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The influence of early linguistic skills and family factors on literacy acquisition in Chinese children: Follow-up from age 3 to age 11

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ABSTRACT

The present longitudinal study investigated the predictive power of preschool linguistic skills and early family factors on children's comprehensive literacy skills at the end of primary school in 262 Chinese children. The results indicated that a substantial (20–34%) share of variance of 5th grade (age 11) literacy skills in Chinese could be explained by early family factors (age 3) and linguistic skills (age 3–age 5). Family socioeconomic status and parent-child reading tuition were associated with different literacy measures. A differential pattern of prediction was also observed among different literacy skills. Furthermore, path analyses indicated that the relationships between early family factors and literacy skills at age 11 were mediated by specific linguistic and cognitive skills at preschool.

1. Introduction

The early prediction of school-age literacy achievement is a long-standing issue. Research has demonstrated that a series of cognitive skills developed by pre-readers, as well environmental factors supporting the development of these skills laid the foundation for later literacy ability (Whitehurst & Lonigan, 1998). However, most longitudinal studies have focused on children's literacy development up to second grade (Hulme, Bowyer-Crane, Carroll, Duff, & Snowling, 2012; Kendeou, Van den Broek, White, & Lynch, 2009) and they have focused particularly on within-child cognitive factors, or on genetic vs. environmental contributions (Heath et al., 2014). Relatively few studies have explored the joint predictive effects of both early linguistic skills and family factors in the long-term from pre-reading to proficient reading at the end of primary school (Sénéchal, 2006). In the current study, a cohort of children tested at preschool at age 3 was followed for eight years. The main aim was to explore the long-term predictive power of both linguistic skills and early family environment on comprehensive literacy skills in proficient readers. A secondary aim was to test causal pathways between early linguistic skills, early family factors and subsequent literacy skills.

1.1. Early linguistic predictors of literacy skills

During the past decades, numerous studies have contributed to a better understanding of the early linguistic predictors of literacy acquisition (Georgiou, Torppa, Manolitsis, Lyytinen, & Parrila, 2012; Hulme et al., 2012; Kendeou et al., 2009; Lonigan, Burgess, & Anthony, 2000; Muter, Hulme, Snowling, & Stevenson, 2004;

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Roth, Speece, & Cooper, 2002; Wagner, Torgesen, & Rashotte, 1994). In general, differential prediction patterns for different literacy skills were observed. As for word reading ability, numerous longitudinal studies consistently demonstrated that phonological awareness, rapid automatized naming (RAN) and letter knowledge at preschool were precursors of subsequent word reading ability in preschool (Hulme et al., 2012; Lonigan et al., 2000; Muter et al., 2004) and in early primary school (Roth et al., 2002; Wagner et al., 1994). Studies on reading comprehension revealed that the key predictors were word decoding, vocabulary and listening comprehension (Kendeou et al., 2009; Roth et al., 2002). Phonological awareness, letter knowledge and RAN have been demonstrated to be important predictors of school-age spelling skill (Georgiou et al., 2012; Landerl & Wimmer, 2008; Savage, Pillay, & Melidona, 2008). Previous longitudinal studies have attempted to capture how early linguistic skills predict various literacy skills, but the majority of them have investigated such development over a relatively short period of time up to 2nd grade (Hulme et al., 2012; Kendeou et al., 2009; Lonigan et al., 2000; Muter et al., 2004; Roth et al., 2002; Wagner et al., 1994). However, children's reading and spelling abilities continue to develop over the entire period of school-age years, at least in languages with opaque orthographic systems, whether alphabetic (such as English or French) or not (e.g., Chinese). Relatively few studies have explored the long-term prediction of literacy development (Adlof, Catts, & Lee, 2010; Kirby, Parrila, & Pfeiffer, 2003; MacDonald & Cornwall, 1995). These studies either used correlation analysis (MacDonald & Cornwall, 1995) or focused on the prediction of reading disability (Adlof et al., 2010). The sample size of those studies was relatively small (from 24 to 79) (Kirby et al., 2003; MacDonald & Cornwall, 1995). Therefore, a larger-scale evaluation of the extent to which the predictive patterns of linguistic skills tested in preschool persist after several years of formal school instructions remains necessary.

1.2. Predictors of literacy skills in Chinese

A number of studies have consistently revealed the close relationship between phonological awareness (PA) and word reading ability across various alphabetic orthographies (Moll et al., 2014; Ziegler et al., 2010). However, the relationship between phonological awareness and reading in Chinese remains less clear. Several studies have reported a close link between phonological awareness (focusing on syllable awareness) and Chinese character recognition (e.g. McBride-Chang & Kail, 2002; Shu, Peng, & McBride-Chang, 2008). However, other studies showed no effect of phonological awareness (using a combination of phoneme and syllable awareness) on Chinese character reading (e.g. McBride-Chang et al., 2005; McBride-Chang, Shu, Zhou, Wat, & Wagner, 2003). These differences may be due to the different types of phonological awareness tasks (morpho-syllabic Chinese characters are more directly related to syllabic than to phonemic tasks), as well as to whether additional predictors of reading (e.g., morphological awareness) are included in the statistical models. Finally, a recent meta-analysis of 35 Chinese studies reflecting this diversity reported a moderate correlation ($r = 0.36$) between phonological awareness and word reading accuracy (Song, Georgiou, Su, & Shu, 2015). Thus it seems relevant to study longer-term effects of PA on reading development at a relatively mature stage. Besides, it is also necessary to examine the cognitive precursors of Chinese literacy development beyond the range of phonological awareness, given the features of Chinese orthography. Morphemic units are the most prominent characteristic of Chinese (Shu, McBride-Chang, Wu, & Liu, 2006). A wide range of Chinese studies have demonstrated that morphological awareness was associated with reading performance and dyslexia (Liu, McBride-Chang, Wong, Shu, & Wong, 2013; McBride-Chang et al., 2003; Shu et al., 2006). Moreover, Chinese writing is reputed for its visual complexity (Chen & Kao, 2002). Visual skills have been found to be essential for literacy development in Chinese children (Mcbride-Chang, Chow, Zhong, Burgess, & Hayward, 2005). Until now, several Chinese longitudinal studies have reported predictive effects of morphological awareness, visual skills and other linguistic skills on Chinese reading ability (Mcbride-Chang, Chow, et al., 2005; Mcbride-Chang & Ho, 2005; Tong et al., 2011). However, most of these studies focused on the short-term predictive effects in kindergartners, and on character recognition as the main indicator of reading skill. Relatively fewer studies have focused on predictors of spelling and reading comprehension (Zhang, McBride-Chang et al.,2012). Thus the present study aims to test the extent to which visual skills and morphological awareness, together with other linguistic and cognitive abilities tested before entering primary school, might predict children's literacy outcome, including Chinese character recognition, reading fluency, character spelling and reading comprehension, at a later stage of their development.

