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Untangling Chinese preschoolers' early writing development: associations among early reading, executive functioning, and early writing skills

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Abstract

Despite a growing body of literature in English-speaking contexts documenting associations among children's early reading, executive function (EF), and early writing development, relatively few studies investigate the development of these skills in young Chinese children. Utilizing a longitudinal research design, this study followed 84 Chinese children (M=4.16 years, SD=0.67) over the preschool year and investigated concurrent and longitudinal associations among young children's early reading (i.e. vocabulary, phonological awareness, and Pinyin knowledge), early writing (i.e. name writing and Chinese word writing), and EF skills (i.e. inhibitory control, behavioral regulation, and cognitive flexibility). Hierarchical regression and multinomial logistic regression analyses showed that Pinyin knowledge was concurrently and longitudinally associated with Chinese children's name writing and word writing skills. Reciprocal associations between Pinyin and Chinese name writing was also detected. Among EF skills, inhibitory control was concurrently associated with Chinese name writing skill, while cognitive flexibility was longitudinally associated with Chinese name writing. Findings suggest an important role of Pinyin knowledge in Chinese children's early writing development and point to the importance of examining the contribution of domain specific EF skills to Chinese early reading and writing development.

Keywords Chinese early literacy · Chinese early writing · Executive functions · Writing development · Early childhood literacy

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Introduction

Early childhood is a critical time for the development of young children's early reading and writing skills (Rimm-Kaufman & Pianta, 2000; Whitehurst & Lonigan, 2001). Meta-analyses of studies of English-speaking preschool children's early writing skills, such as children's ability to independently write their names (name writing), ability of writing dictated letters based on letter names (letter writing), and ability to write dictated words (invented spelling), are key early literacy skills that have a medium to large predictive relation with later literacy development (The National Early Literacy Panel, 2008). In recent years, researchers have not only identified early reading skills (e.g. phonological awareness and letter knowledge) that are critical to early writing skills among English-speaking children (e.g. Puranik & Lonigan, 2011, 2014; Rowe, 2008; Rowe & Wilson, 2015), but have also observed an important role of executive function (EF) in early writing development (e.g., Puranik, Boss, & Wanless, 2019; Zhang, Bingham, & Quinn, 2017).

Despite a growing body of evidence documenting relations between children's early reading and writing in primarily English-speaking contexts, relatively few studies exist on young Chinese children's writing development. Such a limitation is concerning given that over 1 billion people speak Chinese in the world and the majority of research on children's reading and writing development exists on children learning English (Share, 2008). Further, although studies on children that speak other languages may inform studies of young Chinese children's early writing development to some extent, caution should be taken when drawing conclusions across orthographies. For example, Evans and Levinson (2009) argue against the widespread assumption that all languages are 'English-like' but vary as a function of different phonological systems and vocabularies. Similarly, Share (2008) suggests that much more research is needed on children's reading and writing development in orthographies other than English as English can be considered an outlier orthography in terms of spelling-sound correspondence. Although a growing body of research has begun to document Chinese children's early literacy skills, these studies often prioritize reading over writing (e.g., Chung & McBride-Chang, 2011; Yin & McBride, 2015). Many of these studies often employ cross-sectional research designs which limit understandings about the developmental pattern or growth of Chinese children's writing skills during the preschool years (Chan & Louie, 1992; Chi, 1988). In addition, while researchers have observed the associations among EF and early Chinese academic skills, such as Chinese reading and math skills (e.g. Lan, Legare, Ponitz, Li, & Morrison, 2011), the role of EF in early writing development has not been clearly explained. Although EF is not included in existing theoretical models of preschool children's writing development (Puranik & Lonigan, 2014), it is prominently featured in the Simple View of Writing (Berninger & Winn, 2006) as it is believed to support children's ability to plan, review, and revise. Given the unique nature of the Chinese orthography, Chinese children may need to coordinate EF skills in order to enact writing actions in a different way from their peers in alphabetic orthographic contexts. Additional research is clearly needed to examine the possible contribution of EF to young Chinese children's writing development.

The purpose of this longitudinal research study was to explore the developmental pattern of young Chinese children's writing development across preschool. A primary aim of this research is to describe children's writing development across this period. A secondary aim was to investigate concurrent and longitudinal associations among Chinese early reading (e.g. vocabulary, phonological awareness, Pinyin knowledge) and early writing (i.e. name writing and Chinese word writing), as well as among children's EF skills and writing. This analysis will reveal important early skills that may contribute to early writing development in a orthographic context other than English. This study will provide insight into how Chinese literacy development may progress according to existing notions of emergent literacy theory generally (Whitehurst & Lonigan, 1998) and emergent writing specifically (Puranik & Lonigan, 2014).

Conceptualizations of early Chinese writing

Although limited research exists on Chinese children's early writing development, Chinese literacy studies that do exist define "writing skill" in different ways. Such variation appears to be a function of relatively narrow conceptualizations of early writing development, reflects writing assessment approaches utilized within each study, and is constrained by the age of children being assessed. In some studies, "writing" is conceptualized as a mechanical handwriting skill of writing recognizable Chinese characters. For example, in one study, children were asked to copy a series of Chinese characters from word cards with increasing complexity in character forms and structures (i.e. word copying task) without identifying the pronunciation or definition of the characters (Tan, Spinks, Eden, Perfetti, & Siok, 2005). Others conceptualize "writing" as a cognitively demanding Chinese literacy skill that reflects children's coordination of language and comprehension skills. In these studies, a Chinese word writing task is employed and elementary school age children are asked to write a set of Chinese characters that increase in difficulty based on dictation (see Tong, McBride-Chang, Shu, & Wong, 2009; Wang, Yin, & McBride, 2015). To perform the task, children need to coordinate multiple skills to understand the dictated words, to retrieve characters from memory, and to reproduce the characters in writing. Although such a task appears appropriate for elementary aged children, it likely is too challenging for young children in preschool due to their limited vocabulary skills. Although recognizing "writing" is an important component of early literacy, this study conceptualized "writing" as a sociocultural communication tool serving meaningful purposes. Thus, in this study, we did not assess children's Chinese character copying skill, but utilized children's name writing task instead.

Although little attention has been placed on Chinese children's name writing skill, name writing is commonly included in studies of English writing development and viewed as a window into a child's emergent literacy development (Ferreiro & Teberosky, 1982). Children's own names are among the first group of words they can independently write in preschool (Justice, Bowles, & Skibbe, 2006; Pollo, Kessler, & Treiman, 2009). Young children are very attracted to their name letters in reading (Welsch, Sullivan, & Justice, 2003) and in writing (Zhang, Diamond & Powell,

2016). Based on the statistical learning theory, children's frequent exposure to their own names in the print environment at home or in the classroom, and in verbal communication, may contribute to the early emergence and rapid growth of children's name writing skill in early childhood (Levin, Both, Aram, & Bus, 2005; Apfelbaum, Hazeltine, & McMurray, 2013). Children's name writing samples reflect a sequential progression from scribbling to writing recognizable letters and spelling words (e.g. Diamond, Gerde, & Powell, 2008; Puranik & Lonigan, 2012), which also suggest children's emerging understanding of the writing process (i.e. writing from left to right in a linear way) and purpose of writing as a social communication tool.

Although limited, there is research suggesting that young Chinese children as young as four-years-old can perform a name writing task (Yin & Treiman, 2013). In this study, children were encouraged to write their names independently and their name writing products were coded with a detailed rubric. Different from a dichotomous coding scheme of Chinese word writing (i.e. writing correct or incorrect characters), children's name writing samples were coded based on the level of completeness (i.e. scribbling, writing radicals, writing mixture of radicals and characters, and writing characters). In this way, the early emergence and progression of Chinese writing skill can be captured and investigated.

Chinese orthographic features and early writing skills

The Chinese language and writing system represents a unique orthography when compared to alphabetic languages (e.g. English, French, Spanish). Chinese is a logographic language system with no grapheme-phoneme correspondence between its written and oral form. Hence, unlike English which is a speech-based language system, Chinese is meaning-based (Perfetti, Liu, & Tan, 2005). About 80% of Chinese characters are compound characters which are comprised of a phonetic radical and a semantic radical (Chen, Lau, & Yung, 1993). For example, in the Chinese character "妈" (mother), the phonetic radical "马" (sound:/ma/) suggests the sound of the character, and the semantic radical 女 (definition: female) differentiates the character from other characters sharing similar pronunciations, such as 骂 (definition: curse) and 码 (definition: code). And radicals are further comprised of combinations of eight basic strokes (i.e. 丨, 丿, 一, 丶, 乛, 亠, 𠃌, 亅).

