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Tracing children's vocabulary development from preschool through the school-age years: An 8-year longitudinal study

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Abstract

In this 8-year longitudinal study, we traced the vocabulary growth of Chinese children, explored potential precursors of vocabulary knowledge, and investigated how vocabulary growth predicted future reading skills. Two hundred sixty-four (264) native Chinese children from Beijing were measured on a variety of reading and language tasks over 8 years. Between the ages of 4 to 10 years, they were administered tasks of vocabulary and related cognitive skills. At age 11, comprehensive reading skills, including character recognition, reading fluency, and reading comprehension were examined. Individual differences in vocabulary developmental profiles were estimated using the intercept-slope cluster method. Vocabulary development was then examined in relation to later reading outcomes. Three subgroups of lexical growth were classified, namely high-high (with a large initial vocabulary size and a fast growth rate), low-high (with a small initial vocabulary size and a fast growth rate) and low-low (with a small initial vocabulary size and a slow growth rate) groups. Low-high and low-low groups were distinguishable mostly through phonological skills, morphological skills and other reading-related cognitive skills. Childhood vocabulary development (using intercept and slope) explained subsequent reading skills. Findings suggest that language-related and reading-related cognitive skills differ among groups with different developmental trajectories of vocabulary, and the initial size and growth rate of vocabulary may be two predictors for later reading development.

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Keywords

vocabulary development; growth rate; initial size; reading

Children's oral vocabulary knowledge is an important indicator of language development and subsequent reading success or failure during formal schooling (Lee, 2010; Storch & Whitehurst, 2002). Several studies have attempted to capture individual differences in the timing and rate of vocabulary development using a longitudinal approach, but most have traced such development for toddlers (before 46 months) over a relatively short period of time (Huttenlocher, Haight, Bryk, Seltzer, & Lyons, 1991; Pan, Rowe, Singer, & Snow, 2005; Rowe, Raudenbush, & Goldin-Meadow, 2012; Vagh, Pan, & Mancilla-Martinez, 2009). However, children's oral vocabulary continues to grow rapidly and to overlap with reading acquisition in primary school. Understanding the path of children's vocabulary growth after early childhood and its associated potential precursors has both theoretical and applied relevance for instructional approaches. The primary focus of this 8-year longitudinal study was to trace trajectories of Chinese children's oral vocabulary development from ages 4 to 10 years old in mainland Chinese children.

In Perfetti's DVC (Decoding, Vocabulary, and Comprehension) triangle model (Perfetti, 2009), vocabulary knowledge falls between word identification and reading comprehension (Perfetti, Landi, & Oakhill, 2005). Multiple studies have supported this view by showing a close relationship between vocabulary and word reading or reading comprehension (Nation, Cocksey, Taylor, & Bishop, 2010; Zhang et al., 2013; Zhang, McBride-Chang, Wong, Tardif, Shu, & Zhang, 2013). In a recent longitudinal study of 262 Chinese children, Zhang et al. (2013) found that children's vocabulary abilities at age 4 and age 5 mediated the effects of SES on children's word reading ability in the 3rd grade. At a higher-order level of reading, children's vocabulary knowledge at ages 6, 7, and 8 can discriminate typically developing controls from poor reading comprehenders in both English and Chinese (Nation, et al., 2010; Zhang et al., 2013). There is likely a bidirectional relationship (vocabulary-reading development) year by year. Children learn more vocabulary through reading, while vocabulary knowledge also helps children to read. A second goal of the present study, therefore, was to explore the relationship between natural vocabulary development and later reading skills.

Previous studies have often focused on vocabulary growth of toddlers or children in early childhood. These studies have typically used receptive picture naming tasks to measure children's vocabulary breadth (Huttenlocher et al., 1991; Rowe et al., 2012; Vagh et al., 2009). Children's vocabulary ability continues to develop rapidly after they enter school, and large individual differences in vocabulary knowledge have been observed. Given this situation, Perfetti (2009) suggested that variance in knowledge of word meaning might be taken into consideration for older children. In order to detect lexical development both before and after the beginning of literacy skills, in the present study, we chose an expressive vocabulary definition measure. This measure focused on children's knowledge of word meanings and has been used in a number of previous studies as a reasonable indicator of Chinese children's vocabulary development from ages 4 to 9 (Chow, McBride-Chang, &

Burgess, 2005; Lei et al., 2011; McBride-Chang, Chow, Zhong, Burgess, & Hayward, 2005; McBride-Chang, Liu, Wong, Wong, & Shu, 2011; McBride-Chang, Shu, Zhou, Wat, & Wagner, 2003; McBride-Chang & Ho, 2005; McBride-Chang et al., 2008; Pan, McBride-Chang, Shu, Liu, Zhang & Li, 2011).

There is consensus that substantial individual differences exist in the rate and shape of vocabulary growth. Vocabulary varies widely in the initial size and growth rates between children; some start slow and speed up, while others start fast and continue at a steady pace (Rowe et al., 2012). Therefore, initial size and developmental speed may be two meaningful indices of vocabulary growth. In one study, individual differences in initial vocabulary size were observed for both L1 and L2 learners at age 7; such differences could predict the subsequent growth of reading comprehension skills (Lervåg & Aukrust, 2010). Moreover, modeling individual growth rates can provide a sensitive measure of differences between catch-up versus delayed groups and can determine which factors best predict patterns of such group differences (Singer & Willett, 2003). For example, Fernald and Marchman (2012) found that late talkers with efficiency in lexical processing at 18 months showed more accelerated vocabulary growth over the following year compared with late talkers who were less efficient in early speech processing. They also divided children's vocabulary development into four subgroups demonstrating different initial vocabulary size and rate. Such clustering analyses help to clarify the extent to which subgroups of children with different developmental patterns can be identified using early cognitive skills (Boscardin, Muthen, Francis, & Baker, 2008). By using a data-driven approach, we sought to chart individual variation in both initial vocabulary size and growth rate and establish subgroups of lexical growth over a long period of time. In particular, we wanted to determine if children with low vocabulary knowledge at age 4 would remain delayed after they entered primary school or, alternatively, would catch up with development.

