Title: The Roles of Decoding and Vocabulary in Chinese Reading Development: Evidence from a 3-year Longitudinal Study

Running Head: INFLUENCE OF DECODING AND VOCABULARY

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Abstract:

Backgrounds

Decoding and vocabulary are two essential abilities to reading comprehension. Investigating the roles of decoding and vocabulary in Chinese reading development can not only provide empirical evidence to enrich the current reading theories but also have implications for educational practice.

Aims

To examine the developing importance of decoding and vocabulary to reading comprehension and the reciprocal relationship between decoding and vocabulary across the reading development.

Sample

186 Chinese children were followed from grade 1 to grade 3 (aged 6.5 to 8.5 years).

Methods

Participants' decoding, vocabulary, and reading comprehension abilities were measured once a year for three years. Hierarchical multiple regression analyses were conducted to obtain the unique contributions of decoding and vocabulary to reading comprehension in the different grades. A cross-lagged structural equation model was used to explore the reciprocal relationship between decoding and vocabulary over the three years.

Results

Decoding and vocabulary explained nearly 40% of the variance to reading comprehension across grades, and the unique contribution of decoding decreased over the grades (from 29% to 8%) while that of vocabulary increased (from 3% to 9%). Moreover, vocabulary always predicted decoding from grade 1, but decoding predicted later vocabulary only started in grade 2.

Conclusions

Decoding skills are important to reading comprehension in the early learn-to-read grades. However, vocabulary becomes more critical for reading comprehension in later grades. Larger oral vocabularies promote the development of decoding skills, and vice versa.

Keywords:

decoding, vocabulary, reading comprehension, longitudinal

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The data that support the findings of the study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

The Roles of Decoding and Vocabulary in Chinese Reading Development: Evidence from a 3-year Longitudinal Study

Reading is an essential activity that allows humans to engage with written language and thus acquire knowledge without time and space constraints. Children can develop their abilities to understand spoken language naturally in daily life without formal instruction. They build an oral vocabulary — the associations between meanings and pronunciations of words, with the spoken words that they hear from their environment. This is a universal process which manifests across languages. For instance, children grasp that a four-legged furry animal is called /kæt/ in English and /mao1/ in Chinese by virtue of their experiences with others in the world around them who use that language to describe objects or phenomena that they encounter. By comparison, reading is a skill that children must learn gradually, through systematic instructions (Soden et al., 2015). Children must learn decoding skills that enable them to translate the written form of a word into its pronunciation and thus bridge written words to their spoken vocabulary. This depends upon the specific writing systems: /kæt/ is spelled as cat in English, whereas /mao1/ is written as 猫 in Chinese. From a developmental perspective, both decoding and vocabulary are prerequisites for achieving the ultimate goal of reading: reading comprehension (i.e., understanding and applying written texts for learning) (Tighe, Wagner, & Schatschneider, 2015). The focus of the current study was to examine the developmental relationships among decoding, vocabulary, and reading comprehension in a non-alphabetic language – Chinese.

Decoding works fundamentally differently in alphabetic and non-alphabetic languages. In alphabetic languages, there are grapheme-phoneme correspondence (GPC) rules that guide readers' decoding. For example, English readers who acquire decoding skills know the correspondences between /k/ and c, /æ/ and a, /t/ and t, and thus they can decode the written word cat and gain its pronunciation /kæt/ without any difficulty. By contrast, GPC rules are not available in non-alphabetic languages. For example, in the Chinese writing system, the basic unit is the Chinese character (e.g., 猫, which represents a morpheme (cat), and a syllable (/mao1/))(Shu & Anderson, 1997). There is no phoneme segmentation in a character. In order to pronounce a character, readers must map the character to its syllable. As a result, learning written words in Chinese is a very slow process; children spend almost all their elementary school years learning about 3,000 basic characters. These unique characteristics of Chinese are very likely influence the developmental relationships among decoding, vocabulary, and reading comprehension. Therefore, an extension of this body of research to Chinese is critical for enriching reading theories and revealing additional implications for reading education.

