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ORIGINAL ARTICLE

Facilitating Effect of Grapheme and Syllable Cues on the Writing Performance of Children with Chinese Dictation Difficulties

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Abstract

Spelling difficulties is referred to as dictation difficulties in China. The visual-auditory binding deficit hypothesis suggested that Chinese dictation difficulties can be correlated with deficits in binding visual and auditory information. However, how Chinese characters are mentally represented in children with dictation difficulties remained unexplored. In this study, 20 children with dictation difficulties and 18 chronically age-matched controls completed dictation tasks using grapheme cues, syllable cues, and grapheme-syllable cues. Dictation accuracy was recorded. Findings showed that under the grapheme cue condition, dictation accuracy between the two groups did not differ significantly; under the grapheme-syllable and the syllable condition, dictation accuracy in children with dictation difficulties was significantly lower compared to controls. These findings supported that the graphemic and phonological representations of Chinese characters might loosely associated in the mental lexicon of children with dictation difficulties. Intervention strategies should take into account improving their ability to associate graphemes and syllables of Chinese characters.

Keywords Chinese dictation difficulties · Visual-auditory binding · Grapheme and syllable · Spelling · Writing performance

Writing is an essential skill for school-aged children, primary school children spend over 50% of their time in writing tasks (McHale and Cermak 1992). However, writing difficulties are the most prevalent communication disability (Lerner 1976). For Chinese

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characters, the writing problems are prominent due to its logographic nature and complexity in stroke sequence and directions (Lam et al. 2011). Indeed, writing problems are pervasive and are the most frequently observed learning problems among children in China (Meng 2000). 13.3% to 25% children have difficulties in dictation and writing (Guan 2013; Zhang 2006), while the prevalence for Chinese dyslexia is less than 5% (Cai et al. 2020; Sun et al. 2013). Meng et al. (2003) reported that 12.4% of children are unable to write out learned Chinese characters or wrongly write the target characters as the near-homographs.

Writing a spoken word to dictation, or written spelling, is the most basic form of writing, which involves both the spelling and writing processes (Delattre et al. 2006). Under Chinese background, difficulties in dictation or written spelling usually refers to dictation difficulties (e.g., Pan et al. 2010; Tan and Liu 2018; Yang et al. 2010b; Zhang et al. 2006). According to The Chinese Classification and Diagnostic Criteria of Mental Disorders (CMCC-3), Chinese dictation difficulties is characterized by normal reading and mathematics performance and lagging dictation performance compared to chronological age- and IQ-matched peers.

According to the World Health Organizations's International Classification of Diseases (ICD-10) (n.d.), impairment in dictation belongs to spelling disorder. Findings from alphabetic languages have suggested that spelling is influenced by phonological processing, especially phonological awareness (e.g., Bar-Kochva and Nevo 2019; Diamanti et al. 2017; Furnes and Samuelsson 2010; Moll et al. 2014; Plaza and Cohen 2003). Indeed, a close correlation between phonological processing skills and spelling or written output is plausible for alphabetic languages. Alphabetic languages are featured by the grapheme-phoneme correspondence rules (GPC; Gibson et al. 1962; Landerl et al. 1997). The orthographic form of alphabetic writing system is a conventional representation of the pronunciation of a word (Bisani and Ney 2008). However, for non-alphabetic language systems such as Chinese, written output may be less obviously influenced by phonological processing, given that Chinese is 'deep' orthography and has little correspondence between graphemes and syllables (Hu and Catts 1998; He et al. 2016).

Most progress in the field of Chinese dictation difficulties has referred to the visual-auditory binding deficit hypothesis (e.g., Dai et al. 2017; Liu et al. 2014; Yang et al. 2010a; Ning et al. 2017; Yang et al. 2009a). Learning associations between visual and phonological forms of words are prerequisites for developing reading and spelling skills (Moll et al. 2016). In terms of reading development, building up associations between visual and auditory information is a particularly important skill in distinguishing between children with and without Chinese dyslexia (Li et al. 2009). Regarding dictation, studies have demonstrated that children with dictation difficulties have deficit in binding visual and auditory information (Liu et al. 2014; Yang et al. 2009a; Zhang et al. 2006; Zhong et al. 2011), and this deficit correlates with their failure to write out learned Chinese characters (Yang et al. 2009a). In the first study of dictation difficulties, Zhang et al. (2006) presented a series of pairs of visual and auditory stimuli and tested if participants can recall the corresponding sound of each visual stimuli. They found that the recall accuracy for children with dictation difficulties was significantly poorer than typically developed children. Liu et al.