Unique features in Chinese orthography have led researchers to examine and scrutinize young Chinese children's early literacy developmental patterns. McBride and Wang (2015) suggest that the complexity of the Chinese language system requires young children to coordinate multiple cognitive skills to *read* Chinese characters, which include early reading skills (i.e. phonological sensitivity and morphological awareness), visual skill (i.e. visual-orthographical skill), and reading fluency (i.e. rapid-automatized naming). These cognitive skills collectively support children's recognition, acquisition, and comprehension of Chinese characters. However, very few studies investigate the early skills Chinese children must coordinate in order to *write* recognizable Chinese characters.

In fact, in comparison to increasing literature about Chinese reading development, very few studies describe young Chinese children's writing development during the early childhood period (ages 3 to 6). In a qualitative study of Chinese preschool children writing samples, Chan and Louis (1992) noted an upward sequential pattern of Chinese children's early writing development. This suggests that even young children, around the age of three, begin to show a certain level of Chinese character configuration knowledge (Ho, Yau, & Au, 2003). Others have noted that young children first differentiate Chinese characters from drawing (e.g. Qian, Zhao, Song, & Bi, 2015; Treiman & Yin, 2011). At the earliest writing stages, Chinese children tend to conceptualize each Chinese character as an individual symbolic unit and write simple characters with simple combinations of strokes (Ho et al., 2003). Over time, children appear to gradually develop an understanding about semantic and phonetic radicals in characters, as well as the position of the radicals within the characters. Eventually, they will write Chinese characters combining their knowledge of the forms, functions, and positions of radicals (McBride, 2015). Such developmental pattern of children's early writing, with children moving from scribbling to writing recognizable simple characters or words, is similar to young children's early writing development in English (e.g., Puranik & Lonigan, 2011) and Hebrew (e.g., Levin & Bus, 2003).

The sequential progression of children's early writing development is related to children's growing English reading skills. For example, American children perform better in early writing tasks, such as name writing and letter writing, if they have better letter knowledge (Diamond & Baroody, 2013; Mofese et al., 2011). And phonological awareness skill is consistently associated with children's skill of spelling dictated words (Ouellette & Sénéchal, 2008). Essentially, in English learning contexts, children need to coordinate early reading skills to decode familiar words they hear and reproduce dictated letters and words in writing (e.g. Zhang, Bingham, & Quinn, 2017). It is unclear, however, whether early Chinese reading and writing skills also correlate with each other in a similar manner.

Chinese phonological awareness and writing development

This study investigates the role of phonological awareness and pinyin knowledge in young Chinese children's writing development. Although morphological awareness skill supports children's understanding of morphemes, which is critical to Chinese character recognition skill in reading development (McBride-Chang et al., 2003), existing morphological measures have been primarily used in Chinese reading study of children in elementary school (e.g. Liu & McBride, 2010). These measures greatly rely on children's existing Chinese language skills in order for children to manipulate morphemes in a manner that creates a new word based on verbal prompts without visuals. Such tasks, however, may be too challenging for preschool aged children who are just developing this awareness.

The potential contribution of phonological awareness skills to Chinese early writing may be supported through its relation to early reading skills. Studies of Chinese early reading development suggest that Chinese children develop

phonological sensitivity in early childhood. Chinese preschoolers cannot only detect syllables in speech (Shu, Peng, & McBride-Chang, 2008), but also understand the correspondence between units of writing (i.e. Chinese character) and units of speech much earlier than children of the alphabetic language system (Zhang, Yin, & Treiman, 2017). Researchers also noted that Chinese children begin to distinguish Chinese characters from alphabetic scripts and drawings at age three (Qian et al., 2015). And by age five children may be able to recognize and distinguish characters based on phonetic and semantic radicals in reading (i.e. the structural knowledge of Chinese characters, Ho et al., 2003; Shu & Anderson, 1997). These findings indicate that phonological awareness may develop along with children's skills of writing Chinese characters. If children recognize phonetic radical by age five, they should be able to map "sound" information to familiar characters that are simple in form and structure and reproduce these characters in writing. In Tong et al. (2009)'s study of six-year-old Chinese children's literacy skills, children's errors in writing dictated characters primarily reflect their limited understanding of the forms and function of the Chinese radical. For example, when asked to write wash face (洗脸 xi lian), many children made lexical errors and wrote face (面 mian). When children were asked to write 'see you again' (再见), very few children made sound-based phonological errors, such as mistakenly writing exist (在, zai) as again (再, zai). In other words, children by age six may have started coordinating phonological awareness to retrieve Chinese characters from memory when writing them.

Although some studies suggest a relation between phonological awareness and children's skill of writing dictated Chinese words, the role of phonological awareness and writing in other writing contexts (across different tasks) is still unclear. In the Lin, McBride-Chang, Aram, & Levin (2011) study of mother–child writing interaction with 6-year-old children found that phonological awareness was concurrently and significantly associated with children's skills of writing dictated Chinese characters. However, Wang et al.'s study (2015) examining the correlations between early reading and writing skills did not detect a significant concurrent or longitudinal association between phonological awareness and Chinese word writing skills in similarly aged children. Because only limited research exists examining these associations, and much of it is carried out with samples of children who are beginning formal schooling, this study expands existing research by considering the role of phonological awareness in early writing across a range of tasks, including children's name writing skill.

Pinyin knowledge as a phonological decoding system

In the Chinese mainland area, since the 1950s, Chinese Pinyin is used as a phonetic alphabetic system to annotate the pronunciation of Chinese characters (Chinese Pinyin Standard, 汉语拼音方案, 1958). Unlike the alphabetic letters in English, Pinyin letters do not have "letter names" but only "letter sounds." The Pinyin letter system includes 23 initial sounds (20 single letters and 3 two-letter combinations) and 39 final sounds (10 single letters and 29 two- or three-letter combinations). Four

diacritical signs are used to mark four tones of Chinese character pronunciation. For example, Mother, 妈 includes combinations of Latin letters "m" and "a" to represent the sound "ma", and diacritic "-" to indicate the tone of the pronunciation. Although children do not receive explicit instruction about the Pinyin system until 1st grade in primary school, some parents and teachers introduce Pinyin informally as early as preschool (Cheung & Ng, 2003; McBride-Chang et al., 2010) through children's books and environmental print in which Pinyin is annotated above each Chinese character (Fredlein & Fredlein, 1994; Lee, 1993).

Pinyin annotation may not be a difficult concept for young children to understand because young Chinese children, similar to English-speaking children (de Boysson-Bardies, 1999), develop awareness of syllables and rhymes by the age of five or six (Shu et al., 2008). Lin et al. (2010) and Wang, McBride-Chang, and Chan (2014) found similar developmental patterns in Chinese 5- and 6-years-old children's Pinyin knowledge, suggesting that this knowledge may reflect children's phonological sensitivity, which promotes Chinese character word reading. Pinyin may also support children's writing attempts. Shen and Bear (2000) found that a large number of lower-elementary grade Chinese children wrote Pinyin annotations to substitute Chinese characters in their writing samples. Children's Pinyin annotation writings suggest that many young children understand the correspondence between Chinese character pronunciation and Pinyin letters (e.g. 妈/ma/consists of Pinyin letters "m" and "a"), as well as knowledge of Pinyin letters—Chinese character print correspondence (e.g. 妈 can be written as ma). Very few studies examine the contribution of Pinyin knowledge to early writing development, although the positive association between Pinyin knowledge, phonological awareness, and Chinese character reading skill is evident in existing literature (Lin et al., 2010; Wang et al., 2014).

Bidirectional associations between reading skills and Chinese writing in young children

Existing research suggests bidirectional associations between early reading and writing skills in alphabetic languages. For example, phonological awareness facilitates young children's invented spelling abilities and practicing spelling in turn improves phonological awareness (Ehri, 2005; Marins & Silva, 2006). Writing activities, such as name writing (Diamond & Baroody, 2013), support young children's early reading development through its promotion of letter knowledge and word decoding skills. Bidirectional associations are also observed among Chinese children in elementary school. Based on their experiments of Chinese elementary year children's reading and writing skills, Tan et al. (2005) found that Chinese children's reading depends on their Chinese character writing fluency. Writing Chinese characters may support children's learning of early Chinese reading skills through the support of children's phonological representations. For example, in the study of young Chinese children's reading and writing skills, Wang et al. (2015) found that Chinese writing skill (i.e., writing dictated Chinese characters) was longitudinally correlated with children's later phonological awareness (i.e., syllable deletion). This study investigates whether

such bidirectional associations between Chinese reading and writing skills emerges in early childhood, similar to children from English language contexts.