Among reading theories, two influential models are useful to discuss the relationships among decoding, vocabulary, and reading comprehension: the Simple View of Reading (SVR; e.g., Gough & Tunmer, 1986; Hoover & Gough, 1990) and the Decoding- Vocabulary-Comprehension (DVC) triangle model (Perfetti, 2009). In the Simple View of Reading, reading comprehension is simplified into the product of decoding and linguistic comprehension— understanding the meaning of spoken language. In order to achieve reading comprehension, readers must acquire both sufficient decoding skills and adequate linguistic comprehension. Although linguistic comprehension includes multiple dimensions, previous work has shown that vocabulary knowledge, as measured by a vocabulary definition task, can serve as a broad proxy for an aspect of linguistic comprehension (e.g., Braze et al., 2016; Savage, 2006). Therefore, based on the SVR, decoding and vocabulary both contribute to reading comprehension. Note that existing research in alphabetic languages suggests that the relative importance of decoding and vocabulary to reading comprehension changes over the course of children's reading development (e.g., LARRC, 2012; Tilstra, Mcmaster, Broek, Kendeou, & Rapp, 2009).

In the Decoding-Vocabulary-Comprehension (DVC) triangle model (Perfetti, 2009), reading development is thought of as the interaction among decoding, vocabulary, and reading comprehension. Although both decoding and vocabulary have an impact on reading comprehension, the prominent role of vocabulary is emphasized in this model. Vocabulary not only directly contributes to reading comprehension, but also mediates the effects of decoding on reading comprehension. Readers rely on vocabulary knowledge to retrieve the meanings of decoded written words (Perfetti, Landi, & Oakhill, 2005). Further, in the DVC model, decoding and vocabulary form a reciprocal relationship. Decoding skills are stronger in readers with larger vocabulary and readers with strong decoding skills are more facile at learning new vocabulary from text. Very few studies in alphabetic languages have tested this claim either only on the decoding-to-vocabulary relationship (Cunningham & Stanovich, 1991) or on the vocabulary-to-decoding relationship (Duff, Reen, Plunkett, & Nation, 2015), and even fewer have examined the reciprocal relationship between these two components (but see Verhoeven, van Leeuwe, & Vermeer, 2011).

The Developmental Importance of Decoding and Vocabulary to Reading Comprehension

It has been well established that decoding and vocabulary are both important for reading comprehension. Decoding significantly predicts reading comprehension across alphabetic languages (e.g., Dutch: de Jong & van der Leij, 2002; English: LARRC, 2012; French: Megherbi, Seigneuric, & Ehrlich, 2006), as well as in non-alphabetic languages such as Chinese (e.g., Chik et al., 2012; Joshi Tao, Aaron, & Quiroz, 2012). In Chinese research, decoding skills are normally measured by a character naming task, in which children are asked to pronounce a list of written characters that are visually presented to them. Furthermore, vocabulary contributes to reading comprehension significantly in different alphabetic languages such as English (Ouellette, 2006), Finnish (Lepola, Lynch, Kiuru, Laakkonen, & Niemi, 2016) and Norwegian (Lervåg & Aukrust, 2010), and in non-alphabetic languages such as Chinese (e.g., Song et al., 2015; Zhang et al., 2012). In measuring children's vocabulary knowledge, a widely used measure is the vocabulary definition task, in which children are asked to verbally define a spoken word provided to them.

Interestingly, the relative importance of decoding and vocabulary to reading comprehension may vary over the course of reading development. Research in alphabetic languages suggests that as children develop their reading skills over time, the importance of decoding to reading comprehension decreases (Florit & Cain, 2011; LARRC, 2012; Megherbi et al., 2006; Tilstra et al., 2009), whereas that of vocabulary increases (Tilstra et al., 2009). For example, decoding accounted for less variance in reading comprehension for third-grade English-speaking children ($\beta = .81$) compared to first-grade English-speaking children ($\beta = .48$) (LARRC, 2012). Similarly, among French-speaking children, decoding added less unique variance to reading comprehension for second-grade children (8%) than for first-graders (17%) (Megherbi et al., 2006). Moreover, Florit and Cain's (2011) meta-analysis suggest that decoding skills are more critical to reading comprehension in the early years than late years. Tilstra et al. (2009) found that decoding accounted for a decreasing amount of variance in English-speaking students' reading comprehension from grade 4 (42%) to grade 7 (13%) and grade 9 (17%), whereas, vocabulary explained an increasing number of variances in reading comprehension in grade 4 (5%), grade 7 (8%), and grade 9 (12%). It seems that in early years, children's major learning task is to acquire decoding skills and thus decoding contributes to reading comprehension more than vocabulary; later on, decoding becomes automatic and effortless, and thus children's vocabulary plays a more important role in reading comprehension than decoding. Note that among the aforementioned studies, only Tilstra et al. (2009) included decoding, vocabulary, and reading comprehension simultaneously in one study, and so the interacting roles of each of these components is understudied.