(2014) and Dai et al. (2017) used the change detection paradigm to test the visual-auditory binding ability of dictation difficulties. In this paradigm, a sample array containing visual and auditory stimuli is presented, followed by an altering pair of visual and auditory stimuli (Fig. 1). The altering stimuli can be the same or different from the sample array of stimuli, participants were required to decide if the altering stimuli were the same or different with those in the sample array. They found that children with dictation difficulties showed poorer accuracy than others. Moreover, their accuracy became worse if visual information was complicated, whereas the complexity of auditory information did not exert substantial influence (e.g., Liu et al. 2014; Yang et al. 2010a). Thus, impairment in binding visual-auditory information is apparently attributable to deficit in visual or orthographic processing, rather than phonological processing.

Although impairment in forming visual-auditory associations in children with Chinese dictation difficulties is evident, relevant studies can only inform about the outcome of processing (Moll et al. 2016); how Chinese characters are mentally represented among children with dictation difficulties remains unknown. According to the dual-route model of spelling (Caramazza et al. 1987; Miceli 1989; Houghton and Zorzi 2003), successful spelling of familiar words starts with auditory input activating relevant phonological representations and then semantic representations in the mental lexicon. The phonological and semantic representations together activate the target graphemic representations, which finally lead to the spelling output (Fig. 2). Chinese dictation difficulties is possibly impaired in graphemic representation (Tan and Liu 2018; Mao et al. 2013; Ning and Yang 2016) or the association between phonological and graphemic representations (Tan and Liu 2018; Yang et al. 2009a). Evidences for impairment in graphemic representation mainly come from the findings that children with dictation difficulties were less likely to be affected by grapheme distractions when processing Chinese characters than those without the difficulties (Yang et al. 2009a, 2010c). However, impairment in mental graphemic representation should lead to wrongly written characters in writing or dictation tasks (Ning et al. 2017). But the percentage of wrongly written characters was significantly lower in children with

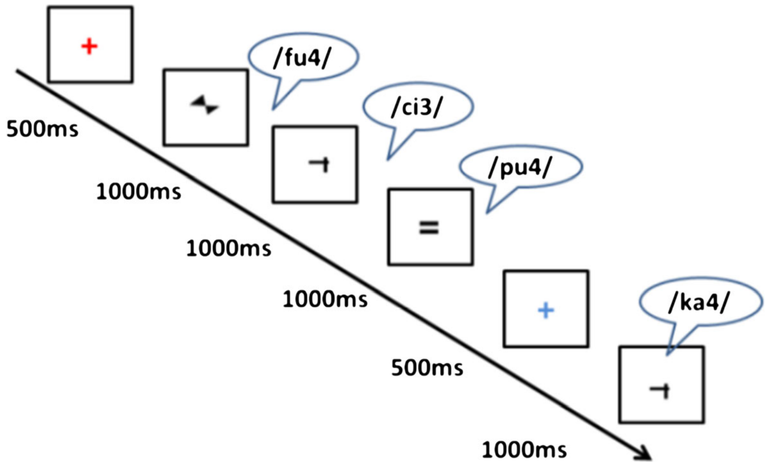

Fig. 1 Change detection paradigm

dictation difficulties. Instead, they showed significantly higher zero-response errors (Yang et al. 2009a). The other assumption, impairment in the association between phonological and graphemic representations, is in line with the visual-auditory binding deficit hypothesis. However, this assumption has not been tested yet, except one relevant study. Yang et al. (2008) found that when provided the phonetic radicals, which indicate the pronunciation of pictophonetic characters, typically developed children improved significantly more than children with dictation difficulties. This finding implies that children without dictation difficulties are more able to use syllable information to activate graphemic information of a character compared with dictation difficulties, indicating graphemes and syllables of Chinese characters might not as tight as others in their mental lexicon. However, such inference needs further examination.

Thus, how Chinese characters are mentally represented in children with dictation difficulties is an unresolved problem. To further explore the problem, this study advances the paradigm in Yang et al. (2009a)'s study. In their study, target characters were dictated to participants. If participants could not dictate some characters correctly, strokes or structure of these characters, which served as the grapheme cues, were presented to examined if they facilitated the dictation performance. In our study, not only grapheme cues but also syllable cues and grapheme-syllable cues were provided to compare their facilitation effects on the dictation performance. Besides, this study investigated how these effects differed between children with and without dictation difficulties. Based on the findings of visual-auditory binding deficit hypothesis, it was expected that under the grapheme cue condition, differences in dictation accuracy would not reach statistical significance between the two groups; under the syllable cue and the grapheme-syllable cue conditions, dictation accuracy in children with dictation difficulties would be significantly lower than children without the difficulties.