1.3. The role of the early family environment

Besides within-child linguistic skills, the early family environment plays a crucially important role in children's literacy development. Consequently, an extensive body of research has highlighted the importance of “socioeconomic status (SES)” in children's emergent literacy skills (Hoff, 2003; Noble, Farah, & McCandliss, 2006; Noble, McCandliss, & Farah, 2007; Rowe & Goldin-Meadow, 2009). Results from these studies consistently showed that children from high socioeconomic families had higher pre-reading and language skills prior to and upon entering formal schooling than those from low socioeconomic families. Other studies have explored the influence of more specific family factors, such as the early home literacy environment, on subsequent literacy acquisition (Deng, Silinskas, Wei, & Georgiou, 2015; Levy, Gong, Hessels, Evans, & Jared, 2006; Manolitsis, Georgiou, & Parrila, 2011; Shu, Li, Anderson, Ku, & Xuan, 2002, pp. 207–223; Sénéchal, 2006). One of the models that explain the role of home literacy environment in reading development is the home literacy model (Manolitsis et al., 2011; Sénéchal, 2006). According to the model, parent reading tuition promotes the development of early literacy skills, whereas storybook exposure promotes the acquisition of language skills. Compared with the abundant evidence on the importance of home literacy environment in alphabetic languages, studies exploring home literacy environment in Chinese children are relatively scarce (Deng et al., 2015; Li & Rao, 2000; Shu et al., 2002, pp. 207–223). For example, Deng et al. (2015) followed 177 Chinese children from Grade 1 to Grade 2 and they found no influence of home literacy environment in Grade 1 on reading in Grade 2. In another Chinese study, Shu et al. (2002, pp. 207–223) collected data on 276 first graders and 269 fourth graders and measured the home-literacy environment cross-sectionally along four dimensions (literacy resources at home, parent-child literacy-related activities, children's literacy-related activities and parents' education). They found that the four family factors could explain 10.3% and 17.5% of the variance in reading scores for the 1st and 4th graders, respectively (Shu et al., 2002, pp. 207–223). Here, we measured home literacy factors in the same way as in Shu et al.'s study, with the aim of examining whether they extend their effects on literacy skills to the end of primary school.

Furthermore, it is not easy to disentangle early family factors from early linguistic skills given that they tend to correlate with each other (Noble et al., 2007). In order to solve this problem and unravel the relationship between early linguistic skills, family factors and literacy skills, some studies have tested the impact of a

potential mediating role for early linguistic skills or experiences on the relation between early familial influences and later language and reading ability (Hood, Conlon, & Andrews, 2008; Manolitsis, Georgiou, & Tziraki, 2013; Rowe & Goldin-Meadow, 2009; Sénéchal, 2006; Zhang, Tardif et al., 2013). For example, one longitudinal study of fifty kindergartners showed that child gesture use at 14 months could mediate the relationship between SES and lexical development at 54 months, even after controlling for early child speech ability (Rowe & Goldin-Meadow, 2009). Manolitsis et al. (2013) also documented a mediating role of early literacy skills on the relation between home literacy environment and reading fluency in Grade 1. However, as children get older, their reading abilities meet increasing challenges (higher complexity of Chinese orthography), not only in word recognition, but most importantly in fluency, spelling and comprehension abilities, particularly in Chinese. It is therefore important to investigate the prediction of a broader range of reading abilities at more mature stages of development.

The present study thus extends previous studies in three directions: Firstly, it examines the specificity of predictive relationships between a set of diverse early linguistics skills and a wide range of mature literacy abilities (reading fluency, reading comprehension and word spelling) in addition to word reading ability. Secondly, it asks to what extent early family factors still exert some influence on mature reading abilities at 11 years of age. And finally, it tests to what extent the influence of family factors on each reading skill is mediated by specific early language skills.

2. Method

2.1. Participants

All the participants belonged to a large ongoing longitudinal study of Chinese language and literacy development that has started in China since 2000 (Tardif, Fletcher, Zhang, & Liang, 2008). The original sample size was 309. Every year we give a development report to each child and we maintain good relations with all the children and their parents. So there were still 293 children remaining in the study at age 11. Of the 293, we selected the 262 participants entering primary school in the same year who were in 5th grade at age 11. All 262 children were native Beijing people. Both their home and their school language environment were Mandarin Chinese, and they were rarely exposed to other Chinese dialects. All the children had normal nonverbal IQ, which was assessed at age 4 by the Raven's Progressive Matrices test (Raven, Court, & Raven, 1996). There were 143 boys and 119 girls. At the first measurement point, the mean age of the children was 3.4 years old (SD = 0.3). We obtained informed consent from all the participants and their parents.

2.2. Measures

Table 1 summarizes literacy skills in Grade 5, early linguistic skills (at their first measurement time points) and also early family background information.

2.2.1. Literacy measures at age 11

2.2.1.1. Character recognition. This task consisted of 150 single characters that were arranged in increasing difficulty level and decreasing frequency. Children were required to name the characters consecutively. There was no time limit and the test was terminated when the children failed in 15 successive items. This measure is widely used to represent Chinese children's reading accuracy skill (McBride-Chang & Kail, 2002; Pan et al., 2011).

2.2.1.2. Reading fluency. Following the procedure of a previous study in alphabetic language (Moll, Fussenegger, Willburger, & Landerl, 2009), this task consisted of one hundred sentences in order of increasing length. Children were required to read them silently in 3 min. Their task was to judge the meaning of each sentence as quickly as possible. For example, a sentence is “The sun rises in the west” or “Strawberries are very blue”. The characters and semantics of the sentences used in this task were designed to be simple. The total number of characters in correct sentences was calculated as child's reading fluency score.

