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Concurrent and longitudinal predictors of beginning writing in Chinese: the unique role of copying skills

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Abstract

Pure copying skill (copying of unfamiliar scripts) and delayed copying (copying of unfamiliar Chinese characters presented previously) can both be important correlates in learning to write Chinese. The present study tested both traditional literacy-related skills and copying skills among 267 Chinese kindergarteners (mean age = 5.52) to examine the relations between these skills and Chinese beginning word dictation, or spelling, both concurrently and one year later. A series of hierarchical regression analyses revealed that both pure and delayed copying skills contributed a relatively large amount of unique variance to Chinese spelling both concurrently and subsequently. Mediation analyses showed that with the auto-regressor effect included, delayed copying had both significant direct and indirect effects on Time 2 spelling performance, while morphological awareness, phonological awareness, orthographic awareness, and pure copying contributed to subsequent Chinese spelling mainly through their influence on Time 1 spelling performance. This study highlights the importance of copying for Chinese dictation/spelling acquisition.

Keywords Copying skills · Chinese · Kindergarteners · Spelling development

Introduction

Compared to word recognition, spelling, or dictation, in Chinese is relatively underresearched. The current study considers the importance of pure copying (defined here as copying of unfamiliar scripts) and delayed copying skills (defined here as

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representations of unfamiliar Chinese characters from memory following their brief presentation) for Chinese word dictation (we refer to this as spelling in the rest of the paper). Pure copying may tap into visual-motor skill and visual-spatial skill, while delayed copying may involve visual processing, motor processing, visual-orthographic knowledge (Anderson et al., 2013), visual-chunking skill (Pak et al., 2005), and orthographic working memory (Mo et al., 2018). These skills seem to be important in Chinese spelling acquisition (Anderson et al., 2013; Lam & McBride, 2018; Mo et al., 2018; Ye et al., 2020) Anderson et al. (2013) defined the term "visual-orthographic" as features of Chinese written language that are separated from phonological, morphological, and semantic information. Specifically, visual-orthographic properties may involve the specific visual features of Chinese writing that are distinct from other writing systems, including stroke patterns (radicals and smaller components), legal radical positions, and other orthographic rules. Several previous studies have shown that visual-orthographic skill is important for Chinese children's literacy learning (Anderson et al., 2013; Siok & Fletcher, 2001; Wang & Geva, 2003). Although the precise nature of both pure copying and delayed copying skills have not been fully determined, we used pure copying and delayed copying to represent in aggregate those skills that are co-opted for each task. We used both concurrent and longitudinal data to examine the roles of these skills in Chinese spelling development across time.

Theories in spelling development

Theories of spelling have outlined the developmental stages and phases of spelling, primarily in English (Ehri, 2000; Frith, 1980). These theories define stages of spelling development based on the acquisition of phonological skills, and do not suggest the roles of other skills such as morphological and orthographic awareness until later stages. Alternative theories describe the use of various skills and knowledge during spelling, such as the statistical learning hypothesis and the Integrating of Multiple Patterns (IMP) theory (Treiman, 2017; Treiman & Kessler, 2014), which states that children can simultaneously coordinate multiple strategies (phonological, orthographic, and morphological) to spell: Variations in spelling development can be characterized by each component. Although these two theories are more domain-general than the stage and phase theories (Deacon & Sparks, 2015) and have a possibility to be applied to nonalphabetic writing systems such as Chinese (Yin & Treiman, 2013), they have not clearly specified how they can predict spelling development and how they can be applied to different writing systems (Deacon & Sparks, 2015).

Ho, Yau, and Au (2003) proposed a model of orthographic knowledge development in Chinese. The model suggests that the development of orthographic knowledge and literacy learning in Chinese are closely related; in some ways, this is similar to the relationship between phonological skills and literacy learning in alphabetic writing systems (Ho & Au, 2003; McBride, 2015). According to this model, there are six stages of orthographic knowledge development. The first stage is the character configuration knowledge stage which begins before formal literacy instruction.

Kindergarteners with exposure to Chinese characters in daily life and basic practices at school acquire some simple orthographic knowledge about the square configuration, spatial arrangement, and orientation of strokes within a Chinese character. During this stage, visual-spatial knowledge develops and becomes a critical skill for reading and spelling. Here, children perceive Chinese characters as unanalyzed wholes.

As children develop, they learn to make use of the constituents to form a compound character and break down a character into different stroke patterns, entering the structural segmentation knowledge stage. This knowledge might possibly help a beginner to reduce the number of processing units from more than ten thousand characters to a more manageable set of around a thousand radicals. This analytic approach may help children to learn to read and spell efficiently. The knowledge, in turn, seems to be acquired through the process of learning to read and spell Chinese characters.

The third and fourth stages have comparable positions in the course of orthographic knowledge development. At the third stage, children acquire radical information knowledge (i.e., semantic information and phonological information) and positional knowledge (i.e., the legal position of radicals). At this stage, children have a sense of radicals but do not have clear knowledge of the radical functions. The fourth stage is the functional knowledge stage, in which children begin to recognize semantic radicals and phonetic radicals and to understand their functions.

After acquiring different types of orthographic knowledge in the first four stages, children eventually need to merge the various types of orthographic knowledge for efficient application of the knowledge to reading and spelling, which brings them to the amalgamation stage, stage five. The final stage (stage 6) is the complete orthographic knowledge stage, in which children consolidate all types of orthographic knowledge and use this knowledge skillfully. This model emphasizes that there are two foci of Chinese literacy development differing from other writing systems: first, orthographic skills, rather than phonological skills, are particularly critical early on. Second, experience with print is crucial for learning to read and to write characters, especially at the beginning of literacy learning (Stage One and Two). However, this theory does not clearly demonstrate specifically how experience in literacy learning might facilitate orthographic development and what the critical skills in literacy learning are that can be enhanced by such experiences.