Executive functions and Chinese writing

Existing research with English speaking children suggests that early EF skills (inhibitory control, working memory, and cognitive flexibility; Garon, Bryson, & Smith, 2008) are important predictors of short and long-term academic achievement among preschool-aged children (Chung & McBride-Chang, 2011; McClelland et al., 2007). Among American preschool children, EF skills and early literacy skills (e.g., letter knowledge and phonological awareness) are correlated (Blair & Razza, 2007; Kegel & Bus, 2014; Purpura, Schmitt, & Ganley, 2017). Early EF skills, as measured by the Head, Toes, Knees, and Shoulders (McClelland and Cameron, 2012), have also been found to be directly associated with children's name writing (Gerde, Skibbe, Bowles, & Martoccio, 2012) and letter writing and invented spelling skills (Puranik, Boss, & Wanless, 2019). Findings aren't always consistent, however, in documenting direct associations between EF and children's early writing development. Zhang et al. (2017) documents that EF is associated to children's invented spelling through children's early reading skills (e.g., letter knowledge and phonological awareness skills).

Although less prevalent, studies of young Chinese children reveal similar associations among EF and early academic skills, such as Chinese reading and math skills (Chung & McBride-Chang, 2011; Lan et al., 2011). For example, Chung and McBride-Change (2011) found that Chinese kindergarteners' inhibitory control and working memory scores (modeled together) explained unique variance in their early reading comprehension (concurrently) beyond other early reading skills such as phonological awareness and vocabulary knowledge. Although studies suggest associations between EF and early ready related skills, the contribution of EF to Chinese early writing skills remains unclear. Given the complexity of the Chinese language system, writing recognizable Chinese characters is likely cognitively demanding for young children. Unlike English vocabulary that consists of a linear combination of letters, Chinese characters are comprised of radicals which represent varying nonlinear combinations of strokes. In the progression of early writing development from scribbling to writing characters, various EF skills may support Chinese children's retrieval of familiar characters from memory and in coordinating reading skills to enact writing with strokes. For example, in order to write Chinese words that are dictated to them (e.g. Tong et al., 2009; Wang et al., 2015), children need to map the pronunciation of the dictated words to the words they understand first before retrieving characters from memory and writing the characters down.

As recent research of English speaking children suggests that the association among EF and writing skills may vary in relation to the challenge of different writing tasks (e.g., name writing, letter writing, invented spelling; Puranik et al., 2019), this study utilizes multiple EF and writing measures. Because of the exploratory nature of this study, and the young age of the sample, we included measures of inhibitory control, cognitive flexibility, and integrated behavioral control (i.e., the

HTKS) that have been previously used with some success with young children when studying preschoolers' early academic skills (i.e., early math and literacy, Cameron, Kim, Duncan, Becker, & McClelland, 2019). Although working memory has been demonstrated to be important to children's reading comprehension (Leong, Tse, Loh & Hau, 2008) and word reading skill (Chung & McBride-Chang, 2011), we did not assess this component of EF given that existing studies only administered working memory to Chinese children older than first grade (e.g., So & Siegel, 1997; Yeung, Ho, Chan, & Chung, 2019).

Research questions

This study explores and investigates concurrent and longitudinal associations among Chinese reading, EF, and writing skills by addressing the following questions: (1) How do Chinese children's writing skills develop across the preschool year? It is hypothesized that young Chinese children will demonstrate variations in their writing development (e.g., from scribbling to writing recognizable characters), similar to research of children who are learning to write in an alphabetic orthographic system. (2) To what extent are Chinese early reading skills (i.e., vocabulary, phonological awareness, and Pinyin skills) and EF skills concurrently and longitudinally associated with Chinese children's early writing skills? and (3) Whether Chinese children's early writing and reading skills are bidirectionally associated? It is hypothesized that children with better initial writing skills will evidence stronger performance on reading tasks at the end of preschool.

Method

Participants

Ninety-four Chinese children were recruited from two preschools, one in urban Shanghai city and one in rural Jiangxi province. Eighty-four Chinese children ($M = 4.16$ years, $SD = 0.67$) (40 children from Shanghai, 44 children from Jiangxi) completed early literacy and writing tasks. Children were generally evenly split by gender (54% girls) and 64% of the sample were from low socioeconomic status backgrounds as determined by parent education levels (i.e., lower than a high school education). Children were assessed in the Fall (October) and in Spring (May) of the preschool year. Sixty-six children ($M = 4.21$ years, $SD = 0.67$) were assessed at both time points (60% girls). No significant differences of literacy (vocabulary, $p = .20$; pinyin, $p = .30$) and writing (name writing $p = .72$, word writing, $p = .66$) in the Fall were found between the 18 children who were absent for the Spring data collection time point and children who were retained in the study for the entire year. All participating children came from families who spoke Mandarin Chinese and who used simplified Chinese characters in daily communication.

Procedure

Research staff visited the two preschools at the beginning of the preschool year (September) and explained the purpose and procedures of the study to teachers. Upon obtaining teachers' permission, a letter explaining the purpose and procedures of the study, parent permission forms asking for children's participation, and a family background questionnaire were distributed to parents of children in each classroom. The children whose parents returned signed consent forms were included in this study. Trained research assistants assessed children in the beginning of (October) and in the end of the preschool year (May). Children were assessed in a quiet space outside of their classroom (e.g., teacher's office or empty gym) and assessments were broken up into two separate sessions to prevent child fatigue. All assessments were administered in Mandarin Chinese, children's native language. Research assistants completed two, 2 to 3 h training sessions before data collection began. During the training, research assistants practiced assessment tools and established reliability with the authors ($k > .90$). Research assistants completed a review training session before data collection in May, in which reliability was checked again and maintained at a high level ($k > .90$).

Measures

A series of writing, early reading, language assessments, and EF were given to children in the fall and spring of the school year. Each assessment and its target skill is described in detail below.

Children's writing skills

Name-writing

During the assessment, children were given a blank sheet of $8.5'' \times 11''$ paper and a marker. Children were asked to write their names "as much as you can". We ask children to write as much as they can, so their writing samples may reflect the stage of their writing development (i.e., scribbling, strokes, radicals or characters) and to encourage them generate any writing sample. Children were prompted to write in Pinyin letters if they could not write Chinese characters. However, none of the children generated Pinyin name writing. Children's writing was coded based on a 4-point continuum similar to Bloodgood (1999) and Sulzby, Barnhart, and Hieshima's (1989) approaches. Because Chinese children write characters comprised of strokes and radicals, we modified the rating scheme based on the completeness of characters: refusal to write '0', scribbling '1', writing with strokes or radicals '2', writing at least one recognizable character from name with a mixture of radicals '3', writing recognizable characters from names '4' (see Fig. 1). This coding scheme aligns with Yin and Treiman's (2013) observation of young Chinese children's name writing performance. Our original coding scheme also included a category of "writing correct non-name Chinese characters," but none of the participating children

wrote non-name characters. Children's writing samples were coded by two research assistants. The research assistants established coding reliability with the authors before coding. Inter-rater reliability was checked when coding every 10 children's writing samples to maintain high reliability $k > .90$. In this study, the test–retest reliability of this task is $r = .66$, $p < .001$.

Chinese word writing

Children's Chinese word writing skill was assessed by a Chinese writing assessment developed by Lin, Wong, and McBride-Chang (2012). Research assistants dictated 14 Chinese words to children in a sequential order from simple to more advanced characters, with complexity of characters increasing as the number of strokes in a Chinese character increases. Children were asked to write down the words they heard on a blank piece of paper. The 14 words included four single-character words and 10 two-character words. These words were common daily words selected from standard kindergarten textbooks. Children's writing was scored based on the number of characters children correctly wrote (24 characters total in the assessment). This measure, which evidences adequate internal consistency ($\alpha = .70$), has been used in previous studies of Chinese children's early writing (see Wang et al., 2014). The maximum score is 24 points. In this study, the test–retest reliability of this task is $r = .67$, $p < .001$.