2.2.1.3. Character spelling. In this dictation task, the experimenter orally presented 40 characters along with words including the target character. Children were required to write down the target character. 1 point was assigned for each correctly written item. Several studies have used this task as a measure of spelling ability in Chinese children (Pan et al., 2011; Zhang, Li et al.,2012).

2.2.1.4. Reading comprehension. Four passages were provided for the participants to complete. There were ten or more multi-choice questions after each passage. The children's task was to choose the best answer from the four options. Answers were presented in the form of single words, phrases or sentences (Zhang, McBride-Chang et al.,2013).

2.2.2. Early cognitive skills

2.2.2.1. Non-word repetition. Non-word repetition was measured at age 3. In this task, the participants were required to repeat 24 nonsense words from 1 to 4 syllables. Items were prerecorded by a native Mandarin speaker and presented by tape recorder. Each response was scored as 0, 1 or 2, according to a standard scoring scheme. This widely used non-word repetition task has been suggested as a reasonable index for phonological working memory (Lei et al., 2011; Nation & Hulme, 2011).

2.2.2.2. Receptive grammar. Receptive grammar was tested at age 3. The experimenter orally presented a phrase or a sentence to the participant (e.g., eating bread). The participant was required to select one picture that matched the description of the experimenter (e.g., drinking water, eating bread, drinking milk, eating banana). The test was similar to Bishop's (1979) Test for Reception of Grammar (TROG) and it was adapted for the Chinese children (Lei et al., 2011).

2.2.2.3. Syllable deletion. Syllable deletion was measured at age 4. Children's task was to omit one syllable from orally presented words (e.g. /mian4 bao4/, “bread”, without the syllable /bao1/ would be /mian4/, “flour”; /hong2 yan2 se4/, “red color”, without /hong2/ would be /yan2 se4/, “color”). The test consisted of seven 2-syllable and eight 3-syllable experimental trials. This task has been widely used in several studies of Chinese children (Shu et al., 2008; Zhang, Tardif et al.,2013).

2.2.2.4. Morphological construction. This task was given at age 4. The children's task was to combine separate morphemes they knew into a new compound word. For example, a board with black color is called blackboard (/hei1 ban3/, /hei1/ means black and /ban3/ means board). If the color of the board was white, what could it be called? The answer should be whiteboard (/bai2 ban3/, /bai2/ means white and /ban3/ means board). The morphological construction task has been suggested to be a reliable proxy for morphological awareness in Chinese children (McBride-Chang et al., 2008).

2.2.2.5. Rapid automatized naming (RAN). This rapid automatized

Table 1
Descriptive statistics for 5th grade literacy skills and early linguistic and family factors.

Measures	Range	Mean(S.D.)	Skewness	Kurtosis	Reliability
5th grade literacy skills					
Character recognition (items correct/150)	68–144	123.3(11.9)	−1.2	2.3	0.97
Reading fluency (characters/3 min)	270–2577	1151.4(413.1)	0.7	0.7	0.97
Character spelling (items correct/40)	6–38	24.3(7.0)	−0.3	−0.5	0.90
Reading comprehension (items correct/42)	0–42	30.2(6.6)	−1.0	1.6	0.85
Early linguistic skills					
Non-word repetition (score/24)	1–22	11.9(4.9)	0.0	−0.7	0.83
Receptive grammar (items correct/86)	0–80	59.4(12.5)	−1.4	3.1	0.91
Syllable deletion (items correct/15)	0–15	8.1(4.8)	−0.4	−1.1	0.97
Morphological construction (items correct/15)	0–15	10.2(3.2)	−1.2	1.4	0.82
Rapid automatized naming (items/s)	0.4–2.3	1.2(0.3)	0.5	0.1	0.77
Vocabulary (score/64)	0–19	6.1(3.6)	0.5	−0.2	0.58
Visual-spatial relationships (items correct/16)	1–16	11.4(3.7)	−1.0	0.5	0.92
Early family factors					
Mothers' education	1–7	4.6(1.0)	0.1	0.2	–
Fathers' education	3–7	4.7(1.1)	0.3	−0.7	–
Mothers' income	1–6	4.1(1.4)	−0.6	−0.9	–
Fathers' income	1–6	4.9(1.0)	−1.6	3.3	–
Number of adults' books	1–6	4.7(1.5)	−0.9	0.0	–
Number of children's books	1–6	4.3(1.2)	−0.3	−0.2	–
Parents' reading habit (days/week)	1–5	4.5(1.1)	−2.0	2.5	–
Parents' reading habit (hours/day)	1–6	3.1(1.0)	0.3	0.1	–
Character teaching age	1–6	4.0(1.0)	−0.6	0.6	–
Reading teaching age	1–6	4.6(1.2)	−1.0	1.3	–

naming task was measured at age 4. Participants were presented with an A4 paper consisting of 5 different line drawings of objects (e.g., apple, monkey, rainbow, pencil, watermelon). These five items were repeated 5 times in random order and they were all 2-syllable Chinese words. The participants were required to state all the objects as rapidly as possible, twice in two separate measures. Then the mean time of the two separate measures was obtained. Finally, we calculated the number of correct items per second as the score for this task. This task has been successfully applied in previous studies (Pan et al., 2011).

2.2.2.6. Vocabulary. The vocabulary task was assessed at age 4. Children were orally presented with 32 words representing objects or concepts ordered by increasing conceptual difficulty. The task was to explain the meaning of each word. The full mark for each item was 2. Two experimenters rated the answers of the children. Pilot tests showed that the inter-rater reliability between the two experimenters was high ($r > 0.9$). Previous studies have also suggested this vocabulary definition task as a proper indicator for vocabulary knowledge (McBride-Chang et al., 2005; Pan et al., 2011; Song, Su, et al., 2015).

2.2.2.7. Visual-spatial relationships. This task was administered at age 5. It was taken from the subtest of the Test of Visual–Perceptual Skills (Non-Motor) –revised (Gardner, 1996). It consisted of 16 test items. In each trial, children were visually presented with 5 black and white line drawings. Children were required to select one that had a different orientation with the other four pictures. This task has been widely used to test Chinese children's visual-processing skills (Mcbride-Chang, Chow, et al., 2005; McBride-Chang et al., 2011).