Chinese spelling and important cognitive-linguistic skills

Chinese spelling refers to the process of producing a written form based on certain orthographic rules of the Chinese writing system; it is measured by a Chinese word dictation task in the present paper. The model from Ho and Au (2003) described above provides a foundation for the investigation into how spelling is performed and develops in Chinese.

In Chinese, the character is the basic literacy unit. Each character represents a syllable and a morpheme. For example, 湖 is a character, the basic literacy unit. It represents a syllable (wu) and a morpheme (meaning lake). The character 湖is

comprised of radicals (氵 and 胡) and logographemes which are smaller units such as 氵, 十, 口, 月, segmented based on orthographic rules. Phonological skills, morphological awareness, and orthographic skills are necessary for the acquisition of Chinese spelling ability (Ho et al., 2003). Indeed, findings from participants who are typically developing (Li et al., 2012; Tong et al., , 2009, 2017; Yeung et al., 2009, 2013) and from those with dyslexia (McBride-Chang et al., 2011) have demonstrated that phonological skills, morphological skills, and orthographic skills are important correlates for learning to spell in Chinese. At the same time, however, previous studies (Tong et al., 2009, 2017; Yeung et al., 2009, 2013) have typically found that these skills together have explained a relatively low total amount of variance of learning to write in Chinese (no more than 32%). This relatively low amount of variance explained suggests that there may be predictors remain undiscovered. Given that Chinese has the most complicated visual appearance across scripts worldwide (Chang et al., 2018), researchers have proposed that reading and spelling in Chinese might require skills that are somewhat different from those used for spelling in alphabetic writing systems. Here, we focus on two copying skills that have the potential to play a role in Chinese spelling acquisition, namely, pure copying and delayed copying. We aimed to tease apart the associations of pure copying, delayed copying, and other linguistic skills associated with Chinese spelling development, both concurrently and longitudinally.

Copying practice and Chinese literacy development

Copying skills have received increasing attention in Chinese literacy research (Anderson et al., 2013; Lam & McBride, 2018; Lo et al., 2018; McBride-Chang et al., 2011; Mo et al., 2018; Pak et al., 2005; Wang et al., 2014, 2015). The attention in copying skills comes partly from copying practice in traditional Chinese literacy learning classes. Children copy strokes, radicals, and characters tens of times when they first learn to read and write. The original purpose of copying practice was to help children to master handwriting skills.

To a beginner, spelling in Chinese is a process of transforming spoken words into seemingly arbitrary visual written forms in the absence of clear phonological information (Wang et al., 2015). The shape of the character is the most important cue for beginners to rely on. This makes writing in Chinese complicated because learners need to use rote memorization for dealing with somewhat arbitrary visual patterns. In addition, stroke order, the order in which the strokes should be produced in order to correctly write a character, is not intuitive to beginners. Learners need to rehearse the stroke orders multiple times when they learn how to write. Therefore, mastery of Chinese writing involves internalization of the visual-motor aspects of this writing (Kao, 2006). Tan et al., (2005) claimed that copying of Chinese characters benefited children's literacy learning in two ways, namely by promoting children's internalization of the visual-orthographic aspects of Chinese writing and by facilitating the formation of motor memory of Chinese characters. Researchers have asserted that repeated copying can help children attend to stroke order and simultaneously recognize visual-orthographic aspects (Wang, et al., 2014; Yeung et al., 2013).

Yin and McBride (2015) found that Chinese kindergarteners detected visual-orthographic information in written Chinese even before they received formal literacy instructions. They highlighted the importance of learning to read and write Chinese in an analytical way, which is in accordance with the structural segmentation knowledge stage in the model from Ho et al., (2003). At the early stage of learning to write, a holistic approach will be applied because of the lack of visual-orthographic knowledge (Ho & Au, 2003; Yin & McBride, 2015). This approach relies on rote memorization and is not efficient. However, it is the main strategy for beginners. After developing with visual-orthographic knowledge, children (and adult beginning learners of Chinese as well) tend to adopt a more efficient analytic approach that views Chinese characters as separate functional units (logographemes or radicals).

Copying practice that facilitates children's memory for strokes and implicit knowledge of character structure might be particularly important for acquiring writing in an early learning stage. This copying could possibly be the experience that particularly benefits orthographic knowledge development as suggested by Ho et al., (2003)'s theory.

For literacy in Chinese, researchers have utilized two types of copying tasks (Wang et al., 2014), namely, pure copying and delayed copying. In a pure copying task, children are required to copy symbols, sometimes from an unfamiliar script. The pure copying skill is important in learning to write Chinese in the early stage mainly because it taps into visual-motor integration skill that is essential in handwriting. In addition, the use of unfamiliar script removes the confound of prior visual-orthographic knowledge and potential verbal pronunciation, making pure copying a 'purer' measure for handwriting ability (McBride-Chang et al., 2011; Vellutino, 1979). Controlling for prior experience is important because poor literacy learners tend to have less experience with print, and their overall performances on any tasks involving familiar print, including familiar figures, may be affected due to this lack of experience (McBride-Chang et al., 2011; Vellutino, 1979). Other types of visual-motor skill such as line-drawing that contains geometric shapes that are familiar to children also tend to confound achievement with previous experience and knowledge (McBride-Chang et al., 2011; Vellutino, 1979). In a delayed copying task, children are required to write down as much as they can remember of an unfamiliar but real Chinese character which has been briefly presented. Visual processing, motor processing, and working memory are all necessary for completing this task. Yet, beyond these skills, visual-chunking and visual-orthographic knowledge are additionally required. For example, suppose a presented character is unfamiliar and complex (i.e., containing many strokes). In that case, it is difficult for the participant to remember the whole character, stroke by stroke, because of a limited capacity in working memory. In this case, visual-chunking skill will greatly improve the efficiency of working memory (Pak et al., 2005). In addition, individuals tend to create chunks with which they are familiar; moreover, previous knowledge in a domain may help a person in chunking (Chase, & Ericsson, 1982; Gobet, 2005; Gobet, et al., 2001). Thus, in the delayed copying task, visual-orthographic knowledge may help participants to chunk and thereby improve their performance in this task. Thus, in addition to visual processing, motor processing, and working memory,