Individual differences in children's vocabulary growth can be explained in terms of experience-based factors, such as family socioeconomic status (SES) (Hoff, 2003; Rowe & Goldin-Meadow, 2009; Rowe et al., 2012), parent language input (Hurtado, Marchman, & Fernald, 2008; Pan et al., 2005) and home literacy (Duursma et al., 2007). Studies across languages have also demonstrated that children's early vocabulary growth is associated with certain cognitive skills, such as working memory, phonological processing skills and morphological awareness (Bowey, 2001; Gathercole, Willis, Emslie, & Baddeley, 1992; Just & Carpenter, 1992; McBride-Chang, Wagner, Muse, Chow, & Shu, 2005; Stokes & Klee, 2009). In the present study, we tested whether and how children's initial vocabulary and vocabulary growth are affected by both environmental factors and these cognitive skills. Because vocabulary and reading development overlap after children enter school, we also included some other reading-related cognitive factors, including rapid automatized naming (Pan et al., 2011) and orthographic awareness (Ho, Chan, Lee, Tsang, & Luan, 2004; Li, Shu, McBride-Chang, Liu, & Peng, 2012; Shu & Anderson, 1998). We, thus, investigated if and how environmental and cognitive factors might jointly account for individual differences in Chinese children's vocabulary development.

The role of vocabulary knowledge in reading development has attracted much attention in recent years. Perfetti's Decoding, Vocabulary, and Comprehension triangle model

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emphasizes the central role of vocabulary and vocabulary by assuming that it has respective reciprocal relations with both decoding and comprehension (Perfetti, 2009). This theoretical explanation has led to many studies focusing on the relations between vocabulary growth and reading development (Lee, 2010; Verhoeven, van Leeuwe, & Vermeer, 2011; Zhang et al., 2013). The present longitudinal study allowed us to investigate the relationship between vocabulary growth and later reading skills. One recent study showed that compared to estimates of initial size, the estimated rate and/or acceleration in vocabulary growth between 14 and 46 months could better predict later vocabulary size at 54 months (Rowe et al., 2012). In the present study, we wanted to determine if the rate and/or acceleration in vocabulary growth of older children could also explain later reading performance. By using an intercept-slope cluster method, we investigated how the growth rate of children's vocabulary from ages 4 to 10 and the initial vocabulary size explained later reading skills at age 11.

Three research questions were addressed in the present study. First, could we describe a long-term dynamic change in vocabulary growth and separate the subgroups from age 4 to age 10? Second, and more specifically, what are the associated factors, particularly cognitive skills, behind different vocabulary development profiles? Finally, to what extent can original vocabulary and lexical growth rate from age 4 to age 10 predict reading performance at age 11?

Method

Participants

In this 8-year longitudinal study, 264 typically developing Chinese children (145 boys and 119 girls) were included from a longitudinal study of language and literacy Chinese Communicative Development Inventory (CCDI; Tardif, Fletcher, Zhang, & Liang, 2008). This study has been ongoing since 2000 (Lei et al., 2011; Pan et al., 2011). Initially, 338 children with normal IQs were recruited from the longitudinal study of language and literacy. Thanks to the cooperation of parents, the attrition rate was low, with 293 from the initial sample continuing to participate in the project at present. In the present study, we report on data from 264 children who entered school in the same year. All 264 children were native Mandarin speakers from Beijing, China, with their first language being Mandarin Chinese. All of these children have been tested annually on a variety of tasks since 2001 with an interval of approximately 12 months. There were virtually no missing data, with no more than 3 missing values on several measures. The present study focused on the vocabulary skills and language and reading related cognitive skills, so we selected the data for those from 4.4 years old to 11.4 years old. Informed consent was obtained from the parents. Table 1 shows the details of each task across years.

Measures

Vocabulary definitions—This Vocabulary definitions task was used for children from age 4 to age 10. From age 4 to age 8, 32 words representing concepts or objects arranged in order of increasing conceptual difficulty and with decreasing word frequency were orally presented to children. Children were required to provide the definition for each word. This task was translated and adapted for Mandarin Chinese-speaking children from the vocabulary subset of the Stanford-Binet Intelligence Scale (Thorndike, Hagen, & Sattler, 1986). It was similar to those used in previous studies (e.g. Anglin, 1993; Gathercole, Service, Hitch, Adams, & Martin, 1999; Lervåg et al., 2010). For instance, the experimenters asked a child "What is a kitchen?" Scoring was based on the number of important semantic features included, following the scoring scheme in the test manual. The ("well-formed-ness") form of the definition (syntactic ability) was not considered in the marking process. One point was given for each feature with a maximum score of 2 for each item. A complete definition had to include the proper semantic category and one or more features. For example, for the target word kitchen, a 2-point answer is "a place for cooking." A 1-point answer is "a place at home." An example of a zero-point answer would be that the child would simply repeat the word again. Examples of tested words and the model answers with key features are provided in the Appendix. The task was stopped when the child obtained zero marks across five consecutive items; the maximum score of the task was 64. Children's responses were rated by two trained experimenters with high inter-rater reliability during pilot tests. This task has been used in previous studies and has been suggested to be a reasonable proxy for vocabulary knowledge (Chow et al., 2005; Lei et al., 2011; Liu & McBride-Chang, 2010; McBride-Chang et al., 2005; McBride-Chang et al., 2005; McBride-Chang, et al., 2011; McBride-Chang et al., 2003; McBride-Chang et al., 2005; McBride-Chang et al., 2008; Pan et al., 2011; Tong, McBride-Chang, & Shu, 2009; Zhang et al., 2013). To avoid a ceiling effect, the age-10 version included an additional 13 items from the Hong Kong version. Because we rapped a variety of children's cognitive abilities every year in this longitudinal study, the measures administered each year were not necessarily the same. When the children were age 9, we added some more tests tapping children's attention. Given that the testing time for a child had to be limited to 2 hours or less in order to avoid tiredness of the children, we did not measure vocabulary knowledge of the children at age 9.