Children's name writing samples coding scheme

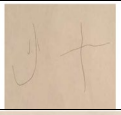
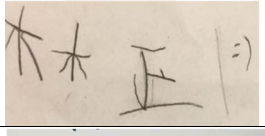
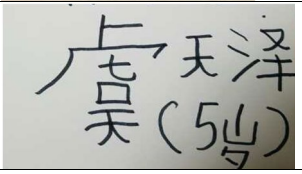
Description	Sample	Coding
Scribbling		1
Writing with strokes/radicals		2
Writing recognizable Chinese characters with mixture of radical		3
Writing names with correct Chinese characters		4

Fig. 1 Children's name writing samples coding scheme

Children's Chinese reading skills

Pinyin knowledge

Children's Pinyin knowledge was assessed by reading printed individual Pinyin letters selected from official Chinese Pinyin Standard. Children were shown a sheet with printed Pinyin letters in a format similar to the PALS-K (Invernizzi, Swank, Juel, & Meier, 2007) letter sound subtest. It includes 20 initial consonants and six final vowels. Research assistants pointed to each Pinyin letter and asked children to pronounce the sound (e.g., "How do you pronounce this Pinyin?"). Chinese Pinyin system also includes four tones in the Chinese Mandarin system. In this assessment, printed Pinyin letters are not marked with diacritical signs. This decision was made partly because the assessment primarily focuses on initial consonants, such as/b//p//d/sounds, which cannot be pronounced with tones. In addition, Pinyin letters, when presented individually in environmental print (i.e. the Pinyin table, 拼音字母表) or Chinese dictionary for children, are typically shown without diacritical signs. Environmental print in public areas, such as street signs, also only have Pinyin annotations of Chinese characters without diacritical signs. In order to avoid potential confusion, children were only prompted to pronounce Pinyin without tones. This is also a common practice when Chinese children are taught to recognize individual Pinyin letters in classrooms. The total score of this Pinyin assessment is 26. This author developed measure evidences good internal validity ($\alpha = .83$). In this study, the test–retest reliability of this task is $r = .83$, $p < .001$.

Phonological awareness

Chinese phonological awareness was assessed using a syllable deletion test developed by McBride-Chang and Kail (2002). In this task, research assistants read a three-syllable word to children, asked them to delete one of the syllables, and then say aloud the deleted word component. For example, *da` me´n ko˘u* without saying *me´n* would become *da` ko˘u*. This assessment includes 15 syllable deletion items containing all real words with deletions in different parts of the word (five initial, five middle, and five final). This task has been used in previous studies of Chinese children's early literacy skill and demonstrates high internal consistency among Mandarin speaking children ($\alpha = .91$; McBride-Chang et al., 2005). In this study, the test–retest reliability of this task is $r = .68$, $p < .001$.

Vocabulary skills

Children's vocabulary was assessed with a 53-item Chinese vocabulary definition task. This expressive vocabulary task asks children to give an oral definition of a concept or object presented by the experimenter. Items in this production task were ranked in order of ascending difficulty. This task has been successfully used to assess Hong Kong Chinese children's Cantonese vocabulary knowledge in previous work (e.g., McBride-Chang et al., 2008). The task employs a format similar to that of the marking scheme used in the Stanford-Binet Intelligence Scale vocabulary subtest

(Thorndike, Hagen, & Sattler, 1986) and the scores for each word were developed with reference to a Chinese dictionary (Lau, 1999). Children's answers for each word were scored as either 0, 1, or 2 as a reference in the marking scheme. Testing stopped when a child failed on five consecutive items. The maximum possible score on this test is 106 and the scale evidences good internal consistency ($\alpha = .78$). In this study, the test–retest reliability of this task is $r = .69$, $p < .001$. In this study, the test–retest reliability of this task is $r = .79$, $p < .001$.

Children's executive function

Inhibitory control

The Sun/Moon (Archibald & Kerns, 1999) task was used as a measure of children's inhibitory control. This task is a modified, Stroop-like assessment that requires children to verbally respond to a series of pictures. Children were shown a page with pictures of suns and moons in a 5×6 layout (30 total pictures) and asked to say "moon" when displayed a picture of a moon and "sun" when displayed a picture of a sun. Their responses were timed to measure how many pictures they correctly responded to in 45 s. In the second trial, children were told to say the opposite of the picture (e.g., "moon" for picture of the sun and "sun" for picture of the moon). In both trials, children could not continue to the next picture until a correct response was provided. The final score was the number of items completed on the "opposite" trial in 45 s. In this study, the test–retest reliability of this task is $r = .69$, $p < .001$.

Cognitive flexibility

A card sorting task similar to the Three-Dimensional Change Card Sort task (DCCS; Frye, Zelazo, & Palfai, 1995) was used to measure children's cognitive flexibility. Children were asked to sort picture cards on the basis of three different dimensions: shape, color, and size. For example, for the first 6 items, children were asked to sort on the basis of shape (e.g., fish cards go in a sorting box with a picture of a fish affixed to it), and for the second 6 items, the rule changes and children are asked to sort on the basis of color (e.g., the blue fish goes in a sorting box with a picture that has blue affixed to it). If children score 5 or more points on the third section (size) a fourth set of 6 items were administered which consist of a more complex rule: when a card included a thick black border, children were to sort on the basis of size; when the card did not have this thick black border, children were to sort on the basis of color. One point was given for each correct response, with scores ranging from 0 to 24. This measure has shown strong reliability (using tetrachoric correlations) in previous research (McClelland et al., 2014). In this study, the test–retest reliability of this task is $r = .69$, $p < .001$.

Behavioral regulation

The Head–Toes–Knees–Shoulders (HTKS) task is a global and behavioral assessment of EF that taps the integration of working memory, cognitive flexibility, and inhibitory control (McClelland & Cameron, 2012; McClelland & Tominey, 2014). This task consists of three phases. During the first phase of the task, children were asked to respond naturally in overt behavior to a command (e.g., "Touch your head"). Then children were asked to do the opposite of the original instruction. In subsequent phases, additional commands were added and rules were changed, increasing the cognitive complexity of the task. Because children need to enact behaviors based on specific instruction, this assessment is often called as the assessment of behavioral regulation (McClelland et al., 2014). The measure consists of 30 items, with a range in scores from 0 to 60. Children were given a score of '0' for an incorrect response; a score of '1' for a self-corrected response; and a score of a '2' for a correct response. Past research documents high inter-rater reliability ($\kappa > .90$), which was also achieved in this study, and validity of the HTKS in assessing children's EF with economically and culturally diverse samples (McClelland et al., 2014; von Suchodoletz et al., 2013; Wanless, McClelland, Acock, Chen, & Chen, 2011). In this study, the test–retest reliability of this task is $r = .72$, $p < .001$.

Data analyses

To address the question of developmental patterns in early writing development among Chinese preschool children, descriptive statistics and correlational matrixes were examined. Hierarchical regression analyses and logistic regression analyses were conducted to investigate concurrent and longitudinal relations among early reading, writing, and EF skills. In data analyses, missing data were treated with both pairwise deletion and maximum likelihood imputation in SPSS 26. The analytic results with the two missing value treatment approaches were the same. Given the exploratory nature of this study and the lack of existing research on Chinese children's early writing development, we present results with pairwise deletion as they allow for more accurate interpretation (i.e., children who actually generated writing samples and completed assessments were retained).

Results

Developmental pattern of Chinese early writing

Descriptive statistics of children's early skills in the fall and spring semester are provided in Table 1. One-way ANOVA analyses showed no gender related difference in children's early reading, writing, and EF assessments at either time point. Paired t-tests demonstrated that Chinese children made significant progress in all early skill domains, except name writing. Correlation matrixes suggested that although

Chinese children's early skills were highly correlated, children's age was significantly related to all early skills at both time points (see Table 2). Descriptive statistics revealed that a large number of Chinese preschool children could not perform name writing and word writing tasks. In the Fall semester, about 50% of children could not perform the Chinese name writing and word writing tasks. In the spring, more children wrote recognizable Chinese characters during the name writing task and at least one character for the word writing task (e.g., 口, mouth). However, close to 45% of children could not perform the name writing task and 35% of children had difficulty with completion of the word writing task. We recognized that some children's names were simpler than other children's names. For example, the last name Wang (王) has fewer strokes and a less complex radical structure than the last name Zhang (张). In order to check whether the complexity of Chinese name characters may be related to children's name writing, we conducted a zero-order correlation test and partial correlation test controlling children's age to examine the associations between the total number of strokes of children's name characters and children's name writing skill. No significant correlation was detected.