2.2.3. Early family factors

Parents' education and income level was collected from the mothers of the particits after they gave birth to the children. Questions on the home literacy environment were asked when children were 3.37 years old on average.

2.2.3.1. Parents' education level. This family factor was measured with a seven-point scale: 1 = below Grade 3, 2 = Grade 4 to Grade 6, 3 = junior high school, 4 = senior high school, 5 = junior college, 6 = undergraduate school and 7 = graduate school.

2.2.3.2. Parents' income level. Parents' income level was measured on a six-point scale: 1 = lower than 300, 2 = 300 to 499, 3 = 500 to 999, 4 = 1000 to 1,999, 5 = 2000 to 8999 and 6 = higher than 9000 Chinese Renminbi (RMB) per month.

2.2.3.3. Number of books at home. Numbers of adults' and children's books at home (when children were 3) were measured by two six-point scales: 1 = 0 to 5, 2 = 6 to 10, 3 = 11 to 25, 4 = 26 to 50, 5 = 51 to 100 and 6 = more than 100 adults'/children's books.

2.2.3.4. Parents' reading habits. Two questions were asked about parents' reading habit at home. First, on how many days in a week do you usually read books or magazines? 1 = 0 day, 2 = 1–2 days, 3 = 3–4 days, 4 = 5–6 days and 5 = 7 days. Second, for how long do you read each time? 1 = 0–10 min, 2 = 11–30 min, 3 = 31–60 min, 4 = 1–2 h, 5 = 2–4 h and 6 = more than 4 h.

2.2.3.5. Parent-child reading tuition. Parents were asked about the time when they began (or planned to begin) teaching their child Chinese characters and Chinese reading respectively. These were measured by two six-point scales when children were at the age of 3. The choices were 1 = have no plan, 2 = after 4 years old, 3 = 3–4 years old, 4 = 2–3 years old, 5 = 1–2 years old and 6 = 0–1 year old.

2.3. Statistical analysis

In order to reduce the 10 variables representing children's early family characteristics, an exploratory factor analysis was performed to determine the main sources of variance. Based on the resulting factors, components were computed as mean z-scores of the variables with highest loadings.

The main aim of this study was to assess the predictive pattern of early linguistic skills and family factors for literacy development in Grade 5. Thus our main analytical approach was linear regression analysis. In a first step, in order to examine the separate

contribution of early linguistic skills and family factors to subsequent literacy performance, univariate linear regression analysis was used, with each of the four literacy measures at Grade 5 as dependent variable, and the early linguistic skills and family factors as independent variables. As previous studies showed significant association between age, sex and nonverbal IQ with later literacy development, all analyses were a priori adjusted for the following variables: sex, age and non-verbal IQ at age 4. In a second step, family factors that showed significant association ($p < 0.05$) with each literacy measure were entered into simultaneous multiple linear regression models (hierarchical linear regression models), then early linguistic skills were added. In order to estimate the risk of multicollinearity, we checked the *tolerance* and *VIF* values of the early linguistic skills in the regression analysis. Finally, in order to clarify the relationships between family factors and literacy acquisition, we performed path analyses with linguistic skills as mediating variables. Furthermore, a secondary path analysis investigated to what extent the effect of early linguistic skills on later literacy skills are mediated by early literacy skills. In order to test the significance of mediation effects, bias-corrected bootstrapping was performed (McCartney, Burchinal, & Bub, 2006). This method directly produces confidence intervals from percentiles. In this study, we chose 95% confidence intervals. MacKinnon, Lockwood, and Williams (2004) demonstrated that, in small to moderate-sized samples, the bias-corrected bootstrapping method could provide the most accurate confidence intervals and the greatest statistical power to detect the mediation effect.

3. Results

In Table 1, Means, SDs, range and other descriptive statistic information are reported. Generally, most of the measures followed a normal distribution with reasonable skewness and kurtosis, and all tasks showed relatively high reliabilities.

Table 2 displays the results of the exploratory factor analysis for the early familial variables. Three factors explaining 58.27% of the total variance (first component = 32.26%; second component = 15.11%; third component = 10.54%) were obtained. Based on the highest loadings, the first component mainly consisted of 4 measures (number of adults' books, number of children's books, parents' reading habit in days and parents' reading habit in hours) reflecting parents' reading habits and more generally the home literacy environment. The second component mainly consisted of 4 measures (mothers' income, fathers' income, mothers' education and fathers' education) representing family socioeconomic status (SES). The final component mainly consisted of 2 measures (character teaching age and reading teaching age) representing reading tuition at home. Based on this exploratory factor analysis, three components (literacy environment, family SES and reading tuition) were calculated as the mean standard scores of the corresponding measures indicated above. These three components were used as early family factors in further analyses.

Table 3 describes the correlations among the family factors, early predictors and the reading outcome. Early family factors and linguistic skills were significantly correlated with later literacy skills in most cases, suggesting that early familial and linguistic factors are predictive of reading outcome at age 11.

To investigate how early cognitive skills and family factors each contributed to the four 5th grade literacy skills, we performed univariate regression analyses for each dependent variable, controlling for sex, age and non-verbal IQ. R^2 change and standardized *beta* coefficients for each variable are reported in Table 4. Table 4 indicates that when sex, age and non-verbal IQ were statistically controlled, family socioeconomic status (SES) was a significant predictor for character recognition, reading fluency, character spelling and reading comprehension, with about 3–5% variance explained. Reading tuition was also a significant predictor for reading fluency and reading comprehension. However the literacy environment did not significantly contribute to any literacy skill. As for early cognitive skills, almost all of them explained some variance in each of the four literacy measures, except for the non-significant associations between non-word repetition and reading comprehension, and between receptive grammar and spelling.