Phonological awareness

Syllable deletion: Used for children between ages 4 and 6 (Lei, et al., 2011), this task asked children to delete one syllable from two or three syllable phrases (e.g., /hong2 yan2 se4/, meaning red color, with the syllable /hong2/ taken away would be /yan2 se4/, meaning color).

Tone detection: Used between ages 7 and 9, the tone detection task is closely related to the tone awareness task used by Chen et al. (2004). It consists of 12 syllable trials and 12 non-syllable trials. Children were presented with 3 syllables and asked to identify one syllable with a different tone from the other two syllables (e.g., the tone that is different from the other two among the following three syllables, /kui2/ meaning sunflower, /bo2/ meaning thin, and /ban1/ meaning class, is /ban1/).

Morphological awareness

Morphological construction: Following previous work (McBride-Chang, Shu et al., 2003), in this task, children were required to construct a new compound word with the morphemes they had previously acquired. For instance, the experimenter asked "A piece of paper with white color is called white paper /bai2 zhi3/; what would it be called if the color of the paper was red?” The right answer in this case is ‘red paper’ /hong2 zhi3/. This task was used from ages 4 to 6 years.

Morphological production: In this task, children listened to a compound word composed of two morphemes. They were asked to produce two new words with the target morpheme (e.g., one target morpheme was /bao1/ meaning bag from /pi2 bao1/ meaning leather bag). The morpheme in one of these two words was required to have the same meaning as that of the target morpheme (e.g., the /bao1/ in /shou3 bao1/ meaning hand bag, has the same meaning as the /bao1/ in /pi2bao1/), while the morpheme in the other word has a different meaning than the target morpheme (e.g., in the word /mian4 bao1/ meaning bread, /bao1/ has to do with bread, rather than a bag). This task has been successfully used in a previous study (Shu, McBride-Chang, Wu, & Liu, 2006) and was used for ages 7 to 9.

Orthographic judgment—This task was used for children from age 6 to age 8. Shu and Anderson (1998) created this orthographic judgment task to measure the orthographic awareness of Chinese children. It has been used in previous research as a reasonable index for orthographic awareness (Li, et al., 2012; Zhang et al., 2013). In this lexical decision task, children were visually presented with 70 items consisting of line drawings, non-characters and real characters. They were asked to judge whether the item was a real character or not. One point was obtained for a right answer, so the total score was 70. Of the 70 items, 10 were black-and-white line drawings with no conventional stroke patterns (e.g.). The other 20 items included two types of compound non-characters: 10 were ill-formed structure non-characters with real radicals in illegal positions (e.g.) and 10 were ill-formed radical non-characters which looked like standard compound characters with the radical in a legal position (e.g.). In addition, there were 10 well-formed structure and radical pseudo-characters, which were not real characters in the Chinese writing system (e.g.). Thirty real Chinese characters were also included as fillers.

Rapid digit naming—Used from age 5 to age 10, rapid digital naming consisted of 5 different digits repeated randomly five times (Lei, et al., 2011; Pan, et al., 2011). The children's task was to name the digits as accurately and as quickly as possible twice. Mean time in seconds was calculated.

Character recognition—This task was measured at age 11. It comprised 150 characters of increasing difficulty level. Children were asked to name the characters without a time limit. All of these particular characters are required to be learned in China by the end of primary school (Shu, Chen, Anderson, Wu, & Xuan, 2003). The character recognition task has been widely used as an indicator for Chinese children's literacy skills (Lei, et al., 2011; McBride-Chang, et al., 2003).

Reading fluency—Following the procedures of previous research (Moll, Fussenegger, Willburger, & Landerl, 2009; Pan, et al., 2011), children were asked to silently read 100 sentences in 3 minutes and to evaluate whether each sentence was literally correct or not. Characters in corrected sentences per minute were totaled for the child's final score. This task was measured at age 11.

Reading comprehension—This task was measured at age 11. Four passages and 42 multi-choice questions were given. In each question, children were asked to choose one from the four choices that would best answer the question. Answers ranged from single words to phrases or sentences.

Nonverbal IQ—This task was measured at age 4, and only the first two sets from Raven's Standard Progressive Matrices (Raven, Court, & Raven, 1996) were chosen.

Mother's education level—Mothers of the participants were invited to complete the assessment (Zhang, et al., 2013). The choices for the seven-point self-report scale were 1 = lower than third grade, 2 = fourth to sixth grade, 3 = junior high school completion, 4 = senior high school completion, 5 = college (3 years), 6 = university graduate (4 years), and 7 = graduate school. In China, college refers to the 3-year college or so-called “da zhuan”. The term “university graduate” refers to a 4 year undergraduate education. In China, students who get a better performance will go to the 4-year undergraduate university, while others may go to the 3-year “da zhuan”.

Statistical approach—In this study, we were interested in describing children's individual differences and distinguishing heterogeneous subgroups in vocabulary growth based on our longitudinal data from age 4 to age 10 years. A two-step process was used to identify the subgroups with different initial size and pace of vocabulary development (Tataryn & Chochinov, 2002).