delayed copying may tap visual-chunking skill and visual-orthographic knowledge because rote memorization alone is not enough to successfully write a novel character; rather, this requires visual-orthographic understanding of the Chinese script (e.g., Wang et al., 2014). The model from Ho et al. (2003) highlights the fact that orthographic knowledge development, as well as an analytic approach, is critical in Chinese literacy development. From this perspective, delayed copying might be among the best predictors of Chinese spelling acquisition.

Several cross-sectional studies have highlighted the importance of both copying skills in Chinese literacy development, though longitudinal data on this issue remain scarce (Lam & McBride, 2018; Lo et al., 2018; McBride-Chang et al., 2011; Mo et al., 2018; Wang et al, , 2014, 2015). In a seminal study, McBride-Chang et al. (2011) tested Chinese third and fourth graders with and without dyslexia with tasks of copying of three unfamiliar scripts (Korean, Hebrew, and Vietnamese). They found that all three copying tasks distinguished dyslexic from non-dyslexic children, suggesting that pure copying of unfamiliar print may be a useful skill to understand Chinese literacy development and impairment. In another study with Hong Kong kindergarteners, Lam and McBride (2018) examined the extent to which pure copying skills were associated with Chinese spelling performance. They found that pure copying was a unique correlate of Chinese spelling even after statistically controlling phonological awareness, morphological awareness, and orthographic awareness. The Chinese spelling model they proposed was more comprehensive than previous studies (Lam & McBride, 2018). In this study, focused on beginning readers, they suggested that pure copying skill, in addition to phonological awareness, morphological awareness, and orthographic awareness, might be a unique correlate of Chinese spelling.

Moving away from pure copying skill, Wang et al. (2015) also found that delayed copying was a significant concurrent correlate of Chinese spelling with age, IQ, and reading skill statistically controlled among mainland Chinese kindergarteners. However, they did not statistically control for additional cognitive linguistic abilities including phonological, morphological, and orthographic skills. With data on Hong Kong Chinese kindergartners, Mo et al., (2018) conducted a confirmatory factor analysis (CFA), identifying a latent construct they called orthographic working memory (measured using tasks of visual orthographic judgment and delayed copying); this construct was the strongest correlate of Chinese spelling among Hong Kong kindergarteners. Still, the effect of delayed copying itself on Chinese spelling was not specified. Importantly, a lack of longitudinal data limits our understanding of how these two types of copying skills are associated with Chinese spelling development.

The present study

The cognitive mechanisms of spelling suggested by McCloskey and Rapp (2017) (see also, e.g., Caramazza & McCloskey, 1988; Ellis, 1988; Margolin, 1984; Tainturier & Rapp, 2001) emphasize the spelling process. As a child spells a word, the speech input activates corresponding orthographic representations in memory. This

activation makes these representations available in working memory. To spell a word correctly, children need to hold the orthographic representations efficiently in working memory (orthographic working memory). Thus, activation of orthographic representations in long-term memory, conversion to working memory, and handwriting skills for reproduction of representations stored in memory are all critical components in successful spelling. Working memory and the sizes of these orthographic representations become critical factors that influence the efficiency of word spelling.

As evidence showed that Chinese children learn to read and write analytically (Pak et al., 2005; Yin & McBride, 2015), with practice, they perceive Chinese characters as comprising several components within the character rather than as a holistic structure.

The Psycholinguistic-Grain Size Theory proposed by Ziegler and Goswami (2005) also suggests that the link between the visual form of a word (orthography) and its sound (phonology) can be either at the whole-word level (large size) or at a sub-word level (small size) (Goswami, 2010). The development of phonological and orthographic information progresses from large-to-small and small-to-large sizes (Ziegler & Goswami, 2005). Applying to alphabetic languages, the grain-size theory suggests that children learn to read and spell by linking the whole word to its sound; they then learn to decode words into graphemes that are linked to phonemes. As discussed previously, Chinese literacy learning also reveals a similar pattern. At the beginning of learning to spell, children perceive a character as a whole and link it to its sound. As they develop, they learn to analyze characters into radicals and logographemes which play unique functional roles (different from the phoneme-grapheme relationships in alphabetic writing systems).

However, less is known about this analytical process of learning to read and write. By forcing children overtly to attempt to reproduce their own visual representation of a novel Chinese character in working memory, we can explore the extent to which delayed copying capitalizes on the process of converting initial product of inner visual analysis of orthographic patterns (i.e., they perceive a character analytically) in the presented unfamiliar character to an outer visual written form by reproducing it. Because of these task requirements, delayed copying can be considered a critical task by which to reveal underlying spelling mechanisms.

In addition to delayed copying, the orthographic development model (Ho et al., 2003) suggests that visual-spatial skill is essential at the beginning stage of literacy learning, when Chinese children tend to think of Chinese characters as a set of random strokes. The characters learned at this stage mostly comprise simple structures and a limited number of strokes. It is likely that visual-spatial skill is important at this stage when other skills have not yet been well-developed. As children develop and encounter more complex characters, visual-spatial skill alone may not be enough for supporting efficient processing of characters. Other skills such as visual-orthographic knowledge become more important in helping children to process the complex structures of Chinese characters efficiently by allowing children to perceive functional units within characters (Wang et al., 2015). In this way, visual-orthographic knowledge enhances orthographic working memory during the spelling process. Pure copying, which taps visual-spatial skill, and delayed copying,

which includes visual-orthographic knowledge, may be specifically crucial for Chinese spelling acquisition because phonological cues are not reliable.