In the next step, we carried out multivariate regression analyses (Table 5) for the four 5th grade literacy skills with sex, age and IQ included in the first step. The family factors that were significant in the univariate regression models were then entered in the second step, and early linguistic skills in the third step. While family factors continued to explain overall about 5% of literacy skills, only SES remained a marginally significant predictor ($p = 0.08$) of subsequent character spelling ability. In contrast, with all demographic and family factors statistically controlled, early linguistic skills uniquely explained substantial amounts of variance in character recognition (18.6%), reading fluency (18.0%), character spelling (10.8%) and reading comprehension (10.0%). Most interestingly, the predictive pattern of early linguistic skills differed according to each literacy skill. More specifically, the strongest predictor of character recognition was syllable deletion and morphological construction (all $ps \leq 0.05$). RAN and vocabulary were the two significant predictors for reading fluency (all $ps < 0.05$). The predictors of reading comprehension were morphological awareness and visual-spatial skills (all $ps < 0.05$). Finally, character spelling was best predicted by phonological awareness and visual-spatial skills (all $ps < 0.05$). Furthermore, sex was significantly positively related with reading fluency and reading comprehension, with girls performing better than boys in these two semantic-related reading

Table 2
Loading coefficients on all familial variables in the factor analysis.

Measures	Component		
	1. Literacy environment	2. SES	3. Reading tuition
Number of adults' books	**0.706**	−0.363	0.315
Number of children's books	**0.677**	−0.159	0.324
Parents' reading habit in days	**0.667**	−0.064	0.156
Parents' reading habit in hours	**0.660**	0.008	0.188
Mothers' income	0.149	**−0.795**	−0.025
Fathers' income	−0.035	**−0.742**	0.230
Mothers' education	0.599	**−0.639**	0.055
Fathers' education	0.560	**−0.634**	0.068
Character teaching age	0.203	−0.046	**0.834**
Reading teaching age	0.356	−0.140	**0.779**

Note: Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalization.
The highest loading of each variable is shown in bold.

Table 3
Correlations among family factors, early predictors and literacy skills at age 11.

Measures	SES	Age 3 LE	Age 3 RT	Age 3 NWR	Age 3 RG	Age 4 SD	Age 4 MC	Age 4 RAN	Age 4 VOC	Age 5 VSR	Age 11 CR	Age 11 RF	Age 11 CS	Age 11 RC
SES	–													
Age 3 LE	-0.025	–												
Age 3 RT	-0.010	0.010	–											
Age 3 NWR	0.132*	-0.103	-0.010	–										
Age 3 RG	0.231**	0.144*	0.060	0.193**	–									
Age 4 SD	0.179**	0.153*	0.146*	0.225**	0.200**	–								
Age 4 MC	0.159*	0.247**	0.094	0.191**	0.328**	0.542**	–							
Age 4 RAN	0.186**	0.179**	0.211**	0.131*	0.157*	0.279**	0.334**	–						
Age 4 VOC	0.212**	0.183**	0.155*	0.090	0.237**	0.224**	0.395**	0.330**	–					
Age 5 VSR	0.180**	0.183**	0.027	-0.044	0.230**	0.143*	0.194**	0.182**	0.191**	–				
Age 11 CR	0.206**	0.030	0.058	0.209**	0.213**	0.388**	0.378**	0.267**	0.254**	0.211**	–			
Age 11 RF	0.180**	0.073	0.129*	0.146*	0.190**	0.254**	0.287**	0.450**	0.340**	0.171**	0.570**	–		
Age 11 CS	0.197**	0.093	0.045	0.155*	0.116	0.293**	0.267**	0.243**	0.169**	0.222**	0.736**	0.427**	–	
Age 11 RC	0.165**	0.074	0.098	0.093	0.144*	0.224**	0.305**	0.231**	0.269**	0.229**	0.572**	0.469**	0.383**	–

Note: Partial correlation controlling for sex, age and IQ. $^{*}p < 0.05$. $^{**}p < 0.01$. LE = literacy environment; RT = reading tuition; NWR = non-word repetition; RG = receptive grammar; SD = syllable deletion, MC = morphological construction, RAN = rapid automatized naming, VOC = vocabulary, VSR=Visual-spatial relationships, CR = character recognition, RF = reading fluency, CS = character spelling, RC = reading comprehension.

Table 4
Univariate regression analysis of 5th grade literacy skills using early family factors and early linguistic skills as predictors.

Measures	Character recognition		Reading fluency		Character spelling		Reading comprehension	
	ΔR^2	*Beta*	ΔR^2	*Beta*	ΔR^2	*Beta*	ΔR^2	*Beta*
Control variables								
Sex	0.013	0.102	0.049**	0.213**	0.010	0.085	0.024*	0.144*
Age	0.013	0.081	0.002	−0.012	0.021*	0.111	0.002	−0.021
Age 4 non-verbal IQ	0.013	0.119	0.041**	0.210**	0.013	0.117	0.061**	0.257**
Early family factors								
SES	0.047**	0.224**	0.044**	0.216**	0.050**	0.232**	0.032**	0.186**
Age 3 literacy environment	0.000	0.021	0.005	0.075	0.008	0.093	0.004	0.064
Age 3 reading tuition	0.011	0.105	0.031**	0.176**	0.008	0.092	0.021*	0.145*
Early linguistic skills								
Age 3 non-word repetition	0.042**	0.217**	0.019*	0.148*	0.023*	0.161*	0.008	0.094
Age 3 receptive grammar	0.044**	0.223**	0.033**	0.193**	0.013	0.121	0.019*	0.146*
Age 4 syllable deletion	0.145**	0.405**	0.059**	0.258**	0.082**	0.305**	0.046**	0.228**
Age 4 morphological construction	0.137**	0.397**	0.075**	0.293**	0.068**	0.280**	0.085**	0.312**
Age 4 rapid object naming	0.068**	0.278**	0.184**	0.455**	0.056**	0.252**	0.049**	0.235**
Age 4 vocabulary	0.062**	0.266**	0.105**	0.345**	0.027**	0.176**	0.066**	0.274**
Age 5 visual-spatial relationships	0.043**	0.219**	0.026**	0.172**	0.047**	0.230**	0.048**	0.231**

Note: $^{*}p < 0.05$. $^{**}p < 0.01$.

Table 5
Simultaneous multiple regression analysis of 5th grade literacy skills using early family factors and early linguistic skills as predictors.