To our best knowledge, very few researchers have investigated the developmental roles of decoding (Joshi et al., 2012; Yan et al., 2020) and vocabulary (Yan et al., 2020) in Chinese reading comprehension using a cross-sectional design, and existing findings on the role of decoding are inconsistent. Joshi et al. (2012), for example, found that decoding explained more variance in reading comprehension in fourth graders (32%) than in second graders (22%), contrary to previous findings in alphabetic languages (e.g., Florit & Cain, 2011). Note that Joshi et al. (2012) measured the children's character decoding skills by asking them to write down Pinyin syllables—an alphabetic system that denotes the pronunciation of characters—for the characters presented to them, instead of pronouncing the characters (i.e., the commonly used character naming task). It is possible that the demand of Pinyin spelling skills has confounded the measure of children's decoding skills, thus producing this inconsistency. This speculation is supported by a recent study, Yan et al. (2020), which found that among Chinese children in kindergarten and grades 1 through 4, the unique contribution of decoding (measured by a character naming task) to reading comprehension decreased over the grades (from 68% to 10%), whereas that of vocabulary increased (from 2% to 11%). More evidence is required to clarify the current inconsistency. The previous work was extended in the current investigation by simultaneously examining the role of decoding and vocabulary in Chinese reading comprehension and by using a longitudinal design.

The Relationship between Decoding and Vocabulary

According to the DVC model, decoding and vocabulary form a reciprocal relationship (Perfetti, 2009). Children's vocabulary predicts their decoding abilities later on, while early decoding skills affect vocabulary development. In learning to read, children are first taught to build the associations between unfamiliar written text and familiar spoken language. Thus, it is reasonable that children with a large vocabulary can decode new words better than those who have a limited vocabulary, particularly later on in development, when they have had more time and exposure to develop their vocabulary knowledge. This is supported by previous longitudinal studies in alphabetic languages. For example, English-speaking children's vocabulary in infancy (aged 16-24 months) significantly predicted their decoding skills at school-age (Duff et al., 2015). Verhoeven et al. (2011) found Dutch-speaking children's vocabulary in grade 1 predicted their later decoding in grade 2. It seems that vocabulary development in early infancy predicts decoding at school-age, and it continues to affect later decoding skills, even after schooling.

Readers with sufficient decoding skills can read more efficiently and thus have more reading experiences and more print exposures than their less-sufficient peers. They are also able to read more complex texts that contain more contextual information providing the meaning of unfamiliar words embedded in the texts than their less-proficient peers, thus facilitating their subsequent vocabulary growth (Cunningham & Stanovich, 1991). Verhoeven et al. (2011) suggested that decoding in grades 2 and 3 predicted later vocabulary in grades 3 and 4, respectively. The contribution of decoding to later vocabulary only started from grade 2, but no earlier, as in grade 1. Verhoeven et al. (2011) pointed out that the contribution of vocabulary to later decoding starts earlier (i.e., grade 1) than the contribution of decoding to later vocabulary (i.e., grade 2).

Very few researchers have ever investigated the reciprocal relationship between decoding and vocabulary directly, even in alphabetic languages. It remains an open question whether or not the bidirectional relationship between decoding and vocabulary applies to non-alphabetic languages, such as Chinese, and whether the starting points of the vocabulary-to-decoding and the decoding-to-vocabulary relationships differ. These gaps in the literature were addressed in the current investigation.

The Present Study

As reviewed above, the relative importance of decoding and vocabulary to reading comprehension seems to vary over the course of children's reading development; decoding plays a more important role than vocabulary during the early years, and less so in the later years. Existing research has heavily focused on alphabetic languages, and has primarily included either decoding and reading comprehension or vocabulary and reading comprehension, though not decoding and vocabulary together. The only one study that considered both decoding and vocabulary simultaneously in a non-alphabetic language was a cross-sectional study in Chinese (Yan et al., 2020). Therefore, the first research question of the present study is: How does the contribution of decoding and vocabulary to reading comprehension change over the course of first- to third-grade Chinese children's reading development?