Previous studies have suggested that pure copying and delayed copying skills are critical concurrent correlates of beginning Chinese spelling. The present study examined this question with a wider variety of cognitive-linguistic measures and a longitudinal design, major improvements over previous work. One specific aim was to specify the roles of delayed copying and pure copying in Chinese spelling development with better known existing cognitive-linguistic predictors, such as phonological, morphological, and orthographic awareness, included.

Methods

Participants and procedures

Originally, there were 325 native Cantonese-speaking kindergarteners from nine different kindergartens located in all three geographical regions of Hong Kong who participated in the first timepoint of testing (Time 1). Fifty-eight of them dropped out for various reasons at Time 2. Thus, a final sample of 267 (mean age = 5.52 years, SD = 0.46) children participated across testing sessions of both timepoints; there were 117 girls and 150 boys. Only those who participated across both timepoints of testing were included in the present analyses. The students completed the first battery of tests at time 1 when they were at the third year (final year) of kindergarten (K3 level). Researchers visited children one year later to test their dictation skills again. The procedure was approved by our university ethics board. Informed consent was obtained from participants' parents.

Measures

Nonverbal IQ

Sets A to C of Raven's Standard Progressive Matrices (Raven et al., 2003) were used to measure participants' nonverbal IQ. For each item, participants were shown a visual pattern that with a missing piece, and they were required to choose a part of a geometric pattern from six choices to fit into the missing piece of the visual pattern. There were 36 items with one point for each. Thus, the maximum score of the task was 36.

Chinese vocabulary knowledge

A shortened version of the Chinese translation of the Peabody Picture Vocabulary Test-Third Edition (PPVT-III) was used to measure Chinese vocabulary knowledge. This task includes three parts, namely receptive vocabulary, expressive vocabulary, and the vocabulary definitions section. In the receptive vocabulary section, a word was orally presented and the participants were asked to identify the corresponding

word from a set of four pictures. In the expressive vocabulary section, a picture was presented and the participants were asked to name the object or describe the situation in the picture. In the vocabulary definition task, the participants were asked to provide the definition of a word, including the description and the function. One point was given for each correct answer in the receptive and expressive vocabulary tasks. In the vocabulary definition task, two points were given for an accurate definition of the word, one point was given for a correct example of usage of the word, and no points were given for irrelevant answers or answers that were too generic. There was a total of 10 items in the receptive vocabulary task, 10 items in the expressive vocabulary task and 5 items in the definition task, summing to a maximum score of 30.

Chinese phonological awareness

Chinese phonological awareness has been successfully assessed using a combination of syllable and phoneme onset deletion in previous studies (e.g., Tong & McBride-Chang, 2010). In the syllable deletion section, participants heard a two- or three-character word and were required to delete one syllable in the word and then say it. For example, when required to say the word /fo2 ce1 zaam6/ (火車站) without /fo2/ (火), the participant was expected to say /ce1 zaam6/ (車站). In the onset deletion section, participants heard a one- to three- syllable word and were requested to say each syllable aloud without the first consonant. For example, when asked to say /kun1 mek1 paau6/ without the initial sound of each syllable, participants were expected to answer /un1 ek1 aau6/. There were a total of 29 items in the syllable deletion and 22 items in the onset deletion sections. One point was given for each correct answer. The maximum score on this task was 51.

Chinese morphological construction

This task was adapted from McBride-Chang et al. (2003). Participants were first presented with a description of an object or a situation orally and were then required to create a new name for the described object or situation by combining Chinese morphemes. For example, the experimenter would say: "When we see a piece of paper that is white in color, we call it 'white paper'. Now if we have a piece of paper that is red in color. What would you call it?" (The correct answer would be "red paper"). There are 48 items. One point was allotted to each correct answer, and the maximum score of the task was 48.

Chinese orthographic awareness

Character decision task is used for measuring orthographic awareness, which was adapted from the study by Tong and McBride-Chang (2010) to measure participants' sensitivity to the structure of Chinese characters. Participants were asked to identify the real character in a set of 70 characters (including 30 real characters, 9 pseudo-characters, 21 non-characters, and 10 visual symbols). Pseudo-characters are not real characters, but they fulfill the orthographic regularities in Chinese.

Non-characters do not fulfill the orthographic regularities in Chinese. The maximum score of this task is 70.

Pure copying

This task requires copying of patterns/words in unfamiliar scripts, including Hebrew and Korean, similar to the task used by McBride-Chang et al., (2011). The participants were required to copy a total of eight items in each script. An item in Hebrew contained two to four Hebrew letters and an item in Korean contained one Korean character. The criteria for legibility scoring focused on shape and position for components in Korean characters. The scoring scale for shape ranged from 0 to 2, where an incorrect or no answer would be given 0 points, 1 point for a partially correct answer, and 2 points for correct answers. One point was given for a correct and 0 for an incorrect position. For Hebrew, shape, sequence, and alignment of components were assessed. The total score of the task was 141. In addition, this task was coded by two well-trained research assistants independently because the two unfamiliar scripts were relatively difficult to discriminate. Their interrater reliability was 99% ($r = 0.99$, $p < 0.001$).

Delayed copying

In this task, a real but unfamiliar (according to the Hong Kong curriculum) Chinese character was exposed for 5 s and then removed from view. Participants were then required to write down the whole character from memory. Throughout the task, participants were encouraged to do their best to recall and write down the characters. Scoring focused on partial information based on the components (logographemes) of the characters. A logographeme consists of several strokes (some of them can be radicals or single characters). For example, the item <侯> has three logographemes: <亻>, <亡>, and <女>. Two points for a correct logographeme, one point for slightly errors, and zero points for a null or incorrect response were allotted. Thus, on average, this whole character was worth a maximum of six points. There was a total of 15 items with various numbers of components, and the maximum score was 82.