In our first step, for each participant i at time t , linear growth models were used to transform scores of participants into two parameters, the slope and the intercept (Rogosa, Brandt, & Zimowski, 1982):

$$\mathrm{y_i}\left(\mathrm{t}\right) - \delta_{01} | \delta_{1\mathrm{i}} \left(\mathrm{t} \quad \mathrm{t}_0\right) | \mathrm{e}_{it}, \quad \mathrm{e}_{it} \sim \mathrm{N}\left(0, \sigma_1^2\right)$$

where $y_i(t)$ is the vocabulary score of participant i at time t, δ_{01} is the estimate of intercept for participant i, δ_{1i} is the estimate of slope for participant i, and t_0 is the youngest age of all participants in the first measure. Here ε_{it} means residual error. The individual data were transformed by using the MATLAB software “polyfit” function. The ordinary least square method (OLS) made it reliable to estimate the parameters for participants with missing data. Since children's development appeared to be relatively steady, these estimates, including six time points, could well explain their development.

In our second step, a clustering nearest centroid sorting method was used with the fastclus procedure with the Statistical Analyses Software (SAS). The main idea for the clustering was to classify several similar participants into one subgroup. In the cluster procedure, two statistical indices were considered to determine the number of groups, namely the R-square and the Pseudo-F statistics. The larger the R-square, the better the groups clustered. Larger Pseudo-F statistics were also considered better (Kale, 1995).

Results

Table 1 displays the means and standard deviations of all measures, as well as the skewness, kurtosis and reliability estimates of each task. Generally, most of the measures were normally distributed with relatively high reliabilities, and children's performance on the measures improved with age.

Based on vocabulary raw scores, clusters with between two and five classes were tried for the intercept and slope. The results showed that compared with other cluster solutions, the three-cluster model had the highest Pseudo-F statistics (172.00) and responsible R-square statistics (0.67). Therefore, the three-cluster model provided the most meaningful and concise fit for the data. Figure 1(A) presents the scatter plot of intercepts and slopes for our three subgroups. The first subgroup (n=85), called the high-high group, was characterized by a high intercept (4.72) and a high slope (6.80). The second (n=137), called the low-high group, showed a low intercept (−.60) but a high slope (7.05). The third (n=42), termed the low-low group, had both a low intercept (2.55) and a low slope (4.49). The mean scores of the vocabulary definition task across 6 time points for participants in the three clusters are plotted in Figure 1(B).

The means and standard deviations of the 6 time points' vocabulary scores, value of F, and comparisons (Tukey's post-hoc test) among the three groups are shown in Table 2. The results revealed that children in the high-high group performed significantly better than those in the low-high and low-low groups at 4 years old ($F(2, 261)=97.54$, $p< .001$), and the latter two groups did not differ significantly until age 7. After entering school at age 7, participants in the low-high group quickly became significantly better than those in the low-low group.

Table 2 also includes the means and standard deviations of other measures at different ages among the three trajectories. Children in the high-high group tended to have relatively higher IQs and mothers' education levels as compared to those in the low-high group, while there were no significant differences in these between the low-high and low-low groups, suggesting that children in the high-high group were apparently advantaged in both their IQs and in environmental conditions compared with the low-high and low-low groups.

Table 2 further shows that children in the high-high group performed better than those in the low-low group on almost all tasks at all ages. However, for phonological and morphological skills, the low-high group performed differently at preschool and school ages. The low-high group performed similarly to the low-low group in preschool. However, this group differed significantly from the low-low group for syllable deletion at age 6 ($F(2, 261)=9.80$, $p< .001$) and on the tone detection task between age 7 ($F(2, 261)=5.56$, $p= .004$) and age 9 ($F(2, 260)=4.14$, $p= .017$). A similar pattern was found for the low-high group on morphological skills. The low-high group's scores on morphological construction were close to those of the low-low group in preschool but became significantly different from the low-low group on morphological production when children received formal education between ages 7 and 9. Detailed effect sizes are shown in Figure 2a.

The same trend for the low-high group can also be found in rapid digit naming and orthographic judgment tasks in the primary school (Table 2). That is, for the orthographic tasks, although there were no significant differences among the three groups at age 6, the low-high group's scores were significantly higher than those of the low-low group and similar to those of the high-high group at ages 7 and 8. A similar pattern was found for rapid digit naming.

Overall, then, the low-high group performed similarly to the low-low group across most cognitive tasks in preschool but became significantly higher than the low-low group and on par with the high-high group after entering school; in contrast, the high-high and low-low groups were consistent in their performances across tasks throughout childhood. This pattern reflects the vocabulary profiles themselves among the three groups over the same period.

Finally, these groups could also discriminate the three reading outcomes at 11 years old. To assess the predictive power of vocabulary growth for subsequent reading skills, correlations among mother's education level, non-verbal IQ, vocabulary intercept, vocabulary slope and reading skills (reading comprehension, reading fluency and character recognition) were calculated. Mothers' education levels, non-verbal IQ, vocabulary intercepts and slopes were all significantly correlated with the three reading outcomes (Table 3).

Hierarchical regression models further showed that controlling for mothers' education levels and non-verbal IQ, both vocabulary intercept and vocabulary slope from ages 4 to 10 uniquely explained the variations in reading comprehension, reading fluency and character recognition at age 11. Together, they explained approximately 16.0%, 17.4% and 15.8% of the total variation in each, respectively (Table 4). Moreover, the intercept and slope variables could explain 10.6%, 9.4% and 7.3% of the variance in reading comprehension, reading fluency and character recognition separately even after statistically controlling early phonological skills, morphological skills, and rapid naming (Table 5).

Discussion

In this 8-year longitudinal study, we investigated vocabulary development of Chinese children in relation to reading from age 4 to age 11. Three subgroups were clustered according to developmental trajectories of vocabulary growth (i.e., high-high group, low-high group, low-low group). The vocabulary knowledge of the high-high group was clearly distinguishable from those of both the low-high and low-low groups at age 4. Vocabulary knowledge of the low-high group and the low-low group were comparable at the start, but they were distinguishable after these children entered primary school, despite sharing a similar background vis-à-vis mothers' education levels. Similar patterns were also found in their development of cognitive skills. Furthermore, both the initial size and growth rate of lexical development predicted subsequent reading skills.