Moreover, the reciprocal relationship between decoding and vocabulary proposed by the DVC model (Perfetti, 2009) has not yet been thoroughly investigated. Among the very few previous studies on alphabetic languages, only either the decoding-to-vocabulary or the vocabulary-to-decoding direction was tested. To fill this gap, the second research question of the present study is: Is there a reciprocal relationship between decoding and vocabulary from first grade to third grade in Chinese children's reading development? Specifically, does decoding predict vocabulary in later grades and does vocabulary predict decoding in later grades?

To address the two questions, the present study used a longitudinal design, following 186 Chinese children's decoding, vocabulary and reading comprehension abilities, tested once per year for three years, from grades 1 to 3.

Method

Participants

One hundred and ninety-five first-grade students from a working-class elementary school in Beijing were recruited and followed over the course of 3 years. The written informed consent was obtained from the parents before the start of testing. All participating children were native Mandarin Chinese speakers and did not have any cognitive developmental deficits confirmed by the school teachers. The three measurement time points were the Fall semester of grade 1 (T1; n = 195), grade 2 (T2; n = 190), and grade 3 (T3; n = 186). The current analysis includes 186 students (94 boys) who were tested at all of the three time points. The mean ages at the three time points were 79.96 months (SD = 3.61), 90.96 months (SD = 3.61), and 102.96 months (SD = 3.61), respectively.

Measures

Character Naming Test. The Character Naming task was adapted from Li, Shu, McBride-Chang, Liu, and Peng (2012) to measure children's decoding skills. All 150 single characters were listed in the order of increasing difficulty and the participants were required to read the characters aloud, one by one. The first 40 characters were taken from a Chinese character recognition list for kindergarteners (Shu et al., 2008). The other 100 characters were from Chinese language textbooks: 20 from each grade level from Grade 2 to Grade 6 (Shu, Chen, et al., 2003). The last 10 characters were not introduced in elementary textbooks. One point was given to each correctly read character. The test was discontinued after 15 consecutive failures. The maximum score on this test was 150. The internal consistencies (Cronbach's α) were as follows: 0.92 at T1, 0.89 at T2, and 0.90 at T3.

Vocabulary Definition Test. The Vocabulary Definition Test was adapted from Liu and McBride-Chang (2010) and Zhang et al. (2013) to evaluate students' oral vocabulary. This test included 1 practice two-character word and 32 formally tested two-character words. The participants were asked to verbally explain the meaning of each word they hear. The experimenter recorded participants' answers and gave 2, 1, or 0 points to a completely correct, a partially correct, or an irrelevant response, accordingly. Take the target word postman as an example: a completely correct response was a man delivering letters or goods to others; a partially correct response was an occupation; an irrelevant response was an animal. Formal testing words were arranged in the order of increasing difficulty, and the test was discontinued when children provided five 0-point responses in succession. All responses were recorded at test and then scored independently by two well-trained psychology graduate students. The inter-rater reliabilities were calculated as follows: 0.91 at T1, 0.92 at T2, and 0.94 at T3. The internal consistencies were as follows: 0.72 at T1, 0.76 at T2, and 0.81 at T3.

Chinese Reading Comprehension Test. The Reading Comprehension test assesses children's abilities to comprehend written sentences and passages. In the present study, different comprehension test materials from previous studies were required to account for children's different reading abilities in each grade. No norm-referred reading assessments, as yet, are available in Mandarin Chinese. At T1, the test was a sentence comprehension task that assessed beginner readers' comprehension abilities (Cheng & Wu, 2017; Wu et al., 2009). The test included 2 practice items and 40 formal test items. For each item, the children were presented with a written phrase or sentence along with four alternative pictures, including only one target picture that correctly showed the meaning of that phrase or sentence. Their task was to identify the target picture from the three distractors. For example, for the sentence, A rabbit is chasing a cat, and a cat is chasing a mouse, children were required to understand the relationship among these animals described in the sentence and then to identify the correct picture. One point was given for each correct answer, and thus the maximum score of the test was 40. The internal consistency reliability was 0.87.

The test at T2 included one narrative passage, Prince Nezha Conquers the Dragon King, and eighteen multiple-choice questions measuring children's information access and inference-making regarding the selected passage. This passage was chosen from a Chinese reading ability scale that was age-appropriate for second-grade Chinese students (Mo, 2004), and this test has been used to evaluate second graders' reading comprehension abilities in previous research (e.g., Cheng, Zhang, Wu, Liu, & Li, 2016). A sample question includes, "*According to the sentence, 'Nezha made up his mind to punish them and fight for ordinary* *people,' which one of the* following *can be inferred?" (A*) He was very naughty. (B) He sympathized with ordinary people. (C) He wanted to try his two weapons. (D) He fought for *himself."* One point was awarded to each correct answer. The maximum score was 18. The internal consistency reached 0.79.