Chinese spelling

Chinese spelling is measured by a Chinese word dictation task. Each word in this task contained two characters. The words were selected from Chinese textbooks. The list came from those characters identified as suitable for Hong Kong Chinese children in local kindergartens and junior primary schools by the Chinese Language Education Section (2009). Items were arranged in an order of increasing difficulty. There was a total of 15 two-character words administered for Time 1 test and 18 in Time 2. One point was given if the character was spelled correctly, and 0 points

were given for characters that were left blank or that contained any mistakes. The maximum scores of Time 1 and Time 2 word dictation were 30 and 36, respectively.

Results

Means, standard deviations, ranges, possible maximum scores, and reliabilities of raw data are presented in Table 1. The range of the reliability coefficients was between 0.72 and 0.97.

Table 2 summarizes the zero order correlation of all variables. Apart from the gender variable ($rs = 0.04$ for both Time 1 and Time 2), all other measures were substantially and significantly correlated with Chinese word dictation at Time 1 ($r = 0.24$–0.64), and Time 2 ($r = 0.28$–0.60). The correlation coefficient between Time 1 and Time 2 dictation was $r = 0.73$ ($p < 0.01$).

Hierarchical regression analyses

Before conducting multiple regression analyses, we checked for variable multicollinearity because of the high correlations among some variables. The variance inflation factors (VIFs) were all smaller than 3, indicating that multicollinearity here was

Table 1 Reliabilities, ranges, means, standard deviations for all tasks in the present study

Time points	Variables	Reliability coefficient	Maximum possible	Range	Mean	Standard deviation
1	Age	–	–	56.00–77.00	65.89	4.93
	IQ	0.82	36.00	7.00–28.00	16.67	5.09
	Gender	–	2.00	1.00–2.00	–	0.50
	Vocabulary knowledge	0.73	30.00	3.00–26.00	16.43	3.96
	Phonological awareness	0.96	51.00	0.00–51.00	19.80	12.06
	Morphological awareness	0.97	48.00	0.00–36.00	10.41	6.21
	Orthographic awareness	0.88	70.00	22.00–68.00	42.88	5.97
	Pure copying	0.85	141.00	81.00–139.50	112.57	11.58
	Delayed copying	0.72	41.00	0.00–38.00	11.80	6.25
	Spelling	0.84	30.00	0.00–20.00	5.50	4.38
2	Spelling	0.92	36.00	0.00–35.00	15.18	8.67

N = 267; internal consistency reliabilities were computed for Nonverbal IQ, Vocabulary knowledge, Phonological awareness, Morphological awareness, Orthographic awareness, and Spelling in time 1 and time 2

Table 2 Zero-order correlations of all measures

	1	2	3	4	5	6	7	8	9	10	11
1. Age	–										
2. IQ	.26**	–									
3. Gender	−.12	−.01	–								
4. Vocabulary knowledge	.22**	.35**	.04	–							
5. Phonological awareness	.12	.44**	.02	.46**	–						
6. Morphological awareness	.04	.30**	-.01	.54**	.66**	–					
7. Orthographic awareness	.14*	.24**	-.01	.34**	.37**	.34**	–				
8. Pure copying	.28**	.37**	.06	.25**	.26**	.19**	.18**	–			
9. Delayed copying	.37**	.31**	-.01	.39**	.41**	.30**	.24**	.46**	–		
10. Spelling Time 1	.24**	.40**	.04	.43**	.55**	.46**	.39**	.42**	.64**	–	
11. Spelling Time 2	.36**	.28**	.04	.42**	.44**	.41**	.36**	.42**	.60**	.73**	–

N = 267

*$p < .05$

**$p < .01$

not serious. We report the results for Time 1 and Time 2 spelling separately and respectively.

Of primary interest for this set of analyses was whether copying skills uniquely relate to spelling concurrently and longitudinally. Thus, in the hierarchical regression analyses, Time 1 spelling and Time 2 spelling served as dependent variables, with all other measures treated as independent variables. Results are presented in Table 3.

Table 3 Hierarchical regression explaining time 1 and time 2 spelling from time 1 copying skills and all other time 1 literacy-related skills included

Blocks	Variables	Spelling (Time 1)			Spelling (Time 2)		
		R^2	ΔR^2	ΔF ($df1$, $df2$)	R^2	ΔR^2	ΔF ($df1$, $df2$)
1	Age, IQ, gender, vocabulary knowledge	.26	.26	23.44 (4, 262)***	.27	.27	23.71 (4, 262)***
2	Pure copying, delayed copying	.48	.22	54.58 (2, 260)***	.44	.17	39.25 (2, 260)***
2	Phonological awareness, morphological awareness, orthographic awareness	.40	.14	19.84 (3, 259)***	.37	.10	13.82 (3, 259)***
3	Pure copying, delayed copying	.55	.15	44.16 (2, 257)***	.49	.13	31.77 (2, 257)***

N = 267

***$p < .001$

Time 1 spelling

The first regression analysis aimed at examining whether or not copying skills (including delayed copying and pure copying) would explain children's spelling performance at Time 1, when statistically controlling for age, IQ, gender, and vocabulary knowledge. As presented in Table 3, the two copying skills, vocabulary knowledge, age, and IQ altogether contributed 48% of total variance of children's spelling performance at Time 1. After statistically controlling for the effects of age, nonverbal IQ, gender, and vocabulary knowledge, the two copying skills together accounted for 22% additional variance of Time 1 spelling performance, $\Delta R^2 = 0.22$, $\Delta F\ (2, 260) = 54.58$, $p < 0.001$.