Transformation of Chinese name writing skill

Based on the variation of children's name writing performance, we recoded children's name writing skill to capture progression in children's name writing. We categorized children into three groups. Group 1 consisted of children (Fall: 46 children, Spring: 39 children) who could not write their names (i.e., scored zero). Group 2 included children (Fall: 23 children, Spring: 6 children) who were in the process of developing written radicals (i.e., these children had scored either a one or two for scribbling and writing random strokes). Group 3 consisted of children (Fall: 15 children, Spring: 21 children) who showed the ability to write recognizable radicals and characters (i.e., scored three and four). Chi square tests suggested that although more children wrote radicals or characters by the end of the preschool year, children's

Table 1 Descriptive statistics of children's literacy, writing and executive function (EF) skills

	Fall			Spring			*t*	*d*
	Range	*M*	*SD*	Range	*M*	*SD*		
Pinyin	0–26	7.97	8.86	0–26	10.57	10.21	3.56***	0.85
PA	0–14	2.91	4.28	0–16	6.33	5.87	6.45***	1.54
Vocabulary	0–28	12.39	6.75	0–27	16.77	5.49	8.50***	2.03
Word writing	0–4	.70	0.87	0–6	1.53	1.63	5.49***	1.31
Name writing	0–4	1.05	1.49	0–4	1.32	1.76	1.53	0.38
IC	0–98	52.6	22.59	24–117	67.35	20.22	6.56***	1.65
BR	0–60	23.93	20.45	0–60	40.7	20.35	8.96***	2.14
CF	0–22	12.26	6.71	0–23	16.67	6.30	6.67***	1.06

PA phonological awareness, *IC* inhibitory control, *BR* behavioral regulation, *CF* cognitive flexibility

***$p < .001$

Table 2 Zero-order correlational matrix among children's pre-reading, writing and EF skills

		1	2	3	4	5	6	7	8	9	
Fall	1. Pinyin	–	0.09	−0.19	0.73***	0.25*	0.54***	0.02	−0.14	0.55***	Spring
	2. PA	0.18	–	0.58***	0.26*	0.41***	0.57***	0.64***	0.64***	0.50***	
	3. Vocabulary	−0.12	0.53***	–	−0.09	0.16	0.36**	0.57***	0.62***	0.15	
	4. Word writing	0.59***	0.34**	0.03	–	0.53***	0.53***	0.22†	0.07	0.59***	
	5. Name writing	0.39***	0.18	0.33	0.48***	–	0.47***	0.31**	0.32**	0.50***	
	6. IC	0.35***	0.57***	0.51***	0.34**	0.33**	–	0.48***	0.27*	0.72***	
	7. BR	0.19†	0.61***	0.58***	0.17	0.24*	0.67***	–	0.60***	0.36**	
	8. CF	−0.02	0.51***	0.57***	0.14	0.09	0.56***	0.61***	–	0.13	
	9. Age	0.51***	0.58***	0.36***	0.60***	0.41***	0.70***	0.51***	0.51***	–	

PA phonological awareness, *IC* inhibitory control, *BR* behavioral regulation, *CF* cognitive flexibility

†$p < 0.10$; *$p < .05$; **$p < .01$; ***$p < .001$

membership in the three name writing skill groups did not significantly change. For example, the majority of children who could not write radicals or characters at the beginning of the preschool year also did not write radicals or characters at the end of preschool year. This finding was the same for the group of children who wrote recognizable radicals or characters in the fall and spring of the school year.

Associations between Chinese name writing and early skills

Concurrent associations between early reading, EF, and name writing

One-way ANOVA analyses suggested that children's Pinyin knowledge (Fall: $F(2,80) = 12.29$, $p < .001$. $d = 1.59$, Spring: $F(2, 63) = 3.53$, $p = .04$, $d = .80$), phonological awareness (Fall: $F(2,81) = 5.91$, $p = .004$. $d = .58$, Spring: $F(2, 63) = 5.82$, $p = .005$, $d = .88$), Sun and Moon (Fall: $F(2,74) = 8.70$, $p < .001$. d = 1.12, Spring: $F(2, 61) = 8.60$, $p < .001$, $d = 1.01$), HTKS (Fall: $F(2,81) = 6.90$, $p = .002$. d = .47, Spring: $F(2, 63) = 5.30$, $p = .007$, $d = .66$) and Chinese word writing (Fall: $F(2,81) = 17.87$, $p < .001$. $d = 1.86$, Spring: $F(2, 63) = 13.57$, $p < .001$, $d = 1.36$) were significantly different among the three groups of children. Children's card sorting task performance was only significantly different across the three groups of children in the Spring, $F(2, 62) = 4.25$, $p = .02$, $d = .77$. Post-hoc LSD comparisons (See Table 3) suggested that children who wrote recognizable radicals or characters outperformed the other two groups of children significantly on both reading and EF tasks.

Multinomial logistic regression analyses were conducted to further examine whether children's early literacy and EF skills may be related to achieving a certain level of name writing skill (i.e., the membership of a specific group). In these analyses, group one children (i.e., children who could not write their names) was treated as a reference group. The variable that showed significant association with the group membership suggested its important role in children's name writing development. Three models were tested (see Table 4). In the first model, we examined the association between early reading skills and name writing group membership. In the second model, we investigated the association between EF skills and name writing group membership. In the third model, both early reading and EF skills were entered in order to identify which skill was most predictive to children's name writing group membership. All three models demonstrated good model fit and explained a significant amount of variance of children's name writing skill (i.e., Nagelkerke R-square) in both Fall and Spring. Early reading skills (Model 1) explained 36% of name writing variance in Fall and 27% in the Spring, Pinyin was the only skill significantly and concurrently related to children's name writing in Fall. One unit increase in children's Pinyin skill lead to approximately a 50% higher chance of writing Chinese characters on the name writing task in comparison to children who could not write their names. This association was weaker in the Spring, when children's phonological awareness showed a significant association with name writing. EF skills (Model 2) explained 26% of the variance in name writing scores in the Fall and 34% of variance in the Spring.

Table 3 Concurrent post-hoc LSD comparisons of children's pre-reading and EF skill based on name writing

LSD	(I) NW group	Fall							Spring					
Dependent variables		*M*	*SD*	(J) NW Group	*M*	*SD*	Mean difference (I–J)	*SE*	*M*	*SD*	*M*	*SD*	Mean difference (I–J)	*SE*
Pinyin	3	16.60	9.49	1	6.65	8.22	9.95*	2.35	15.29	11.13	9.79	9.61	5.49*	2.69
				2	4.00	5.81	12.60**	2.65			4.50	6.80	10.79**	4.60
PA	3	4.27	4.92	1	2.33	3.96	1.94	1.07	9.38	4.91	6.17	7.86	5.00*	1.47
				2	0.22	0.74	4.05*	1.20			4.38	5.27	3.21	2.51
Vocabulary	3	12.73	5.24	1	11.57	7.31	1.17	1.89	18.14	4.09	15.62	6.20	2.53	1.50
				2	10.35	4.67	2.39	2.11			17.67	5.39	0.48	2.57
Word writing	3	1.67	1.05	1	0.50	0.72	1.17*	0.22	2.86	1.82	1.00	1.21	1.86*	0.38
				2	0.30	0.47	1.36*	0.24			0.50	0.84	2.36*	0.66
IC	3	66.87	24.37	1	45.05	22.00	21.82**	6.71	80.09	14.85	60.02	18.75	20.07**	5.06
				2	36.05	23.5	30.82**	7.51			57.67	27.75	22.43**	8.57
BR	3	32.80	18.6	1	18.24	20.61	14.56**	5.66	48.52	14.62	33.90	22.57	14.63**	5.29
				2	9.35	15.66	23.45*	6.32			46.17	9.81	2.36	9.05
CF	3	12.80	6.85	1	10.48	6.82	2.32	1.91	19.24	3.66	14.55	7.06	4.69*	1.65
				2	8.87	5.23	3.93	2.14			18.00	6.00	1.24	2.82

NW Group = name writing group; 1 = children who could not write their names; 2 = children who were in the process of developing writing radicals; 3 = children who were able to write recognizable radicals and characters

PA phonological awareness, *IC* inhibitory control, *BR* behavioral regulation, *CF* cognitive flexibility