To control for ceiling effects or potential practice effects when using the same passage and eighteen questions from T2, another two passages from previous studies (e.g., Song et al., 2015; Tong, McBride-Chang, Shu, & Wong, 2009) were added to the test at T3, Big cock and The moonlight in pond, each which included 10 multiple-choice questions measuring children's information access and inference-making regarding the selected passage. The scoring was based on the number of correct responses and thus the maximum score was 38 at T3, and the internal consistency was 0.81.

Procedure

At each time point, all the three tests, the Character Naming, Vocabulary Definition, and Reading Comprehension were administered in a quiet room at the participants' school by well-trained research assistants. The reading comprehension test was administered in groups, lasting 30-40 minutes. The Character Naming and Vocabulary Definition tests were conducted on a one-on-one basis over a period of approximately 30 minutes.

Results

Table 1 presents the descriptive statistics of the Character Naming, Vocabulary Definition, and Reading Comprehension tests from T1 to T3. The Character Naming and Vocabulary Definition tests were identical for all three time points and thus the raw accuracy data on each of the two tests can be compared across time. Results from ANOVA and multiple comparisons showed significantly improvements from T1 to T3 (all ps < .001), suggesting that the children's decoding skills and vocabulary improved over the course of the three grades.

Table 2 shows the correlation among the Character Naming, Vocabulary Definition, and Reading Comprehension tests at each of the three time points. Overall, the nine variables correlated significantly among one another. Over the three grades, the correlation between Character Naming and Vocabulary Definition increased from 0.24 to 0.53, and the correlation between Vocabulary Definition and Reading Comprehension increased from 0.30 to 0.53, whereas the correlation between Character Naming and Reading Comprehension decreased from 0.60 to 0.53.

To obtain the unique contributions of decoding and vocabulary towards reading comprehension in the different grades, we conducted two hierarchical multiple regression analyses separately at each of time points. Table 3 shows the summary of the results from the two fixed-order multiple regression analyses with Reading Comprehension as the outcome. In each model, two independent variables, Character Naming and Vocabulary Definition were entered step by step. In Model 1, Character Naming was entered first, followed by Vocabulary Definition, and vice versa for Model 2.

First, the results show that Character Naming and Vocabulary Definition explained 38%, 41%, and 37% of the variance of Reading Comprehension, respectively, from T1 to T3. Second, according to Model 1, the unique contribution of Vocabulary Definition to Reading Comprehension was significant (all ps < .01). Specifically, Vocabulary Definition added 3% of variance over and above Character Naming at T1, 5% at T2, and 9% at T3, thereby increasing over time. Third, according to Model 2, Character Naming explained significant variance in Reading Comprehension after controlling for Vocabulary Definition (all ps < .001). Specifically, when controlling for Vocabulary Definition, the unique contribution of Character Naming to Reading Comprehension decreased from 29% to 8% over the course of the three grades. Furthermore, the total variance explained by Character Naming and Vocabulary Definition, absent the two components' unique explained variance (i.e., their shared contribution to reading comprehension), increased from 6% to 20%. The shared and unique contributions of these variables are illustrated in Figure 1.

Moreover, a cross-lagged structural equation model was used to further explore the developing relationship between Character Naming and Vocabulary Definition over the course of the three grades. Figure 2 shows the hypothesized paths among the variables over time. The model fit was found to be satisfactory (χ^2 = 5.65, df = 4, p = 0.23, CFI = 1.00, TLI = 0.99, RMSEA = 0.05). The standardized regression coefficients for Character Naming from T1 to

T2 and from T2 to T3 had approximate values of 0.70, and that for Vocabulary Definition had approximate values of 0.50; these paths were all significant (all ps < .001), indicating a stable improvement of decoding and vocabulary over the course of the three grades. The paths from prior Vocabulary Definition (β = .20, p < .001; T1 to T2) to later Character Naming (β = .20, p < .001; T2 and T3) were found to be significant. However, the path from Character Naming at T1 to Vocabulary Definition at T2 was not significant (β = .11, p = 0.10). Later, the path from Character Naming at T2 to Vocabulary Definition at T3 became significant (β = .26, p < .001).

