading comprehension, but T1 morphological awareness did not (= 0.02, p = 0.74), mirroring the pattern observed in lower grades. After controlling for all variables and autoregressive effects, T1 vocabulary knowledge significantly predicted T2 reading comprehension (= 0.26, p = 0.001), and T1 reading comprehension significantly predicted T2 vocabulary knowledge (= 0.19, p = 0.014).

Upper grades. As shown in Figure 4 [Figure 4: see original paper], T1 vo-

cabulary knowledge significantly predicted T2 vocabulary knowledge (= 0.41, p < 0.001), and T1 reading comprehension significantly predicted T2 reading comprehension (= 0.28, p < 0.001). Among control variables, T1 morphological awareness significantly predicted T2 vocabulary knowledge (= 0.16, p = 0.03), whereas T1 phonological awareness (= 0.00, p = 0.99) and general cognitive ability (= 0.09, p = 0.25) did not. T1 general cognitive ability significantly predicted T2 reading comprehension (= 0.34, p < 0.001), but T1 phonological awareness (= 0.05, p = 0.47) and morphological awareness (= 0.10, p = 0.16) did not, showing both similarities and differences with lower and middle grades. After controlling for all variables and autoregressive effects, T1 vocabulary knowledge did not predict T2 reading comprehension (= 0.09, p = 0.21), whereas T1 reading comprehension significantly predicted T2 vocabulary knowledge (= 0.17, p = 0.033).

4.1 The Relationship Between Vocabulary Knowledge and Reading Comprehension in Elementary School Children

Using a cross-lagged design, this study examined longitudinal relationships between vocabulary knowledge and reading comprehension among Chinese elementary children across grade levels, with results largely consistent with our hypotheses. Vocabulary knowledge and reading comprehension improved significantly across the one-year interval in all three grade cohorts. Vocabulary knowledge showed larger gains in lower and middle grades, with smaller gains in upper grades. Reading comprehension gains decreased progressively across lower, middle, and upper grades. These patterns align with reading development stage theory (Chall, 1993), which posits that early reading development focuses on mastering basic skills. Consequently, vocabulary knowledge and reading comprehension develop rapidly in lower and middle grades, while the pace slows in upper grades as children become independent readers.

After controlling for phonological awareness, morphological awareness, general cognitive ability, and autoregressive effects, the longitudinal relationship between vocabulary knowledge and reading comprehension varied across grade spans: no significant longitudinal predictions in lower grades; significant bidirectional predictions in middle grades; and in upper grades, only reading comprehension predicted vocabulary knowledge. These findings support reading stage theory (Chall, 1983) and supplement the Reading Triangle Theory (Perfetti, 2010). Lower grades represent the "learning to read" stage, where basic cognitive and linguistic skills support vocabulary acquisition and text comprehension. Middle grades mark the transition to "reading to learn," where enriched vocabulary enables independent reading and text comprehension facilitates vocabulary growth. Upper grades represent full "reading to learn," where reading serves as the primary source of vocabulary knowledge (Nagy, Anderson, & Herman, 1987).

4.1.1 Lower Elementary Grades

Cross-lagged analyses revealed no significant predictive relationship between vocabulary knowledge and reading comprehension in lower grades, consistent with some previous research (Seigneuric & Ehrlich, 2005; Storch & Whitehurst, 2002; Zhang et al., 2012). According to reading stage theory, during the "learning to read" stage, children' s primary task involves mastering foundational reading skills that prepare them for vocabulary and comprehension development (Chall, 1983). First-grade phonological awareness and general cognitive ability significantly predicted second-grade reading comprehension, suggesting that phonological awareness is a more critical factor than vocabulary knowledge for lower-grade reading comprehension (Storch & Whitehurst, 2002). Although some studies have found that first-grade vocabulary predicts second-grade comprehension (Verhoeven & Van Leeuwe, 2008), those studies did not control for phonological awareness. Our correlation analyses showed significant associations between T1 vocabulary and T2 reading comprehension, but these became non-significant in cross-lagged analyses after controlling for phonological awareness and other variables. Early reading comprehension primarily involves understanding basic information and is therefore more strongly influenced by foundational skills like phonological awareness and general cognitive ability. Moreover, lower-grade reading comprehension is too basic to support learning from text (Chall, 1983) and thus cannot predict vocabulary growth. Morphological awareness significantly predicted T2 vocabulary knowledge, consistent with previous findings (Storch & Whitehurst, 2002; Zhao et al., 2016), as children with better morphological awareness can more skillfully manipulate morphemes and acquire word meanings more rapidly. In lower grades, while vocabulary knowledge and reading comprehension are correlated, foundational language and cognitive skills such as phonological awareness, morphological awareness, and general cognitive ability may be the primary drivers of both.

4.1.2 Middle Elementary Grades

Cross-lagged analyses revealed bidirectional predictions between vocabulary knowledge and reading comprehension in middle grades, consistent with previous research (Verhoeven & Van Leeuwe, 2008). By grades 3-4, reading instruction increasingly emphasizes comprehension abilities, marking the transition to "reading to learn" (Chall, 1983). Previous research has shown that vocabulary training for fourth-graders significantly improves reading ability (McKeown, Beck, Omanson, & Perfetti, 1983). At this stage, children possess sufficient vocabulary knowledge to facilitate text understanding. According to the Lexical Quality Hypothesis (Perfetti, 2007), rapid word processing frees cognitive resources for comprehension, enabling children with richer vocabulary knowledge to access word meanings more quickly and allocate more attention to integrating textual information, thereby developing better reading comprehension. Conversely, adequate text understanding helps children learn vocabulary by inferring meanings from context. Research demonstrates that

middle- and upper-grade children can learn new words through reading (Cain et al., 2004; Shu, Anderson, & Zhang, 1995). Children with higher reading comprehension can more accurately guess meanings of unfamiliar words from overall text understanding, thereby acquiring new vocabulary and promoting vocabulary knowledge development, whereas poor comprehension hinders this process (Cunningham & Stanovich, 1991; Nagy & Anderson, 1984; Nagy et al., 2000).