*$p < .05$, **$p < .01$

Table 4 Concurrent logistic regression analyses of the associations among pre-reading, EF and name writing skills

	Group	Predictors	Fall				Spring			
			B	*SE*	Exo(*B*)		*B*	*SE*	Exo(*B*)	
Model 1	2	Pinyin	−0.04	0.04	0.96		−0.07	0.06	0.94	
		PA	−0.45	0.23	0.64		0.05	0.10	1.05	
		Vocabulary	0.03	0.05	1.03		0.03	0.10	1.03	
	3	Pinyin	0.12	0.04	1.13**		0.05	0.03	1.05†	
		PA	0.05	0.09	1.05†		0.15	0.07	1.17**	
		Vocabulary	0.02	0.07	1.02		0.00	0.08	1.00	
R^2						0.35**				0.27**
Model 2	2	IC	−0.01	0.02	0.99		−0.03	0.03	0.97	
		BR	−0.02	0.02	0.98		0.05	0.04	1.05	
		CF	0.01	0.06	1.01		0.04	0.10	1.04	
	3	IC	0.05	0.02	1.05**		0.05	0.02	1.05**	
		BR	0.02	0.02	1.02		−0.00	0.02	1.00	
		CF	−0.08	0.07	0.92		0.12	0.07	1.12	
R^2						0.26**				0.34**
Model 3	2	Pinyin	−0.06	0.05	0.94		−0.07	0.07	0.93	
		PA	−0.38	0.22	0.69		−0.02	0.12	0.98	
		Vocabulary	0.01	0.07	1.01		−0.09	0.14	0.92	
		IC	0.01	0.02	1.01		−0.01	0.04	1.00	
		BR	−0.01	0.03	0.99		0.05	0.04	1.05	
		CF	0.02	0.06	1.02		0.04	0.12	1.04	
	3	Pinyin	0.09	0.04	1.09*		−0.00	0.04	1.00	
		PA	−0.06	0.11	0.95		0.03	0.09	1.03	
		Vocabulary	−0.02	0.08	0.98		−0.16	0.10	0.86	
		IC	0.04	0.02	1.04†		0.03	4.96	1.06*	
		BR	0.02	0.02	1.02		0.01	0.03	1.01	
		CF	−0.01	0.07	0.99		0.15	0.09	1.17†	
R^2						0.41**				0.39**

The reference group is the children who could not write their names (group 1, Fall N = 46, Spring N = 39); 2 = children who were in the process of developing writing radicals (Fall N = 23, Spring N = 6); 3 = children who were able to write recognizable radicals and characters (Fall N = 15, Spring N = 21)

PA phonological awareness, *IC* inhibitory control, *BR* behavioral regulation, *CF* cognitive flexibility

†$p < 0.10$; *$p < .05$; **$p < .01$

Among EF skills, children's inhibitory control was significantly and concurrently associated with name writing skill in both Fall and Spring. With a one unit increase in children's inhibitory control skill, the odds of writing Chinese name characters also improved by approximately 50%. Early reading and EF skills (Model 3) collectively explained 41% variance of name writing in Fall, and 39% variance in Spring. Among both reading and EF skills, Pinyin knowledge was significantly associated with children's name writing in the Fall, while children's

inhibitory control skills was significantly associated with name writing performance in the Spring.

Longitudinal associations among early reading, EF and name writing skills

Similar multinomial logistic regression analyses (see Table 5) were conducted to examine the longitudinal associations between children's early reading, EF skills, and Chinese name writing in the Fall and Spring. We first tested the longitudinal relation between children's early reading skills (Model 1) in Fall to children's name writing membership in Spring. Results demonstrate that children's early reading skills (Model 1) in Fall semester of preschool year explained 27% variance of their later name writing skill in Spring. Among early reading skills, Pinyin was the only significant predictor of name writing. Children who had one unit better Pinyin knowledge than their peers in Fall had about a 50% higher chance than their peers to write recognizable Chinese characters in the name writing task in the Spring. While EF skills (Model 2) in Fall explained about 25% variance of later name writing skill, only cognitive flexibility showed marginal significant association with name writing skill. Collectively, early reading and EF skills (Model 3) in Fall explained 52% variance of name writing skill in the Spring. Children's cognitive flexibility and Pinyin skills at the beginning of preschool year were collectively and significantly predictive of children's name writing skill at the end of the preschool year.

Associations between early reading, EF and Chinese word writing

Hierarchical regression analyses were conducted to examine concurrent and longitudinal associations between early reading, EF, and Chinese word writing skills. Children's early reading skills were entered into the regression model first and EF skills were entered into the model second. Results demonstrate that in the Fall semester of the preschool year, children's Pinyin ($b = .06$, SE $= .01$, $p < .001$) and phonological awareness ($b = .06$, SE $= .03$, $p = .029$) were concurrent significant predictors of children's Chinese word writing skill. Children's early reading skills explained 41% variance of children's word writing skill. None of the EF measures were associated with word writing skill. Such patterns were the same in the Spring semester. Children's Pinyin ($b = .10$, SE $= .02$, $p < .001$) and phonological awareness ($b = .08$, SE $= .03$, $p = .011$) were two early reading skills concurrently associated with word writing skill. Children's early reading skills explained 54% of variance in word writing at the end of the preschool year.

A similar regression analysis was conducted to examine the longitudinal relations among variables from Fall to Spring controlling children's word writing skill in Fall. In this model, children's Fall word writing was entered first, Spring reading skills were entered second, and Spring EF skills were entered the last. The results revealed that children's early reading skills in Fall explained 27% of the variance of children's word writing skill in Spring. Children's Pinyin skill was the only predictor of children's later Chinese word writing ($b = .11$, SE $= .02$, $p < .001$). EF skills in the Fall were not related to word writing skills in the Spring.

Table 5 Longitudinal logistic regression analyses of the associations among pre-reading, EF and name writing skills

	Group	Predictors	*B*	*SE*	Exo(*B*)	
Model 1	2	Pinyin	−0.07	0.09	0.93	
		PA	−0.05	0.14	0.96	
		Vocabulary	0.08	0.09	1.08	
	3	Pinyin	0.11	0.04	1.12***	
		PA	−0.02	0.09	0.98	
		Vocabulary	0.05	0.06	1.05	
R^2						0.27**
Model 2	2	IC	−0.03	0.03	0.97	
		BR	0.01	0.04	1.01	
		CF	0.17	0.10	1.19†	
	3	IC	0.02	0.02	1.02	
		BR	0.02	0.02	1.02	
		CF	0.05	0.06	1.05	
R^2						0.25*
Model 3	2	Pinyin	−0.07	0.10	0.94	
		PA	−0.30	0.26	0.74	
		Vocabulary	0.52	0.34	1.01	
		IC	−0.07	0.06	0.93	
		BR	−0.05	0.06	0.95	
		CF	0.17	0.12	1.18	
	3	Pinyin	0.10	0.05	1.11*	
		PA	−0.17	0.11	0.85	
		Vocabulary	−0.08	0.08	0.93	
		IC	0.02	0.02	1.02	
		BR	0.04	0.03	1.04	
		CF	0.14	0.07	1.16*	
R^2						0.52**

The reference group is the children who could not write their names (Group 1, N = 39); Group 2 = children who were in the process of developing writing radicals (n = 6); Group 3 = children who were able to write recognizable radicals and characters (n = 21)

PA phonological awareness, *IC* inhibitory control, *BR* behavioral regulation, *CF* cognitive flexibility

†$p < 0.10$; *$p < .05$; **$p < .01$

Reciprocal associations between writing and reading skills

One-way ANOVA analyses were conducted to examine whether children's Chinese name writing skills at the beginning of the preschool year were related to children's early reading skills at the end of preschool year. Results demonstrate significant and positive associations between children's name writing, Pinyin, and phonological awareness. Post-hoc LSD comparisons (see Table 6) suggested that children who could write recognizable radicals or characters in the Fall outperformed the other

two groups of children in Pinyin, phonological awareness, and Chinese word writing tasks. These results suggest a reciprocal association between children's Pinyin and Chinese name writing skill. Although children with better Pinyin skills in the Fall tended to have better name writing skills in the Spring, children with better name writing skill in the Fall tended to have stronger Pinyin and phonological awareness skills in the Spring. Children's initial word writing skill was not related to later early reading skills.