Discussion

In the current study, the developing roles of decoding and vocabulary in Chinese reading comprehension from grades 1-3 were investigated. Results showed that both decoding and vocabulary explained a significant amount of variance in reading comprehension across grades, consistent with previous work in alphabetic languages (e.g., LARRC, 2012; Megherbi et al., 2006; Tilstra et al., 2009). More importantly, the current work was among the first to use a longitudinal study to examine the developmental roles of decoding and vocabulary in reading comprehension in Chinese. We found that over the three grades, the unique variance in reading comprehension that was explained by decoding decreased, while that by vocabulary increased, consistent with previous research (e.g., Tilstra et al., 2009; Yan et al., 2020). The results of a cross-lagged model between decoding and vocabulary among the three grades supported the hypothesized reciprocal relationship between decoding and vocabulary during reading development that was proposed by the Decoding-Vocabulary-Comprehension (DVC) Triangle Model (Perfetti, 2009). Furthermore, there seems to be a discrete starting point for the emergence of this reciprocal relationship, and the trade-off in predictive power of the two elements therein. Specifically, as early as the first grade, earlier vocabulary knowledge predicted later decoding skills, whereas starting from the second grade, earlier decoding predicted later vocabulary skills. We discuss our findings in the context of previous research in the following sections.

The Developmental Importance of Decoding and Vocabulary to Reading Comprehension

The current research revealed that the contribution of decoding in children's reading comprehension decreased over the course of the three grades, converging with previous studies conducted on alphabetic languages (Florit & Cain, 2011; LARRC, 2012; Megherbi et al., 2006) and in the non-alphabetic language of Chinese (Yan et al., 2020). The present work also determined that the importance of vocabulary increased over the course of the three grades, consistent with previous research in alphabetic languages (Tilstra et al., 2009) as well as in Chinese (Yan et al., 2020). In comparison to previous work, the present research was among the first to examine: (1) decoding and vocabulary simultaneously; (2) a non-alphabetic language – Chinese; (3) these factors, together, over the course of a longitudinal design.

The current findings enrich the existing evidence on the developmental role of decoding in Chinese reading comprehension, which was contradictory and inconsistent in previous cross-sectional studies. Joshi et al. (2012) found that the unique contribution of decoding to Chinese reading comprehension increased from grade 2 to grade 4, while more recently, Yan et al. (2020) suggested that the variance in Chinese reading comprehension that was uniquely explained by decoding decreased over kindergarten and grades 1 to 4. The findings from this longitudinal study clearly supported (Yan et al., 2020).

Methodologically, the only major difference in the two aforementioned studies was the operationalization of decoding. Joshi et al. (2012) implemented a character recognition task that ask the children to write down Pinyin for written characters that were presented to them, whereas Yan et al. (2020) applied a character naming task that required the participants to pronounce written characters, a method that was replicated in the current study. Note that the more commonly used task of decoding is the word naming task across writing systems (see Florit and Cain (2011) for a meta-analysis). The fact that the current finding coverages with Yan et al. (2020) may imply that the operationalization of decoding matters. The involvement of children's Pinyin skills in the measure of character decoding might have complicated the results in the work by Joshi and colleagues (2012). But we fully acknowledge that this speculation requires further investigation, and we only argue that the current findings contribute to the accumulation of evidence in this line of work.

Furthermore, we contribute to existing evidence of the increasing importance of linguistic comprehension to reading comprehension in the broader context of the Simple View of Reading (SVR) model. As reviewed in the introduction, vocabulary can be considered an aspect of linguistic comprehension abilities (e.g., Braze et al., 2016; Kirby & Savage, 2008; Ho, Chow, Wong, Waye, & Bishop, 2012). The passage listening comprehension task is another operationalization of this linguistic comprehension, as assessed in the present study. Broadly speaking, the findings detailed here are consistent with the findings from previous research in alphabetic languages (e.g. Florit & Cain, 2011) and in Chinese (Joshi et al., 2012) in the theoretical framework of SVR, which found that children's performance on passage listening comprehension predicted increasing amounts of variance in reading comprehension during reading development. Future researchers can aim for more conceptional replications to expand our understanding of the contribution of linguistic comprehension to reading comprehension.