This study provides further evidence for the bidirectional relationship between vocabulary knowledge and reading comprehension in middle-grade Chinese children. While previous research has emphasized vocabulary' s impact on comprehension, our findings demonstrate that reading comprehension also importantly influences vocabulary knowledge. These results support the Reading Triangle Theory, showing that in middle grades, vocabulary knowledge is essential for comprehension, and text understanding helps children infer partial meanings of unfamiliar words, thereby enriching vocabulary knowledge.

4.1.3 Upper Elementary Grades

Cross-lagged analyses in upper grades revealed that T1 vocabulary knowledge did not significantly predict T2 reading comprehension, whereas T1 reading comprehension significantly predicted T2 vocabulary knowledge. In upper grades, beyond general cognitive ability significantly predicting T2 reading comprehension, no other control variables or vocabulary knowledge predicted T2 reading comprehension. According to reading stage theory, upper-grade children have become independent readers who use reading to acquire information as their primary learning pathway (Chall, 1996). At this stage, reading materials become more diverse and complex, and comprehension involves more sophisticated processes such as inference and critical evaluation. Compared to vocabulary knowledge, reading comprehension may be more strongly influenced by semantic analysis, grammatical knowledge, and other higher-level abilities (Storch & Whitehurst, 2002; Chen, Lau, & Yung, 1993). Vocabulary training studies have found that interventions do not improve reading comprehension for upper-grade children (Tuinman & Brady, 1974; Wright & Cervetti, 2017). Upper-grade children must learn more abstract vocabulary from textbooks and classroom discussions (Minskoff, 2005), with vocabulary knowledge primarily acquired through incidental learning during reading (Nagy, Anderson, & Herman, 1987). We therefore infer that in upper elementary grades, reading comprehension' s influence on vocabulary knowledge predominates.

4.2 Implications and Limitations

This study provides a more rigorous and comprehensive investigation of the longitudinal relationship between vocabulary knowledge and reading comprehension in elementary school children, advancing understanding of how these constructs relate across grade levels. Our findings validate and supplement the Reading Triangle Theory (Perfetti, 2010), demonstrating that the relationship

between vocabulary knowledge and reading comprehension undergoes dynamic changes throughout elementary school—from nonsignificant longitudinal predictions in lower grades, to bidirectional predictions in middle grades, to a pattern dominated by comprehension' s influence on vocabulary in upper grades. The results also support reading stage theory (Chall, 1983), revealing distinct developmental characteristics across grade levels. Lower grades focus on "learning to read," with vocabulary and comprehension primarily influenced by foundational skills. Middle grades transition toward "reading to learn," where vocabulary knowledge facilitates comprehension and text understanding promotes vocabulary growth. Upper grades engage primarily in "reading to learn," with comprehension involving more complex processes influenced by higher-level abilities such as grammatical knowledge and metacognition (Storch & Whitehurst, 2002; Chen, Lau, & Yung, 1993), while vocabulary knowledge' s impact diminishes and strong comprehension skills promote vocabulary development.

Based on these findings, reading instruction should be tailored to children' s developmental characteristics. In lower grades, instruction should strengthen foundational language and cognitive abilities such as phonological awareness to establish basic reading skills. In middle grades, instruction should target vocabulary learning to enhance reading ability while simultaneously fostering comprehension skills that enable children to infer word meanings from context. In upper grades, where comprehension primarily influences vocabulary, instruction should emphasize reading training to develop independent readers who learn through reading.

This study has several limitations requiring future research. First, lower-grade reading comprehension was assessed using sentence comprehension rather than higher-level discourse comprehension. However, lower-grade children struggle with independent passage comprehension, and Chinese curriculum standards identify reading as a grade 3-4 objective while grades 1-2 focus on word learning. This assessment thus appropriately captures lower-grade reading comprehension, as evidenced by its use in previous research (Wu et al., 2009). Future studies could develop reading comprehension measures suitable for grades 1-6 to further examine these relationships. Second, this study focused on vocabulary depth while neglecting vocabulary breadth, particularly in lower grades. As grade level increases, vocabulary learning demands become more complex, and individual differences in vocabulary depth may become more pronounced (Perfetti, 2010). Future research should examine both vocabulary depth and breadth to deepen understanding of their interrelationships with reading comprehension throughout elementary school.

In conclusion, after controlling for phonological awareness, morphological awareness, general cognitive ability, and autoregressive effects, the relationship between vocabulary knowledge and reading comprehension varies across elementary grade levels: no significant bidirectional predictions in lower grades, significant bidirectional predictions in middle grades, and a unidirectional prediction from reading comprehension to vocabulary knowledge in upper grades. These

findings validate and supplement the Reading Triangle Theory and support reading stage theory. The relationship between vocabulary knowledge and reading comprehension undergoes dynamic developmental changes: lower grades show predominant influences from foundational language and cognitive skills; middle grades exhibit mutual influence; and upper grades are characterized by comprehension' s dominant influence on vocabulary knowledge.

Acknowledgments: We thank Associate Professor Zhang Jie from the University of Houston for polishing the English abstract of this article.

Funding: This research was supported by the Major Project of the National Social Science Fund of China (13&ZD188).

Correspondence concerning this article should be addressed to: Wu Xinchun, E-mail: xcwu@bnu.edu.cn

Received: November 16, 2018

Note: Figure translations are in progress. See original paper for figures.