Discussion

This study examined the writing development of young Chinese children with attention to early reading and EF skills across the preschool year. This study expands on a small, but growing body of literature documenting Chinese children's early literacy skills and early writing development specifically. This longitudinal study makes an important contribution to our existing knowledge of young Chinese children's name writing and word writing skills by examining the development of these skills across preschool and how writing is supported by children's early reading knowledge and executive functions. Findings are discussed in relation to existing research on young Chinese children's emergent literacy development.

Chinese preschoolers' early writing skills

Studies of English-speaking children suggest that the preschool year is a critical time in the development of children's reading and writing skills and that such skills progress rapidly (Bloodgood, 1999; Puranik & Lonigan, 2014). Though the Chinese

Table 6 Post-hoc LSD comparisons of children's spring pre-reading skills based on fall name writing

Dependent variables	(I) NW group	*M*	*SD*	(J) NW group	*M*	*SD*	Mean difference (I–J)	*SE*
LSD								
Pinyin	3	16.62	11.38	1	10.47	9.74	6.14	3.22
				2	7.73	9.52	8.88*	3.80
PA	3	8.69	5.78	1	6.13	5.92	2.56	1.82
				2	3.93	4.88	4.76*	2.15
Vocabulary	3	18.08	3.95	1	15.95	6.6	2.13	1.80
				2	17	3.65	1.08	2.13
Word writing	3	3.23	1.88	1	1.26	1.31	1.97**	0.47
				2	0.8	1.37	2.43**	0.55

NW Group = name writing group; 1 = children who could not write their names; 2 = children who were in the process of developing writing radicals; 3 = children who were able to write recognizable radicals and characters

PA phonological awareness

*$p < .05$, **$p < .01$

language logographic system is different from the English alphabetic system, our results demonstrate that Chinese preschoolers make significant progress in their reading related skills (i.e., Pinyin, phonological awareness, and vocabulary skills) and word writing skills during preschool. Interestingly, and unlike studies on alphabetic languages (see Gerde et al., 2012; Puranik & Lonigan, 2011), children's name writing skill did not change significantly over the preschool year. Close to half of children could not write their name characters during the preschool year. While this finding echoes existing descriptions of Chinese children's name writing skill (e.g., Chan & Louie, 1992; Yin & Treiman, 2013), one reason for differential growth in Chinese name writing and word writing skills in this study may be a function of the way in which each skill is measured and the complexity of children's names in Chinese. We assessed children's word writing abilities in a manner with some attention to variation in the complexity of Chinese words. The first few Chinese words in the word writing assessment were common words with simple Chinese radicals and structure (e.g. mouth 口, eight 八, horse 马). These words differ from common Chinese name characters (e.g., last name) which are usually more complicated in radical structure (e.g., Chen 陈 Huang 黄, and Fan 范). Unlike preschoolers from alphabetic language systems (Puranik & Lonigan, 2011; Welsch et al., 2003), it may be too challenging for Chinese young children to experiment with writing their names at home or in classrooms given the relative complexity of such names.

Another explanation for the results may be found in children's exposure to early writing in Chinese contexts as a function of developmental writing standards. Chinese national teaching standards of preschool education (Ministry of Education, P. R. China, 2012) suggest that young children between the ages of three and four are expected to perform scribbling, while 4- and 5 year-old children (the age of children in this study) are expected to use pictures and symbols to express ideas and demonstrate appropriate posture for writing with adults' guidance. Standards only emphasize that children are expected to write their names correctly at the age of five and six (i.e., the last year in Chinese preschool). Although no research to our knowledge has documented Chinese preschoolers' writing experiences in early childhood settings, it is possible that Chinese teachers may focus on fine motor skills considered foundational to early writing (e.g., such as holding writing utensils and sitting at a table with appropriate posture for writing) and encourage children to scribble and write simple characters. Writing recognizable Chinese characters may not be the focus of preschool teachers' instructional practices. This may also explain why none of the children in this sample wrote with Pinyin on writing tasks, though many children were able to identify Pinyin sounds when shown Pinyin letter prints. Interestingly, the current Chinese national preschool teaching standard does not recommend that teachers instruct children in Pinyin knowledge until 1st grade (i.e., at the ages of six to seven).

We did not find gender differences in Chinese children's name writing or word writing skills. We also did not find a significant association between the number of strokes in Chinese children's name characters and their reading, writing, or EF skills. These findings differ somewhat from Yin and Treiman's (2013) description of Chinese children's name writing. Their study indicates that children's gender and number of name character strokes are important factors in children's name writing

performance. Findings may vary as a function of the age of the sample, with our sample only including preschool age children while Yin and Treiman's (2013) study included a wider range of children from 2 to 6 years old. It may be that gender related differences in Chinese children's writing performance emerge later in early childhood when more children start to experiment with writing recognizable Chinese characters and receive more instructional supports at home and school.

The role of early reading skills in Chinese writing development

Findings from this study demonstrate that early reading (i.e. Pinyin and phonological awareness) and writing (i.e., name and word writing) skills are significantly and concurrently related. In addition, results reveal that Pinyin knowledge appears to play a supportive role in the development of name writing and word writing skills longitudinally. Pinyin knowledge and phonological awareness have been found to be important to kindergarten children's reading development (Wang et al., 2014), but little research exists to establish associations between Pinyin and preschool writing. One recent exception to this trend is an early literacy invention by Wang and McBride (2017). They found that intervention group children, who received training in Pinyin knowledge in addition to the training in copying Chinese characters, outperformed both the control group and the copying training only group in reading and writing tasks. Supporting children's Pinyin knowledge appears beneficial to supporting both reading and writing skills.

This study further confirmed the relations between Pinyin and Chinese early writing. One explanation may be that Pinyin knowledge facilitates young children's recognition and memorization of logographic characters. Young Chinese children may distinguish Chinese characters, especially those low frequency characters, from other symbols or language by graphic feature (see Zhang et al., 2017). They may decode familiar Chinese characters (e.g., name characters) with Pinyin knowledge so that they can memorize and retrieve the characters by pronunciations rather than by radical structures. Thus, better Pinyin knowledge at the beginning of the preschool year may support children's ability to recognize and memorize more Chinese characters, and in turn, develop better writing skills by the end of the preschool year.

Phonological awareness in this study was assessed by a syllable deletion task intended to capture how a child's understanding of pronunciation-character correspondence relates to name and word writing skills. Phonological awareness may be important to children's writing particularly when writing simple words. For example, to write the word 王子 (Prince), a child needs to coordinate phonological awareness understanding in order to detect that the word is comprised of two different characters based on the pronunciation 王 (wang) and 子 (zi). It is surprising, therefore, that children's phonological awareness was concurrently associated with both name and word writing skill. However, because children's writing development requires the child to produce increasingly sophisticated writing, and coordinate their knowledge of Chinese characters and new vocabulary, this may be one reason why phonological awareness skills were not longitudinally associated with writing but Pinyin knowledge was. Unlike Pinyin knowledge, a child's syllable deletion skill

does not appear to support his/her decoding of each individual character. In other words, because children do not learn to read or write a new character based solely on their syllable deletion skills, children's Pinyin knowledge, and not their syllable deletion knowledge, may play a more important in preschool writing performance across time.

Findings from this study demonstrate the reciprocal association between Pinyin and Chinese name writing skill, with children with stronger name writing skills at the beginning of preschool year demonstrating better Pinyin knowledge at the end of the preschool year than peers with less developed skills. Such bidirectional association between early reading and name writing skill has been reported in early literacy studies among English-speaking children (Diamond et al., 2008). Through spelling names, children gain knowledge about the letters (i.e., letter names and letter sounds) in their names (Bloodgood, 1999; Puranik & Lonigan, 2012; Zhang, Diamond, & Powell, 2017). Results from this study suggest that logographic name writing may also help children develop early reading skills. One explanation may be related to the frequent environmental exposure of Pinyin annotations in children's daily activities (McBride-Chang et al., 2010). In mainland China, the Pinyin annotation system is a supportive decoding system for readers to identify and pronounce the sound of specific characters. The text in Chinese storybooks for young children, and much environmental print in public (e.g., the signs of businesses and organizations) display both Chinese characters and their Pinyin annotations. As a function of this incidental exposure, it is possible that young children may be aware of the Pinyin letters that comprise the sounds of their names before receiving formal training of Pinyin. During name writing practices, children need to recall the pronunciation of their names first and then retrieve the name characters from their memory. This process encourages children to develop knowledge of Pinyin letters and the correspondence between Pinyin annotations and Chinese characters, which may lead to the growth in Pinyin knowledge and phonological awareness.