Most previous studies have examined the lexical developmental trajectories of children in early childhood (Bauer, Goldfield, & Reznick, 2002; Huttenlocher et al., 1991; Pan, et al., 2005; Rowe, et al., 2012; Vagh et al., 2009). Recently, more and more studies have been conducted to determine the vocabulary growth of school-age children and its relation to subsequent reading development (Verhoeven et al., 2011). However, fewer studies have attempted to trace children's vocabulary development from preschool to primary school. Children's vocabulary grows more rapidly after entering primary school and receiving formal reading instruction. Therefore, tracing children's vocabulary development from preschool to schooling is of great importance for understanding how family and school factors interact to influence children's lexical growth in the transition from pre-reader to reader. The present study has addressed this issue by modeling children's vocabulary growth in children from four-to ten-years of age and distinguished three heterogeneous subgroups.

Our results showed that the high-high group performed better than the low-high and low-low groups in vocabulary and cognitive skills prior to school entry, presumably due to the relatively high level of their mothers’ education. This finding is consistent with previous findings, suggesting that experience-related factors, such as mother's education in this study, may affect children's vocabulary growth in early childhood (Hoff, 2003; Rowe et al., 2009; Rowe et al., 2012). The present study's novel finding is that though similar to the low-low group during preschool, children in the low-high group are comparable to the high-high group in vocabulary and cognitive skills after entering primary school. This finding indicates that children's vocabulary and cognitive skills are closely related, and formal schooling may make up for temporary weaknesses of low-high group children in both domains. The relationship between vocabulary and cognitive skills (shown in Table 2 and Figures 2a and 2b) found in the present study is also in line with those from previous studies (e.g., Bowey, 2001; McBride-Chang et al., 2005).

Our results showed that vocabulary knowledge can predict later reading skills, including character recognition, reading fluency, and reading comprehension. To some extent, our findings lend support to Perfetti's (2009) DVC triangle model. Although there is substantial evidence showing the close relationship between vocabulary and reading skills, fewer studies have taken growth rate into consideration. Linear growth models have allowed us to identify the subgroups with different initial sizes and paces of vocabulary development. We found that both starting point and growth rate of vocabulary could predict a variety of later reading skills, including character recognition, reading comprehension and fluency.

Tracing children's vocabulary development over time and unraveling the longitudinal relations between vocabulary and reading skills may contribute to theories of Chinese literacy acquisition. In addition, the findings of the present study may shed light on educational practices relevant to early identification of children at risk for developing language and reading problems. Children who are relatively delayed in vocabulary knowledge in early childhood might still reach a normal level of vocabulary knowledge after they receive formal instruction. Early measures of both vocabulary and language-related cognitive skills are of great value for identifying children who are at risk for language and reading problems.

We are interested in the possible protective factors that enabled the low-high group to show faster growth on virtually all measures and overcome initial weaknesses. As shown in Figure 2a, children's performance on phonological awareness between the low-high group and the low-low group began to be differentiated from age 5. This difference continued and became larger at age 6. We could speculate that the differences in phonological awareness between the low-high and low-low groups may help us to differentiate them even before school entry. So phonological awareness may be a possible preschool protective factors that enabled the low-high group to catch up. After entering school, the development of other cognitive skills, such as morphological awareness and rapid digit naming, are possible protective factors for the low-high group children. Moreover, perhaps dynamic response-to-intervention interactions can also accurately distinguish children who will be able to catch up once they receive adequate instruction versus those who will continue to struggle with language and reading. In the present study, we can only give some descriptive explanations of the factors underlying the differences between the low-high group and the low-low group. Further studies will be needed to fully understand the catch-up or fall-behind changes in children's vocabulary and reading development.

The work presented here had some limitations. First, due to the fact that we had relatively few measurement points for the regression, the estimates of all intercepts and slopes used in the developmental trajectories might have been slightly less reliable than would be optimal. Second, in the scatter graph for individual intercepts and slopes, there were relatively few participants with both not a very low intercept (i.e., a relatively good performance to begin with) and a low slope (falling behind), so they were classified into the low-low group due to their small number and the data-driven method. We did not attempt to understand the characteristics of these high-low group children because of their relatively low prevalence overall. Future research studies on larger samples will be needed to unravel the characteristics of these high-low group children and the reasons for their falling behind afterwards. It should be noted that this study was only preliminary in tackling of the relations among vocabulary, cognitive skills, and reading skills. Because the relations among them are complex, they deserve further investigation in the future.

Conclusion

This study explored the long-term vocabulary development of Chinese children from ages 4 to 10 years. Three growth profiles with different starting points and growth trajectories were observed, namely a high-high group, a low-high group and a low-low group. Familial factors and reading or language related cognitive skills were found to be associated with these developmental subgroups. Meanwhile, both the initial size and growth rate of vocabulary from ages 4 to 10 could well predict children's reading level in fifth grade. These results highlight the importance of focusing on the combination of intercepts and slopes for understanding lexical development. Our findings on the characteristics of the low-high group may stimulate educators to explore better instruction for at-risk children.