The aim of our second regression analysis was to examine the role of copying skills with other important literacy-related skills in relation to spelling at Time 1. Table 3 presents the results. All variables together contributed 55% of the total variance of children's spelling performance at Time 1. After statistically controlling for effects of age, nonverbal IQ, gender, and vocabulary knowledge, phonological awareness, morphological awareness, and orthographic awareness together accounted for 14% of the additional variance of Time 1 spelling performance, $\Delta R^2 = 0.14$, $\Delta F\ (3, 259) = 19.84$, $p < 0.001$. Delayed copying and pure copying skills together accounted for 15% additional variance of Time 1 spelling performance, $\Delta R^2 = 0.15$, $\Delta F\ (2, 257) = 44.16$.

Time 2 spelling

Table 3 shows the results of tested predictors of Time 2 spelling. After statistically controlling for effects of age, nonverbal IQ, gender, and vocabulary knowledge, the two copying skills at Time 1 together accounted for 17% additional variance of Time 2 spelling performance, $\Delta R^2 = 0.17$, $\Delta F\ (2, 260) = 39.25$, $p < 0.001$.

The aim of the next regression analysis was to examine the role of copying skills with other important literacy-related skills statistically controlled in relation to spelling at Time 2. Table 3 presents the results. All variables together contributed 49% of the total variance of children's spelling performance at Time 2. Phonological awareness, morphological awareness, and orthographic awareness at Time 1 together accounted for 10% additional variance of Time 2 spelling performance, after statistically controlling for the effects of age, nonverbal IQ, gender, and vocabulary knowledge, $\Delta R^2 = 0.10$, $\Delta F\ (3, 259) = 13.82$, $p < 0.001$. Delayed copying and pure copying together accounted for 13% of additional variance in Time 2 spelling performance, $\Delta R^2 = 0.13$, $\Delta F\ (2, 257) = 31.77$.

Path analyses

To examine the stability and change of the predictive power of Time 1 cognitive-linguistic skills on Chinese word spelling over time, two sets of path analyses (one on Time 1 spelling and one on Time 2 spelling) were conducted using R studio, a structural equation modeling program. In these path analyses, direct paths from each

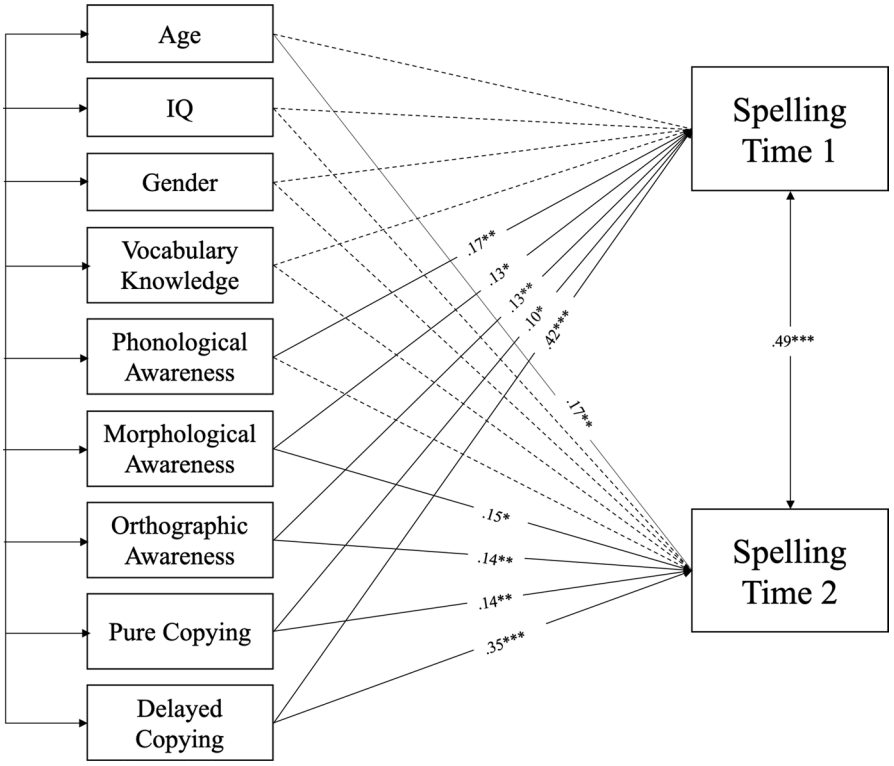

Fig. 1 Path diagram of longitudinal predictors of Chinese word spelling, without auto-regressor effect incorporated. *$p < .05$; **$p < .01$; ***$p < .001$

Time 1 cognitive-linguistic skills to Time 1, and Time 2 word spelling were postulated. In the first model (Model 1, Fig. 1), the auto-regressor effect, the contribution from Time 1 spelling to Time 2 spelling, was not incorporated. In the second model (Model 2, Fig. 2), the auto-regressor effect was included. We report the results for Model 1 and Model 2 separately and respectively.

In model 1 (Fig. 1), the path coefficients of phonological awareness ($\beta = 0.17$, $p < 0.01$), morphological awareness ($\beta = 0.13$, $p < 0.05$) and orthographic awareness ($\beta = 0.13$, $p < 0.01$) were all significant correlates of Chinese spelling at Time 1. Morphological awareness ($\beta = 0.15$, $p < 0.05$) and orthographic awareness ($\beta = 0.14$, $p < 0.01$) were both significant predictors of Chinese spelling at Time 2, while phonological awareness was not a significant predictor of Time 2 spelling ($\beta = 0.09$, $p = 0.16$). The path coefficients of pure copying ($\beta = 0.10$, $p < 0.05$ for Time 1 spelling; and $\beta = 0.14$, $p < 0.01$ for Time 2 spelling) and delayed copying ($\beta = 0.42$, $p < 0.001$ for Time 1 spelling; and $\beta = 0.35$, $p < 0.001$ for Time 2 spelling) were both unique correlates of Chinese spelling at Time 1 and Time 2.