Measures	Character recognition		Reading fluency		Character spelling		Reading comprehension	
	ΔR^2	*Beta*	ΔR^2	*Beta*	ΔR^2	*Beta*	ΔR^2	*Beta*
1. Control variables	0.039*		0.092**		0.043*		0.088**	
Sex		0.085		0.173**		0.075		0.131*
Age		−0.023		−0.085		0.047		−0.077
Non-verbal IQ		−0.108		−0.012		−0.068		0.076
2. Early family factors	0.047**		0.064**		0.050**		0.046**	
SES		0.059		0.038		0.117		0.051
Age 3 literacy environment		–		–		–		–
Age 3 reading tuition		–		0.046		–		0.058
3. Early linguistic skills	0.186**		0.180**		0.108**		0.100**	
Age 3 non-word repetition		0.115		0.062		0.098		0.041
Age 3 receptive grammar		0.035		0.042		−0.047		−0.017
Age 4 syllable deletion		0.222**		0.067		0.160*		0.042
Age 4 morphological construction		0.148†		0.029		0.091		0.165*
Age 4 rapid object naming		0.087		0.329**		0.111		0.072
Age 4 vocabulary		0.072		0.165*		0.007		0.121
Age 5 visual-spatial relationships		0.114		0.046		0.157*		0.146*
	$R^2 = 0.272$		**$R^2 = 0.336$**		**$R^2 = 0.201$**		**$R^2 = 0.234$**	

Note: $^{\dagger}p = 0.05$. $^{*}p < 0.05$. $^{**}p < 0.01$.

measures. The *tolerance* and *VIF values* indicated that multicollinearity was not a problem in the current study (Table S2).

To further disentangle the relationships between family factors and later literacy, we performed path analyses to test the mediation effects of early linguistic skills. Indeed, the fact that the contribution of early family factors (observed in univariate regressions) was generally reduced and became non-significant when entering early linguistic skills in the simultaneous regressions suggested that the relation between early family factors and later literacy skills might be mediated by early linguistic cognitive skills. Therefore, in the next path analyses, we included early linguistic skills with significant effects in the multivariate regressions and early family factors with significant effects in the univariate regressions. Fig. 1 depicts the mediation effects of early linguistic skills on the relationship between early family factors and later character recognition (Fig. 1A, Model A), reading fluency (Fig. 1B, Model B), character spelling (Fig. 1C, Model C) and reading comprehension (Fig. 1D, Model D). In the path analysis models, no direct effect of early family factors on later literacy skills were found (this result is concordant with the results of the multivariate analysis, see Table 5). Mediation effects of early linguistic predictors on the relation between early family factors and later literacy skills were found in Models A, B, C and D (solely for the relationship between SES and RC). To test the significance of the indirect effects, bootstrapping procedures were used (McCartney et al., 2006; Rowe & Goldin-Meadow, 2009). This provided 95% confidence intervals (sum of the two indirect effects in each model, corrected for bias) for character recognition (0.100–0.288; Model A), reading fluency (0.124–0.332 for SES to RF; 0.040–0.218 for RT to RF; Model B), character spelling (0.092–0.242; Model C) and reading comprehension (0.087–0.260 for SES to RC; Model D). As these intervals do not include zero, they indicate a significant mediation effect.

Detailed results of the secondary path analysis are reported in supplementary material. Overall they show that the effects of early linguistic skills on Grade 5 literacy skills are partly, but not entirely, mediated by early literacy skills (as measured in Grade 1).

4. Discussion

In the present study, we sought to examine the familial and early cognitive precursors of four different literacy skills in 5th grade. Our findings suggest that early linguistic skills and family factors, together with age, sex and non-verbal IQ, all measured between ages 3 and 5, jointly account for about 20–34% of the variance in 5th grade literacy achievement. Specific prediction patterns depended on each of the four outcome literacy measures. Furthermore, the associations between family factors and literacy skills were almost entirely mediated by early linguistic skills. More specifically, phonological awareness and morphological awareness at age 4 mediated the relation between early family SES and character recognition at age 11; RAN and vocabulary at age 4 mediated the association between early family factors (SES and parent-child reading tuition) and reading fluency at age 11; age 4 phonological awareness and age 5 visual skills mediated the association between early family SES and spelling at age 11; age 4 morphological awareness and age 5 visual skills mediated the relationship between family SES and reading comprehension.

In line with previous longitudinal study exploring the predictors of literacy ability in alphabetic orthographies (Roth et al., 2002), we found a relatively high (20–34%) predictive power of preschool linguistic skills and early family factors on 5th grade literacy skills. This highlights the long-lasting impact of early literacy skills and environment on later literacy achievement (Whitehurst & Lonigan, 1998). Most previous studies have examined the prediction of reading skills in lower grade students who were still relatively unskilled readers when tested (Hulme et al., 2012; Lonigan et al., 2000; Muter et al., 2004). However, less was known about higher grade students with a higher proficiency level. Children's literacy skills develop rapidly once they receive formal school education. They become increasingly proficient in not only low-level word reading skills but also in high-level reading fluency and comprehension. In the present study, we have filled this gap by tracing children's early linguistic skills to later literacy skills, and we have shown that substantial long-term predictive effects remain, at least