The Reciprocal Relationship between Decoding and Vocabulary

The results from the present study provide supporting evidence of the reciprocal relationship between decoding and vocabulary across reading development proposed in the DVC model (Perfetti, 2009), and extend previous findings in Dutch (Verhoeven et al., 2011) to a non-alphabetic language (i.e., Chinese), for the first time. Specifically, we found that vocabulary in grades 1 and 2 predicted decoding in grades 2, and 3, respectively, and decoding in grade 2 significantly predicted vocabulary in grade 3. Moreover, the contribution of vocabulary to later decoding appears to start earlier (i.e., grade 1) than the contribution of decoding to later vocabulary (i.e., grade 2), consistent with Verhoeven et al.'s (2011) finding among Dutch children.

The current findings can be explained by the stages of reading development theory (Chall, 1996). In grade 1, children are in the "learning to read" stage, and they are first taught to map their existing spoken vocabulary to novel written words. Thus, vocabulary supports their later decoding development from the very beginning of their learning to read. Later, as children gradually acquire decoding skills, they advance to the "reading to learn" stage. In this stage, they are able to decode new written words beyond their existing vocabulary, and read sentences that contain the meaning information of new written words, thus building new vocabulary. Therefore, decoding becomes beneficial for their later vocabulary development.

Note that with a more extended longitudinal study, Verhoeven et al. (2011) also suggested that decoding in grade 4 predicted later vocabulary in grade 5. This is beyond the scope of the current study, but future studies can aim for a more extended longitudinal investigation to gain a fuller picture of the reciprocal relationship between decoding and vocabulary. Given that vocabulary in early as infancy can predict decoding at school-age (Duff et al., 2015), it would be interesting to follow participants from infancy to upper grades to track this development and the variable roles that decoding and vocabulary play throughout its progression.

Limitations and Future Directions

Some limitations should be considered when interpreting the current findings. First, we have a focused scope that only includes two basic reading skills at the word level (i.e., decoding and vocabulary). Reading comprehension is a complex process that involves much more than just decoding and vocabulary, such as passage listening comprehension, grammar, and inference (e.g., Cain, Oakhill, & Bryant, 2004; Tong, Tong, Shu, Chan, & McBride-Chang, 2013). The inclusion of more variables may potentially influence the relationships among decoding, vocabulary, and reading comprehension. As a starting point, we argue that the simplicity of the current design does not compromise the findings reported here, regarding the relationship between decoding, vocabulary, and reading comprehension, and contributions to this literature. We fully acknowledge that our findings need to be treated with caution and are subject to test by future research that includes more variables, a critical extension to this line of work.

Furthermore, given the fact that there were no published norm-referred reading assessments in Mandarin Chinese during the time that we conducted and wrote this study, we had no choice but to select grade-appropriate testing materials from previous studies to measure children’s reading comprehension in each grade. We have done our best to ensure that the three reading comprehension tests all measure children’s reading comprehension skills conceptually. We acknowledge the different operationalizations across grades, a concern that should be addressed in the future when proper norm-referred reading assessments become available.

Educational Implications

Two main take-aways for educators are: (1) Regarding the role in reading comprehension, decoding is more prominent in early elementary school years, whereas vocabulary is more salient in upper grades; (2) Larger oral vocabularies may strengthen later decoding skills, and better decoding skills may contribute to later vocabulary growth. The current Chinese literacy education in Mainland China places greater emphasis on decoding during elementary school years and less attention to vocabulary, if any at all. This may apply to some of other writing systems in some of other countries as well. In practice, educators are encouraged to provide children with support for vocabulary growth inside and outside of classroom as early as grade 1. As vocabulary plays an increasingly important role over time, educators may consider inclining more to vocabulary training rather than decoding instruction as children progress. In sum, more value should be put into vocabulary instruction.

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TABLE 1 Descriptive Statistics for all Variables from T1 to T3

	T1 M(SD)	T2 M(SD)	T3 M(SD)	F	η^2
Character Naming (150)	28.81(25.52)	69.68(22.91)	98.65(15.92)	1397.44***	0.88
Vocabulary Definition (64)	14.65(5.78)	19.59(5.87)	23.44(5.87)	211.58***	0.53
Reading Comprehension					
Sentence reading (40)	31.59(6.49)				
Passage reading (18/38)		10.19(3.97)	24.79(5.69)		

Note. ***p < .001.