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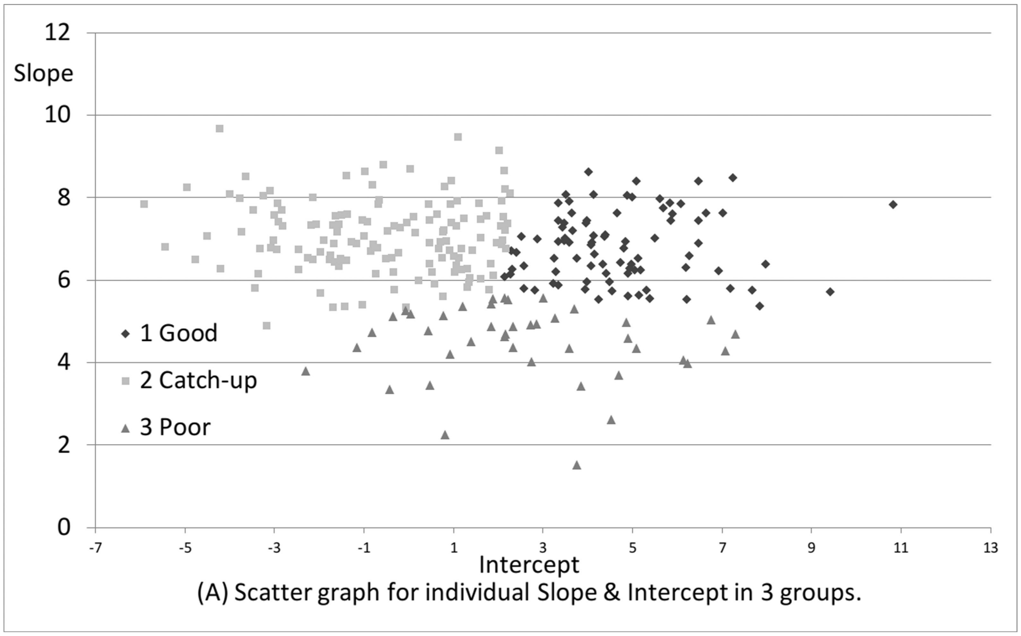


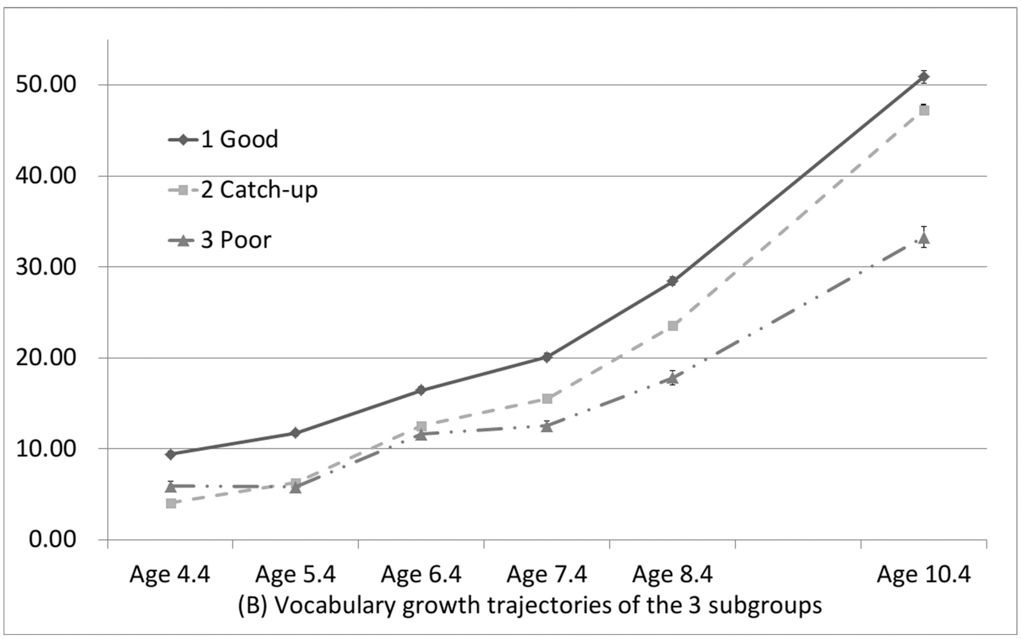
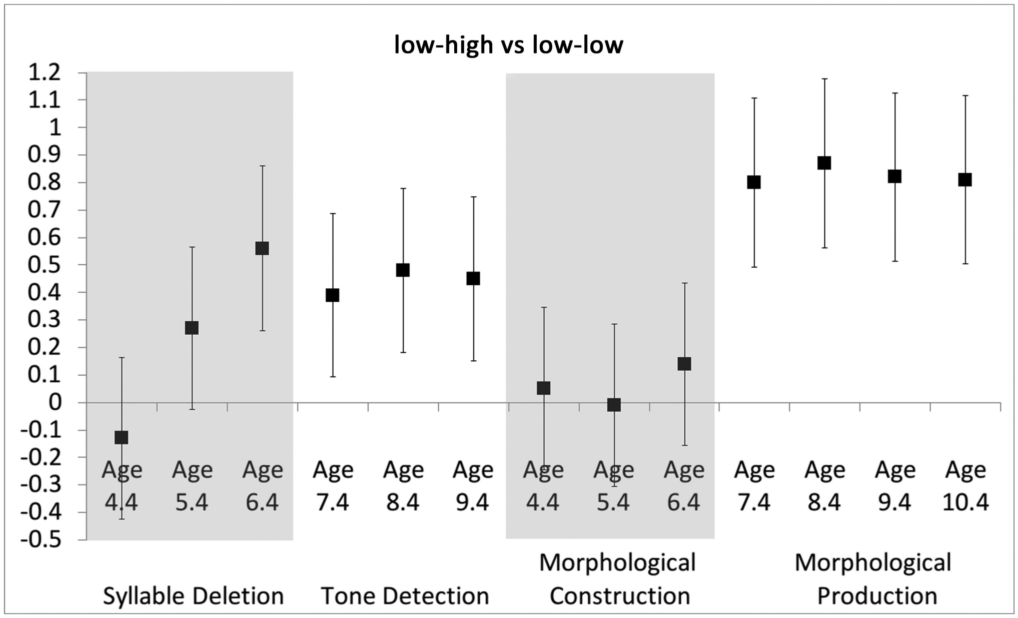
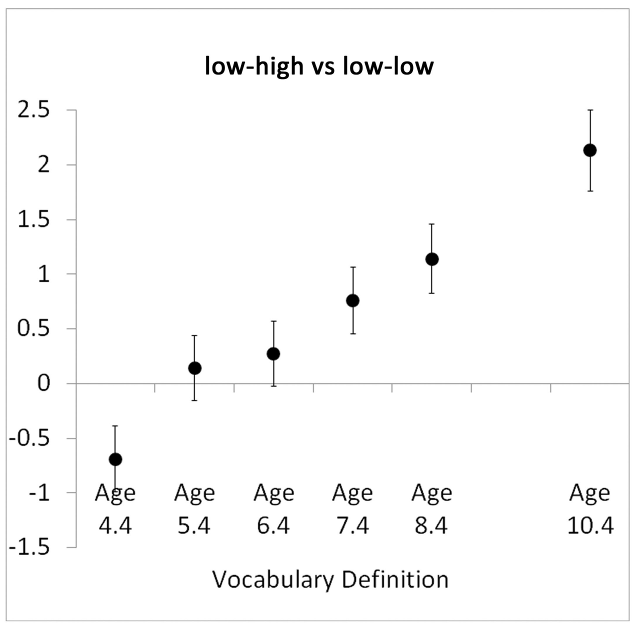