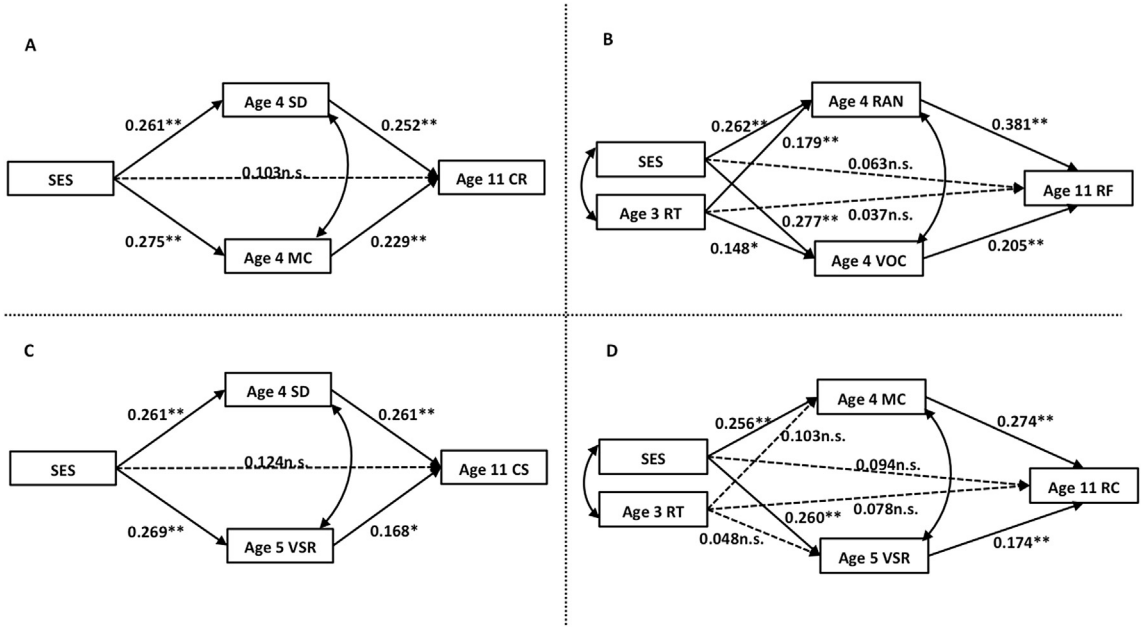

Fig. 1. Mediation effects of early linguistic skills on the relation between early family factors and later literacy skills. Note: The coefficient above the arrow indicates the standardized regression parameter estimate. SES = socioeconomic status, RT = reading tuition, SD = syllable deletion, MC = morphological construction, RAN = rapid automatized naming, VOC = vocabulary, VSR=Visual-spatial relationships, CR = character recognition, RF = reading fluency, CS = character spelling, RC = reading comprehension. $^{*}p < 0.05$. $^{**}p < 0.01$. n.s. not significant (at the $p < 0.05$ level).

in Chinese whose reading and writing takes many years to master.

The acquisition of literacy involves some mechanisms that are shared across cultures and some that are specific to each culture (McBride-Chang & Kail, 2002). In order to explore the specific linguistic predictors of literacy skills in a non-alphabetic language, we administered a broad battery of linguistic tests, including non-word repetition, receptive grammar, phonological awareness, RAN, vocabulary, which are typical precursors of literacy in alphabetic languages, as well as morphological awareness and visual skills, which are two skills that are more particularly relevant to the Chinese language (Liu et al., 2013). Like in alphabetic languages (e.g., Moll et al., 2014), we found that different literacy skills were predicted by different early linguistic skills. Furthermore, the specific predictive patterns observed are largely consistent with those reported in alphabetic languages. More specifically, we found that phonological awareness, together with morphological awareness, both tested at age 4, were the most important contributors to Chinese character recognition ability in 5th graders. These findings are compatible with previous longitudinal studies in Chinese language (Chow, McBride-Chang, & Burgess, 2005; McBride-Chang et al., 2003; Tong et al., 2011), as well as with studies showing the importance of phonological awareness for word reading in alphabetic languages (Hulme et al., 2012; Muter et al., 2004). Secondly, RAN at age 4 was an important predictor of reading fluency, again in line with previous longitudinal studies in both Chinese (Pan et al., 2011) and alphabetic languages (Moll et al., 2014; Ziegler et al., 2010). Although the effect of vocabulary on reading fluency may seem slightly surprising, one should recall that the reading fluency task used in the present study required checking the meaning of sentences. Although the sentences were short and simple, they still required children to recognize and integrate the meaning of words within a short time. It is therefore likely that vocabulary could be a performance factor in this task. As for character spelling and reading comprehension, visual skills were an important predictor for both. This is not so surprising given the visual skill demands of these relatively difficult Chinese literacy tasks (Tong et al., 2011). Indeed, Chinese characters are composed of more strokes than Roman letters on average (1–64 strokes), arranged in visually complex arrays. Thus storing the spelling of a single character imposes high demands on visual memory, and reading a typical sentence involves the fluent recognition of many such characters. Moreover, Chinese children learn to read using a "look-and-say" method (McBride-Chang et al., 2005), such that visual skills play an essential role in Chinese children's text reading development. In addition, syllable awareness contributed to spelling and morphological awareness contributed to reading comprehension, which is consistent with several previous studies (Landerl & Wimmer, 2008; Nikolopoulos, Goulandris, Hulme, & Snowling, 2006; Zhang, McBride-Chang et al., 2012; Shu et al., 2006). However, we did not find that morphological awareness predicted spelling like in alphabetic languages (Casalis, Deacon, & Pacton, 2011; Sénéchal, Basque, & Leclaire, 2006). This can be understood given the role of morphological awareness in Chinese spelling and the nature of the morphological awareness task that we used (morphological construction). According to previous studies in Chinese, there are several different aspects of morphological awareness (McBride-Chang et al., 2003; Shu et al., 2006), with lexical compounding awareness and homophone awareness being the two most important ones (Liu et al., 2013; McBride-Chang et al., 2003). Lexical compounding awareness (tested with the morphological construction task) refers to the ability to understand the morphemic structure in compound words. Homophone awareness reflects the ability to discriminate among homophones with different meanings, and this was not tested in the present study. Yet, there are good reasons to think that homophone awareness is more directly related to spelling skill in Chinese than lexical compounding awareness is. Indeed, in the character dictation test, a target character was orally presented to children within a 2- or 3-character word. Since there are numerous homophones in Chinese characters, the children have to discriminate among the homophones with different meanings and write down the one with the target meaning. In this situation, homophone awareness plays a more essential and direct role than lexical compounding awareness (e.g. Pan et al., 2016). Thus, while we did not find a link between morphological awareness and spelling in the present study, it is not impossible that such a link could be found by using a homophone awareness task instead of a lexical compounding task. These results imply that these early measures do not just reflect overlapping processes, but rather specific cognitive and linguistic skills that each have a specific impact on literacy outcomes. Overall, while the prominent contributions of morphological and visual skills reflect the specific characteristics of the Chinese language (e.g. between morphological/visual skills and reading comprehension), the results of this study also reflect the universality of some mechanisms of literacy acquisition, e.g., between phonological awareness and word recognition and spelling, or between RAN and reading fluency (Moll et al., 2014).