In model 2 (Fig. 2), after the auto-regressor effect was incorporated, the regression coefficients of morphological awareness ($\beta = 0.09$, $p = 0.12$) and orthographic

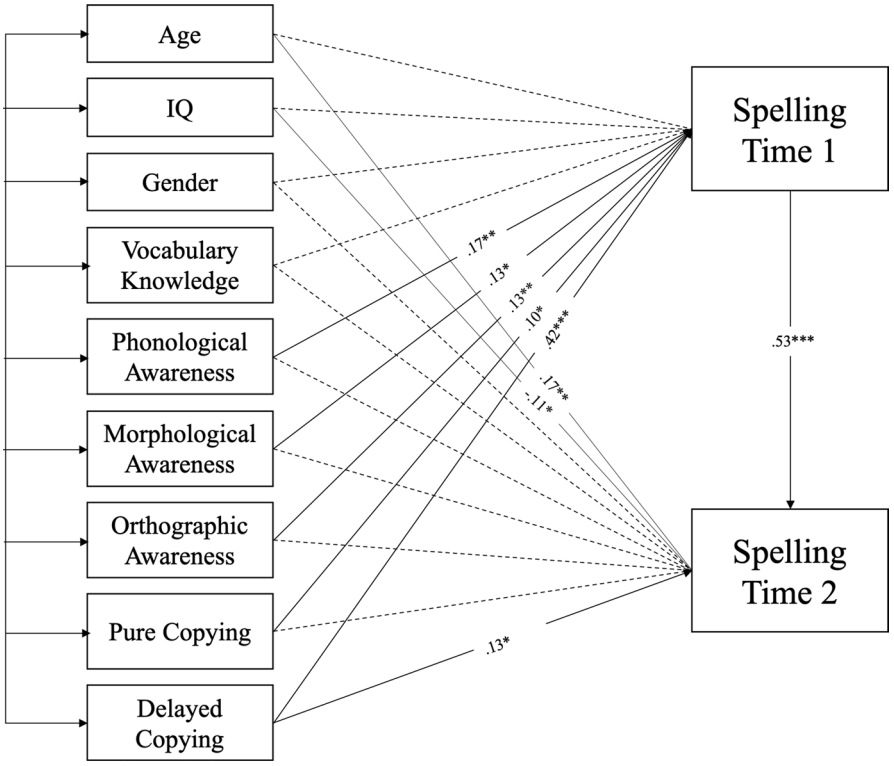

Fig. 2 Path Diagram of longitudinal predictors of Chinese word spelling, with auto-regressor effect incorporated. *$p < .05$; **$p < .01$; ***$p < .001$

awareness ($\beta = 0.07$, $p = 0.12$) were no longer significant for Chinese spelling at Time 2. Pure copying was also no longer significant but marginally significant ($\beta = 0.09$, $p = 0.06$). These results suggest that these skills were fully mediated by Time 1 Chinese spelling performance. Phonological awareness remained a nonsignificant predictor of Time 2 spelling ($\beta = -0.00$, $p = 0.99$).

Delayed copying ($\beta = 0.13$, $p < 0.05$) was still a unique correlate of Chinese spelling at Time 2 when other literacy-related skills and Time 1 spelling performance were included. Since the direct effect from delayed copying to Time 2 Chinese spelling was reduced (from $\beta = 0.42$ to $\beta = 0.13$), a Sobel test was conducted to examine the partial mediation effect. The Sobel test showed that the indirect effect from delayed copying to Time 2 Chinese spelling was significant (*indirect* = 0.054, SE = 0.02, $p < 0.05$), indicating a significant partial mediation effect.

Discussion

The present study made a comprehensive attempt to include many possible linguistic correlates and two copying skills in order to examine the concurrent and longitudinal relations between copying skills and learning to spell in Chinese in Hong Kong kindergarteners. In examining the relations among linguistic skills (including phonological awareness, morphological awareness, and orthographic awareness) and spelling performance concurrently and longitudinally, we found that phonological awareness, morphological awareness, and orthographic awareness were all significant correlates of Chinese spelling performance concurrently. In addition, morphological awareness and orthographic awareness were significant predictors of later spelling performance without statistically controlling for Time 1 spelling. However, after controlling for initial level of spelling performance, these linguistic skills were no longer significant predictors of later spelling performance. This study further clarifies the extent to which the two copying skills may influence spelling development in early Chinese spellers. Importantly, the two copying skills together significantly explained children's spelling performance both concurrently and longitudinally even after statistically controlling for age, nonverbal IQ, vocabulary knowledge, and other cognitive-linguistic skills. In particular, delayed copying was a unique longitudinal correlate of children's spelling performance one year later even after statistically controlling for initial level of spelling performance. These results may have important educational implications for early Chinese spelling pedagogy.

What skills facilitate Chinese spelling?

The present study found that phonological awareness was a significant correlate of Chinese spelling performance in Hong Kong kindergarteners, suggesting that even for early spellers who have not received explicit instruction in phonological coding, phonological skills are still important for spelling in Chinese. However, this was no longer a strong predictor of spelling performance at Time 2. This result is consistent with the idea that phonological skills are important in the early stages of Chinese literacy learning, but the role of phonological skills may diminish substantially later in the development trajectory. The present study further corroborates the ideas of both understanding of morphological construction rules and orthographic awareness being important for spelling in Chinese. However, despite the importance of these cognitive-linguistic predictors, they all ceased to predict unique variance in subsequent Chinese spelling performance when autoregressive effects of Time 1 spelling performance were statistically controlled in the present study.