Figure 1.

Scatter graph and vocabulary growth trajectories of the 3 subgroups.



(a)



(b)

Figure 2.

Effect size (Cohen's *d*) for Low-high and Low-low in phonological and morphological skills, as well as vocabulary definition test.

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Table 1

Raw mean, standard deviation, reliability, skewness, and kurtosis statistics for different tasks

Measures	Max	Age(SD)	M(SD)	Range	Skewness	Kurtosis	Reliability (alpha)
VD	64	4.4(.28)	6.09(3.62)	0-19	.51	−.17	0.587
	64	5.4(.28)	7.97(3.98)	0-19	.19	−.36	0.679
	64	6.4(.27)	13.67(3.88)	3-27	−.09	.43	0.647
	64	7.4(.28)	16.55(4.81)	0-30	−.05	.72	0.718
	64	8.4(.27)	24.24(5.90)	7-39	−.14	−.01	0.762
	90	10.4(.28)	46.33(8.71)	10-69	−.62	1.35	0.775
SD	15	4.4(.28)	8.14(4.82)	0-15	−.42	−1.12	0.927
	15	5.4(.28)	11.92(3.07)	0-15	−1.46	2.32	0.853
	16	6.4(.27)	13.99(2.95)	2-16	−1.88	3.21	0.862
TD	24	7.4(.28)	17.30(4.85)	5-24	−.39	−.74	0.842
	24	8.4(.27)	17.97(4.96)	5-24	−.58	−.66	0.860
	24	9.4(.27)	19.75(4.49)	7-24	−1.19	.56	0.868
MC	15	4.4(.28)	10.15(3.24)	0-15	−1.20	1.34	0.818
	18	5.4(.28)	11.51(3.26)	1-18	−.58	.17	0.758
	17	6.4(.27)	10.65(3.25)	0-17	−.48	.47	0.730
MP	30	7.4(.28)	13.47(4.12)	0-24	.08	−.29	0.734
	30	8.4(.27)	17.02(4.12)	6-28	−.13	−.23	0.718
	30	9.4(.27)	20.56(3.60)	9-28	−.42	.04	0.608
	30	10.4(.28)	22.30(3.76)	9-30	−.54	.14	0.693
OJ	70	6.4(.27)	42.33(5.10)	20-62	1.54	4.59	0.946
	70	7.4(.28)	53.86(6.28)	36-65	−.49	−.45	0.928
	70	8.4(.27)	59.17(3.82)	44-67	−.97	2.09	0.838
RN	25 (items)	5.4(.28)	23.03(7.51)	9.41-49.13	.93	1.07	--
	25 (items)	6.4(.27)	17.18(5.27)	7.49-36.78	.97	1.16	--
	25 (items)	7.4(.28)	12.30(3.49)	4.99-26.10	1.07	1.58	--
	25 (items)	8.4(.27)	10.26(2.69)	3.48-20.22	.99	1.25	--
	25 (items)	9.4(.27)	8.59(2.30)	4.04-17.41	1.15	1.88	--
	25 (items)	10.4(0.28)	8.25(1.96)	4.04-16.74	1.10	2.03	--
CR	150	11.4(.28)	123.25(11.86)	68-144	−1.21	2.34	0.965
RF	2505	11.4(.28)	1145.91(404.27)	270-2425	.61	.44	0.970
RC	42	11.4(.28)	30.15(6.60)	0-42	−1.04	1.59	0.853
IQ	24	4.4(.28)	10.29(2.45)	5-21	.82	1.65	0.524

Note 1: VD=Vocabulary Definition, SD=Syllable Deletion, TD=Tone Detection, MC=Morphological Construction, MP=Morphological Production, OJ=Orthographic Judgment, RN=Rapid Digital Naming, CR=Character Recognition, RF=Reading Fluency, RC=Reading Comprehension, IQ=Nonverbal IQ.

Note 2: Data are reported for 264 children who entered school in the same year except for no more than 3 missing values on some measures.

Table 2

Participants' performance over time among the three groups.