Univariate regression analyses in the present study demonstrated the importance of familial influences on later literacy ability. Among all family factors, SES (composed of parental education and income) was the most significant predictor. Although this is in line with a large body of previous studies on the correlation between SES and language or reading development in early childhood (Noble et al., 2007), it may seem surprising that such a general factor as SES should dominate much more specific predictors of literacy, such as the home literacy environment and reading tuition at home. This may suggest that SES has effects on long-term literacy skills that are not mediated exclusively by the early family environment. Another possibility would be that our measures of the home literacy environment fail to capture all the relevant variance. Finally, it may also be that the share of variance in literacy skills explained by SES does not exclusively reflect environmental factors: it may also reflect the transmission of genetic predispositions that happen to be correlated with SES (Plomin & Bergeman, 1991; Trzaskowski et al., 2014). A novel finding of the present study is the relationship between parent-child reading tuition and reading fluency and comprehension tasks in Grade 5. To some extent, this result is an extension of Shu et al.'s study (2002) in which parent-child literacy-related activities was a unique contributor to first graders' reading ability. On the one hand, this study confirms the role of early parent-child reading tuition; on the other hand, it extends the impact of this family factor to older children, suggesting long-lasting effects of parent-child reading tuition.

It is of interest to note that the association between family factors and later literacy skills gets weaker when taking early linguistic skills into consideration. Path analyses confirmed that the relationship between the early family factors and subsequent literacy ability appeared to be mediated by early linguistic skills, consistent with several studies showing similar effects on emergent reading and language skills (Hood et al., 2008; Manolitsis et al., 2013; Rowe & Goldin-Meadow, 2009; Zhang, Tardif et al.,2013). An important contribution of the present study is to explore the indirect effects of early family factors on comprehensive literacy skills in 5th grade over such a long time period as 8 years. These results show that there is nothing mysterious about the action of the early family environment, and that there is no opposition between the family environment and the child's early linguistic skills. Rather, the early linguistic and cognitive skills are the main mechanism through which the early family environment exerts its influence on later literacy achievement. This reinforces the idea that, whereas it

may be difficult to significantly improve the early family environment of some children, intervening more directly on their linguistic and cognitive skills is both feasible and possibly the best way to compensate for environmental disadvantages.

Similarly, while the main result of the present study is the long-lasting effect of children's preschool linguistic skills on their later literacy skills in 5th grade, it is also interesting to investigate mediating factors between these two measurement occasions. Do early differences in children's precursor skills manifest themselves in early differences in literacy skills that then remain stable across elementary school? Or do early linguistic skills have long-term effects beyond those on early literacy skills? To address this question, we included early reading skills in Grade 1 as predictors of later reading skills, and tested whether early predictors might explain additional variance (Table S1). Furthermore, mediation models were performed, to test the mediation effects of early reading skills on the relation between early predictors and later reading skills (Figure S1 & Figure S2). We found that Grade 1 character recognition entirely mediated the relationship between early phonological awareness and Grade 5 character recognition. In contrast, morphological skill had a direct, unmediated effect on Grade 5 character recognition, presumably reflecting the greater role of morphology at higher literacy levels than at the very initial stages. Finally, Grade 1 reading fluency partly, but not entirely, mediated the effects of early RAN and vocabulary on Grade 5 reading fluency. This means that early RAN and vocabulary have both indirect and direct effects on later reading fluency. Indirect effects suggest that early differences in children's RAN and vocabulary manifest themselves in early differences in reading fluency, that then remain stable across elementary school. Results of the direct effects reflect the long-lasting predictive power of early RAN and vocabulary in subsequent reading fluency even after controlling for the effects of early reading skill. Regarding the direct effect of RAN on grade 5 reading, this may be explained by the fact that Grade 1 reading is not very fluent, so the effect of RAN on reading fluency cannot be fully revealed in Grade 1, thus there is residual variance to be revealed in Grade 5 when reading fluency is much greater. Secondly, proficient vocabulary skills enable children to integrate the meaning of words in sentences efficiently, which may be more advantageous for reading fluency at more mature stages than in Grade 1 (especially since in the present study, the reading fluency task required judging the meaning of sentences rapidly).

The work presented here had several limitations. Since the focus of the present study was the long-term effects of early literary skills on proficient reading, we did not fully explore the data between the two measurement occasions, apart from the above-mentioned Grade 1 mediation analysis. However, it would also be of great value to carry out more sophisticated analyses, using well-established statistical methods to explore the developmental trajectories of reading skills across elementary school. This would be the purpose of future analyses. Another limitation was that not all early measures were administered in the same year. In order to make the testing schedule manageable for young children, some early linguistic skills were tested at age 3, some at age 4, and the visual-spatial relationships task was administered at age 5. Because this latter task is temporally closer to the literacy outcomes, this may have inflated its relative contribution in multiple regression models. However, this advantage, if real, does not seem to drive most of the results obtained. Whether in univariate or in multivariate regression analyses, visual skill never was the strongest predictor. Where it is a significant one (for character spelling and reading comprehension), it may be slightly inflated, but its involvement also makes sense in light of the nature of the task and of the specific properties of reading and spelling in Chinese. In addition, our measures of the home literacy environment may be relatively imprecise. The variable “parent-child reading tuition” in the present study is a general and implicit measure of home literacy obtained from the parental questionnaire. The result may be inflated because of the social-desirability bias. Moreover, we treated this ordinal variable as an interval one in the present study, which may be a problem. Finally, we did not assess shared book reading, but a general indicator of book resources at home. Further studies should investigate more concrete and explicit measures, like direct observations of parent-child reading activities.

With respect to models of reading development, the present study underlines the need to adapt models that were initially constructed for English to the properties of other languages. For instance, Vellutino, Tunmer, Chen's (2007) “Convergent Skills Model of Reading Development” remains a very useful framework to understand the development of word reading and reading comprehension in English, however phonological coding and decoding are largely irrelevant in Chinese (except for pinyin which was not the focus of the present study), and the crucial role of morphological and visual skills is missing from the picture. Overall, the present results are consistent with Ziegler and Goswami's (2005) psycholinguistic grain size theory, with the syllable being the most relevant phonological, morphological and orthographic “grain” in Chinese.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.learninstruc.2016.12.003.

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