The role of copying skills in early literacy learning

Copying skills, especially delayed copying, have been relatively under-explored in relation to Chinese spelling development. Consistent with previous research findings on associations between copying skills and literacy ability (Lam & McBride, 2018; McBride-Chang et al., 2011; Mo et al, 2018; Wang et al., 2014; Ye et al., 2020), the

present study extended and tested the development of this association over time. By recording data for both pure and delayed copying skills, we can examine whether there is a transition from pure visual-motor skills (involving memory and analysis skills for pure visual symbols and the ability to reproduce these), as indexed by pure copying, to visual-chunking skill and visual-orthographic skills (e.g., McBride-Chang et al., 2005), measured by delayed copying. This design helped us to study the developmental trajectory of skills associated with writing in Chinese.

In recent years, there have been emerging debates on whether copying practice is useful. Those supporting copying practice believe that children struggling with writing lack practice with handwriting skills. Therefore, these parents and teachers assign children more copying as practice. Other parents and educators criticize this kind of copying practice, saying that it is placing an extra burden on young children. In general, we propose that copying practice is helpful to children's basic handwriting skills at the beginning of learning to spell. However, in the long run, visual-chunking skill and visual-orthographic knowledge should be the focus of literacy learning. The present study addressed this issue by teasing apart the associations of pure copying, delayed copying, and other linguistic skills associated with Chinese spelling development, both concurrently and longitudinally. In general, the findings suggest that pure copying likely benefits Chinese spellers in the early stages of learning but not in the long run. The role of delayed copying as a critical skill for both current and long-term development of Chinese spelling is particularly important, as the task demands children's visual-orthographic knowledge and visual-chunking skills.

Although it is a powerful predictor of both concurrent and future spelling development in Chinese, delayed copying has yet been completely understood in terms of what exactly it measures and how it relates to spelling. Interpretation of delayed copying is difficult particularly because of its multi-componential nature. In previous studies, delayed copying has been considered as a unitary construct (Anderson et al., 2013; Mo et al., 2018; Pak et al., 2005). Anderson et al. (2013) viewed delayed copying of unfamiliar characters as measuring visual-orthographic knowledge. However, the coding system they used was accuracy of whole character, which led to a loss of information as children typically succeed in copying some components correctly but not all of them, and success in copying components is exactly what we interpret as visual-orthographic knowledge. Mo et al. (2018) utilized structural equation modeling and found that orthographic working memory measured via delayed copying as well as a visual judgement task were both critical correlates of Chinese spelling. This finding was exciting and provides some clarity in understanding the association of delayed copying and Chinese spelling. However, referring to delayed copying as only orthographic working memory is apparently not enough considering the complicated demands of delayed copying. For example, there is a substantial motor component involved in delayed copying. Future studies should focus on establishing the components of delayed copying to provide a more comprehensive explanation for the relationship between delayed copying and Chinese spelling.

Chinese early spelling acquisition

In line with previous studies, the present study suggests that phonological, morphological, and orthographic awareness all play a role at the very beginning of learning to spell Chinese. However, while these skills appear necessary, they cannot fully explain early Chinese spelling acquisition. The present findings suggest that a model of Chinese spelling that only includes these cognitive-linguistic predictors is not enough. Pure copying, which taps into visual-motor skill and visual-spatial integration, should be included in the model of early Chinese spelling. Importantly, delayed copying, which involves visual-chunking skill and visual-orthographic knowledge, appears to be a critical associate of Chinese spelling performance concurrently and it remains a significant longitudinal predictor even after statistically controlling the effect of previous spelling performance. This result is consistent with the model from Ho et al. (2003) focusing on orthography knowledge development. Before formal literacy instruction, children using an analytical strategy with visual-orthographic knowledge (in delayed copying) when writing stand out as better spellers, and this continues to benefit them until grade one. While visual spatial skill (in pure copying) is critical at the beginning of learning to write, the importance of this skill diminishes after children receive formal literacy instruction and gain more visual-orthographic knowledge. In addition, we have expanded the model from Ho et al. (2003) by demonstrating that visual-orthographic knowledge can be enhanced with experience in copying practice.

Limitations and educational implications

One limitation of the present study is that the effect of working memory could not be separated from delayed copying given the variables included initially. It is possible that working memory, as a domain-general ability, is not captured by other tasks in the present study and is a possible factor in explaining the effect of delayed copying on Chinese spelling. The best way to address this concern would be statistically to control for working memory in the analyses, which was not measured in the present study. However, it should be noted that it remains controversial whether working memory contributes unique variance to literacy abilities (see Brandenburg, Klesczewski, Fischbach et al., 2015). In addition, the main objective of the present study was to examine the unique contribution from delayed copying to Chinese spelling, and our analyses have adequately addressed our questions.

Although rote copying is typically accepted by most Chinese parents and teachers as a traditional and regular strategy for learning to read and write Chinese characters (e.g., Chan et al., 2006; Wu et al., 1999), some parents have questioned whether it might cause an additional burden for their children. A more effective process of learning to write is urgently needed. Delayed copying is a relatively new and valid skill for early Chinese literacy learning. In light of our findings, we suggest that copying practice should capture both visual-motor integration and visual-orthographic knowledge in early spellers. Instead of requiring that children rote copy with little attention to what they are copying, copying with meaning, including practice with explicit attention to character structures, radicals, meanings, and logo-graphemes within the character

should be promoted (e.g., Wang & McBride, 2017). This is also in line with Vygotsky's Zone of Proximal Development theory (Vygotsky, 1980). With appropriate scaffolding of visual-orthographic knowledge from instructors, systematic and mindful copying practice maximizes its impact on learning to spell. A focus for future studies can be intervention effects of systematic copying practice on struggling spellers.

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