	1 High-high (n=85)		2 Low-high (n=137)		3 Low-low (n=42)		
Variable	**M**	**SD**	**M**	**SD**	**M**	**SD**	**F(comparison)**
VD							
Age 4.4	9.40	2.96	4.09	2.47	5.93	3.16	97.54**(1>3>2)
Age 5.4	11.76	3.03	6.27	2.96	5.85	3.10	98.77**(1>2=3)
Age 6.4	16.48	3.22	12.55	3.47	11.63	3.28	44.28**(1>2=3)
Age 7.4	20.12	4.06	15.55	4.06	12.54	3.70	58.05**(1>2>3)
Age 8.4	28.45	4.18	23.55	4.99	17.85	5.04	71.81**(1>2>3)
Age 10.4	50.91	6.45	47.30	6.40	33.28	7.19	102.00**(1>2>3)
SD							
Age 4.4	9.52	4.51	7.34	4.85	7.98	4.82	5.59**(1>2)
Age 5.4	13.01	2.50	11.60	2.99	10.74	3.70	9.87**(1>2=3)
Age 6.4	14.71	2.29	14.06	2.84	12.33	3.79	9.80**(1>2>3)
TD							
Age 7.4	18.35	4.62	17.23	4.74	15.36	5.16	5.56**(1=2>3)
Age 8.4	18.29	4.96	18.36	4.84	16.00	5.01	3.94*(1=2>3)
Age 9.4	20.28	4.34	19.96	4.26	17.95	5.17	4.14*(1=2>3)
MC							
Age 4.4	11.87	1.92	9.37	3.25	9.19	3.97	20.39**(1>2=3)
Age 5.4	13.05	2.66	10.77	3.24	10.79	3.38	15.57**(1>2=3)
Age 6.4	11.81	3.18	10.20	2.97	9.76	3.67	8.80**(1>2=3)
MP							
Age 7.4	15.02	4.25	13.42	3.51	10.50	4.09	19.38**(1>2>3)
Age 8.4	18.68	3.53	17.01	3.75	13.61	4.43	24.72**(1>2>3)
Age 9.4	22.24	2.74	20.42	3.36	17.54	3.94	28.73**(1>2>3)
Age 10.4	23.95	3.14	22.16	3.45	19.25	4.04	25.52**(1>2>3)
OJ							
Age 6.4	42.51	5.72	42.45	4.98	41.57	4.13	<1(1=2=3)
Age 7.4	54.91	5.64	54.04	6.22	51.14	7.03	5.34**(1=2>3)
Age 8.4	59.67	3.46	59.48	3.32	57.12	5.26	7.45**(1=2>3)
RN							
Age 5.4	20.46	6.23	23.68	7.89	26.13	7.16	9.66**(1<2=3)
Age 6.4	16.61	5.51	17.01	5.00	18.90	5.44	2.82**(1<3)
Age 7.4	11.45	3.03	12.30	3.47	14.00	3.84	7.95**(1=2<3)
Age 8.4	9.58	2.20	10.21	2.71	11.85	2.98	10.46**(1=2<3)
Age 9.4	8.54	2.13	8.22	2.16	9.94	2.63	9.54**(1=2<3)
Age 10.4	8.04	0.84	8.06	0.97	9.32	1.14	7.39**(1=2<3)
CR[1]	126.54	9.63	123.26	11.18	116.23	15.18	11.09**(1>2>3)
RF[1]	1303.40	460.89	1126.00	339.48	883.27	331.71	16.81**(1>2>3)

	1 High-high (n=85)		2 Low-high (n=137)		3 Low-low (n=42)		
Variable	**M**	**SD**	**M**	**SD**	**M**	**SD**	**F(comparison)**
RC[1]	32.33	5.21	29.82	6.52	26.62	7.82	11.35**(1>2>3)
IQ[2]	11.12	2.67	9.77	2.11	10.33	2.62	8.44**(1>2)
ME	4.84	1.03	4.48	1.01	4.43	0.94	3.86**(1>2=3)

Note 1: ME=Mother's Education.

Note 2: Scores were calculated in seconds in the RN (Rapid Digit Naming task). Thus the quicker, the better.

[1]Tested at age 11.4.

[2]Tested at age 4.4.

Table 3

Correlations among backgrounds, intercepts and slopes of vocabulary definition development and reading outcomes at age 11.

	Mother Education	No-verbal IQ	Intercept	Slope	Age 11 RC	Age 11 RF	Age 11 CR
Mother Education	-						
No-verbal IQ	.261**	-					
Intercept	.271**	.291**	-				
Slope	.080	.074	−.173**	-			
Age 11 RC	.254**	.258**	.269**	.352**	-		
Age 11 RF	.280**	.212**	.240**	.386**	.530**	-	
Age 11 CR	.230**	.147*	.184**	.375**	.587**	.586**	-

Note:

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

Table 4

Hierarchical regression models using mother's education, non-verbal IQ, and intercept and slope of vocabulary development to predict reading comprehension, reading fluency and character recognition at age 11.

	Age 11 Reading Comprehension		Age 11 Reading Fluency		Age 11 Character Recognition	
Predictors	ΔR^2	β	ΔR^2	β	ΔR^2	β
1. Mother's Education	0.104	0.108†	0.099	0.147†	0.061	0.124*
Non-verbal IQ		0.123*		0.070		0.023
2. Intercept	0.160	0.268**	0.174	0.248**	0.158	0.211**
Slope		0.375**		0.405**		0.395**
	R^2=0.264		R^2=0.273		R^2=0.219	

Note:

† p<10.

* p<.05.

** p<.01.

Table 5

Hierarchical regression models using mother's education, non-verbal IQ, early language skills and intercept and slope of vocabulary development to predict reading comprehension, reading fluency and character recognition at age 11.

	Age 11 Reading Comprehension		Age 11 Reading Fluency		Age 11 Character Recognition	
Predictors	**Δ R^2**	β	**Δ R^2**	β	**Δ R^2**	β
1. Mother's Education	0.099	0.094	0.094	0.090	0.061	0.077
Non-verbal IQ		0.08		0.020		−0.051
2. Age 4.4 language skills						
PA	0.079	0.034	0.141	0.058	0.170	0.231**
MA		0.102		−0.007		0.133†
RN		−0.032		−0.263**		−0.06
3. Intercept	0.106	0.209**	0.094	0.190**	0.073	0.082
Slope		0.352**		0.333**		0.298**
	R^2=0.284		R^2=0.329		R^2=0.304	

Note:

PA: phonological awareness (syllable deletion at age 4); MA: morphological awareness (morphological construction at age 4); RN: rapid naming (rapid object naming at age 4).

† p<.10.

* p<.05.

** p<.01.