TABLE 2 Correlations Among all Variables Across the Three Time Points

	1	2	3	4	5	6	7	8	9
1 T1 CN	-								
2 T1 VD	0.24**	-							
3 T1 RC	0.60***	0.30***	-						
4 T2 CN	0.72***	0.36***	0.70***	-					
5 T2 VD	0.22**	0.51***	0.32***	0.39***	-				
6 T2 RC	0.39***	0.33***	0.54***	0.59***	0.44***	-			
7 T3 CN	0.53***	0.37***	0.63***	0.82***	0.49***	0.59***	-		

8 T3 VD	0.30***	0.41***	0.32***	0.45***	0.58***	0.44***	0.53***	-	
9 T3 RC	0.38***	0.53***	0.47***	0.53***	0.38***	0.65***	0.53***	0.53***	-

Note. CN = Character Naming; VD = Vocabulary Definition; RC = Reading Comprehension.

**p < .01, ***p < .001.

TABLE 3 Prediction of Reading Comprehension: Multiple Regression Results

	T1		T2		T3	
	R^2	$\triangle R^2$	R^2	$\triangle R^2$	R^2	$\triangle R^2$
Model 1						
Step1: CN	0.35***		0.36***		0.28***	
Step2: VD	0.38***	0.03**	0.41***	0.05***	0.37***	0.09***
Model 2						
Step1: VD	0.09***		0.20***		0.29***	
Step2: CN	0.38***	0.29***	0.41***	0.21***	0.37***	0.08***

Note. CN = Character Naming; VD = Vocabulary Definition; RC = Reading Comprehension.

**p < .01, ***p < .001.

FIGURE 1. Decomposition of variance accounted for by CN (Character Naming) and VD (Vocabulary Definition) in Reading Comprehension

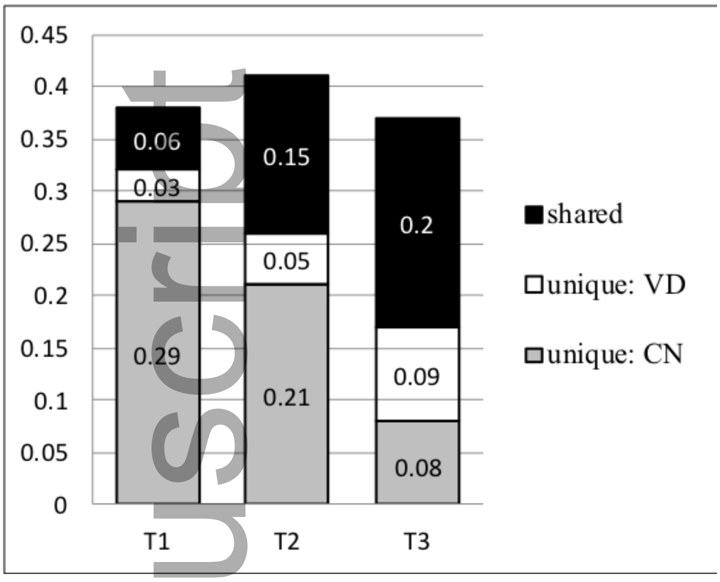
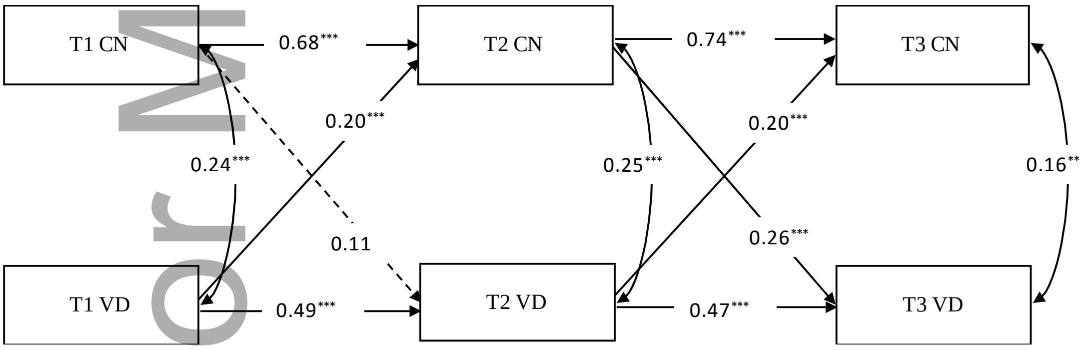


FIGURE 2. Structural models displaying the standardized regression coefficients for CN (character naming) and VD (vocabulary definition) as a function of grade level



Note. Solid lines represent statistically significant relations, **p < .01, ***p < .001, and dashed lines represent nonsignificant relations, p > .05.