The role of EF in Chinese writing development

Although EF is not included in theoretical notions of early writing development during preschool like it is in models of writing with older children (Berninger & Winn, 2006; Kaderavek, Cabell, & Justice, 2009; Puranik & Lonigan, 2014), recent research has begun to document the important role of EF to a wide range of early literacy skills (Garon et al., 2008; Kegel & Bus, 2014; McClelland et al., 2007). Chinese children in this study made significant growth in their EF skills over the preschool year, which aligns with U.S. studies documenting how early childhood represents a time of significant growth in EF skills broadly, and in relation to the development of early literacy skills, specifically (e.g., Blair & Razza, 2007; Zelazo, Carlson, & Kesek, 2008). Among inhibitory control, behavioral regulation, and cognitive flexibility skills, inhibitory control showed a significant concurrent association with children's name writing skill in both the Fall and Spring. Longitudinally, children's initial cognitive flexibility skill at the beginning of preschool year, along

with initial Pinyin knowledge, was the only significant predictor of children's later name writing skill.

These findings, while exploratory and preliminary in nature, extend our limited understanding about the role of EF skills in Chinese children's early reading development to early writing development. Chung and McBride-Chang's (2011) study of Hong Kong preschoolers and Lan et al.'s (2011) study of Chinese Mainland preschoolers both recognized the importance of early EF skills to Chinese word reading skills. Given a complex logographic language system, young children may need to coordinate their EF skills to differentiate Chinese characters and process them cognitively to decode and read Chinese words. Similarly, writing Chinese characters is a cognitively demanding task. Although children may not need to understand the definition of their name characters when learning to write their names in Chinese, they do need to suppress irrelevant behavior and resist distraction to engage in writing their names. Children with stronger inhibitory control skills may be able to generate more complete writing samples during their writing attempts as a result of their ability to stay on task. The consistent concurrent association between inhibitory control and Chinese name writing, along with evidence about the complexity of Chinese children's names, appears to suggest that name writing is a more challenging skill for Chinese preschoolers to perform than preschoolers who speak and write English. In the study of examining the writing skills of American preschool (4 to 5-years old) and kindergarten (5 to 6-years old) children, Puranik et al. (2019) found that EF is related to writing outcomes of a challenging task. For example, EF was significantly associated with letter writing and spelling tasks for preschool aged children but not for kindergarteners, as a result of the fact that the skill had been largely acquired by kindergarten children and therefore required fewer cognitive resources to enact. This explanation may be one reason why a direct significant association between EF and name writing skill was not detected among American preschoolers (e.g. Zhang et al., 2017), but among Chinese preschoolers.

This study also found a longitudinal association between children's initial cognitive flexibility skill and children's later name writing skill. This finding may be related to the fact that Chinese logographic characters may be "written" in different ways. Chinese children are typically taught in elementary schools to write characters conventionally based on stroke orders (笔画顺序). However, preschool children "write" characters in their own ways. Studies of young children's writing samples (e.g. Chan & Louie, 1992; Chen & Zhou, 2010; Yin & Treiman, 2013) document that children did not write based on stroke orders but often "draw" or "scribble" characters. Children who have better cognitive flexibility skill may be able to use more unconventional approaches, such as drawing, to write their names than their peers. However, these associations appear to hold true for name writing but not for word writing as we found no concurrent or longitudinal associations between children's EF skills and Chinese word writing. This may because the word writing task relies heavily on children's reading skills to decode and understand the dictated characters. Unlike the English invented spelling task in which children can spell a word based on its pronunciation, children cannot write a dictated Chinese character without knowing its meaning. For example, when children were dictated "wang zi," they had to understand the word means "prince" and then linked the meaning to

the correspondent Chinese characters "王" and "子," rather than other characters that share the same pronunciation but different meaning. This is likely one reason that Pinyin knowledge and phonological awareness collectively explained more than 40% of variance in word writing.

Limitations and future directions

As an exploratory study, this study has a number of limitations that need to be acknowledged. First, while the study included children from diverse SES backgrounds, the sample size was small. This limited our ability to examine indirect associations (i.e., moderation or mediation) among early reading, early writing, and EF skills. In addition, it limits the generalizability of findings. Future studies should include larger samples of children and examine how children's early writing development is associated with children's family backgrounds (e.g., parents' educational background, home literacy environment, opportunities to learn to write at home) and classroom environments (e.g., teachers' instructional practices, availability of classroom writing materials). Given the consistent impact of Pinyin knowledge to Chinese writing skill, future studies should also address how Pinyin knowledge and exposure to Pinyin instruction (including explicit or implicit exposure) may facilitate young Chinese children's reading and writing development.

Second, several measures may need to be modified, extended, or further developed to accommodate variations in young children's early skills and the complexity of Chinese. Because few measures exist for assessing mainland Chinese children's early literacy skills, our adaptation of English measures may present some challenges to the measurement of Chinese reading and writing development. For example, the name writing task in this study was adapted from studies of early writing development among English speaking preschool children. Many young Chinese children may not be able to write their name characters due to limited fine motor skills and the complexity of Chinese names. Future studies may consider adding a simpler writing task as a supplement to the name writing task or a task that is more connected to how children learn to write in Chinese. Similarly, as the Pinyin knowledge measure in this study was adapted from a letter-sound assessment of English early literacy, it focused primarily on children's identification of individual Pinyin letters (e.g., initial consonants) rather than the combination of Pinyin letters (e.g., Pinyin annotation of a character). Given some research indicating that Pinyin tone awareness supports Chinese character recognition (Shu et al., 2008), future research should assess both visual and auditory Pinyin skills. Finally, it would be helpful if future research utilized additional measures to capture young children's development of Chinese radical awareness and character recognition skills. Including a task that assesses Chinese character recognition skills (i.e., their ability to read aloud a set of Chinese characters) would have provided important insights into how early Chinese reading and writing skills are interlinked across early childhood.

Third, future research should more fully examine associations among young Chinese children's EF, early writing, and early reading skills across time. Although we examined a number of EF and early writing skills in this study, recent research

points to differential, and sometimes indirect, associations among EF, reading, writing skills, which vary as a function of EF skill being assessed and the nature of the writing task (Puranik et al., 2019; Zhang et al., 2017). Puranik et al. (2019) argues that the association between EF (measured in their study by the HTKS) and writing skills is attenuated by the difficulty of the writing task and child's existing skill level. Although the HTKS is considered effective in capturing young children's behavioral regulation skill, which demonstrates the general developmental status of children's EF skills (McClelland & Cameron, 2012; McClelland et al., 2014; McClelland & Tominey, 2014), a domain specific working memory measure may reveal the extent to which each EF domain uniquely contributes to writing development at different time points. Our failure to include working memory as an EF measure is a limitation that affects the majority of research studies examining early EF contributions to children's early writing development. Future research is needed to more fully investigate the concurrent and longitudinal contributions of each EF domain to early Chinese reading and writing development in a much larger sample of young children.

Fourth, because our study primarily investigated the role of early reading skills in writing development, we did not examine other skills that are likely critical to early literacy development. For example, children's visual-orthographic skills (i.e., recognizing and distinguishing real Chinese characters from pseudocharacters or visual symbols) support children's awareness of conventional rules in structuring Chinese characters during reading development (e.g., Ho et al., 2003). Such skills may also support their writing with strokes instead of unrecognizable scribbles or symbols (e.g. writing strokes to form "mouth" □, rather than drawing a circle). Additional research should also attend to how fine motor skills may support Chinese children's early writing development.

Finally, because the nature of the literacy assessments may have impacted children's reading and writing performance, future studies should consider assessing children's literacy and writing skills using multiple measures. Valid, reliable, and developmentally appropriate measures examining children's early reading and writing in non-alphabetic orthographic systems are greatly needed. Such assessments should assess a wide variety of early writing skills (orthographic and composing related processes) and be culturally and linguistically appropriate to Chinese children's development.

Conclusion

This study examined young Chinese children's early reading, writing, and EF skills across the preschool year by investigating concurrent and longitudinal contributions of reading and EF skills to Chinese early writing skills. Pinyin knowledge was concurrently and longitudinally associated with Chinese children's name writing and word writing skills. Reciprocal associations between Pinyin and Chinese name writing was also detected. Among EF skills, inhibitory control was concurrently and significantly associated with Chinese name writing skill, while cognitive flexibility was longitudinally associated with Chinese name writing.

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