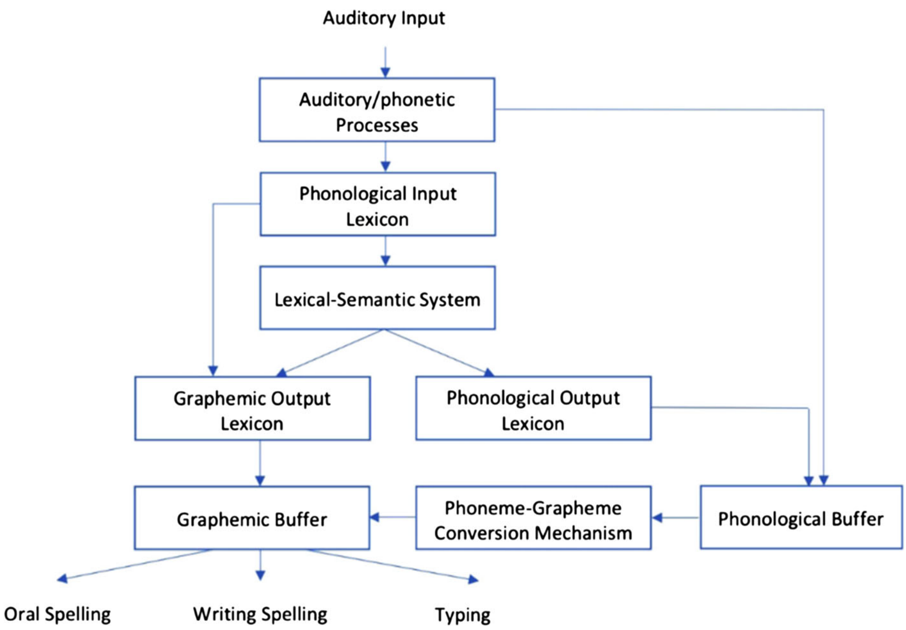

Fig. 2 Dual-route model of the spelling process

Method

Participants

Twenty children with dictation difficulties (13 boys, grade 3 to 6, mean age = 10.68 years, *SD* = 1.17) and 18 typically developed children (8 boys, grade 3 to 6, mean age = 10.53, *SD* = 1.31) matched by chronological age, grade and non-verbal IQ were selected from a primary school in Beijing, China. All participants were native *Putonghua* speakers and right-handed, had normal hearing and normal or corrected-to-normal vision, and showed no symptom of attention deficit hyperactivity disorder (ADHD). The researcher obtained signed informed consent from all participants and their guardians prior to the study. This study was approved by the Academic Committee of the School of Psychology, Beijing Normal University, China.

According to Chinese classification of mental disorders (Chinese Society of Psychiatry 2001), children with dictation difficulties are characterized by normal reading performance and lagging dictation performance. Accordingly, inclusion criteria of dictation difficulties are as follows: (a) showing normal to above-average reading ability; (b) showing higher-than-average discrepancy between reading and dictation abilities; (c) demonstrating inability to write but ability to read learned Chinese characters; (d) having lower-than-average Chinese examination scores compared with classmates; (e) having higher-than-average math examination scores compared with classmates (Mao and Liu 2012; Tan et al. 2016; Tan and Liu 2018; Yang et al. 2010a, b). As standardized tests of dictation difficulties are not available in China, the identification of children's dictation difficulties is primarily based on their school performance and teacher's recommendation, and self-constructed tests of reading and dictation abilities.

The screening procedure follows previous studies (Tan et al. 2016; Tan and Liu 2018). In the first phase, homeroom teachers and Chinese language teacher of each class were invited to provide a name list of children at risk of dictation difficulties that meet criteria (c), (d) and (e). A chronological age- and IQ-matched control group was also nominated. In the second phase, name-listed participants' reading ability, dictation ability, and discrepancy between reading and dictation abilities were measured by reading test and dictation test for criteria (a) and (b). Reading ability was operationalized by the ratio of the number of characters read correctly in the reading test; the discrepancy between reading and dictation abilities was operationalized by the ratio of the number of characters read correctly in the reading test, but written incorrectly in the dictation test, over the total number of the characters in the reading test (Mao and Liu 2012; Tan and Liu 2018; Tan et al. 2016; Yang et al. 2010a; Yang et al. 2010b). Raven's Standard Progressive Matrices-Chinese Revised (R'SPM-CR) was also administered to measure non-verbal IQ.

Dictation test and reading test developed by researcher. Following previous studies (Mao and Liu 2012; Tan and Liu 2018; Tan et al. 2016; Yang et al. 2010a, b), the dictation test and reading test for each grade were developed by the researcher. These tests were used for participant screening in this study only. The tests consisted of high-frequency Chinese characters, which are selected from textbooks for Chinese language for Beijing primary schools. The textbooks attached two lists of characters. According to teaching requirements, students should be able to read characters the first list, and can read and write characters in the second list after each semester. All characters included in the dictation test and reading test for each grade were chosen from the second lists taught before this grade. Characters included in the reading test were identical to the dictation test for the same grade. The number of strokes and structures of the chosen characters were controlled: all chosen characters had 8 to 12 strokes, 1/3 were top-down structured, 1/3 were left-right structured, and 1/3 were other structured.

Raven's Standard Progressive Matrices-Chinese Revised (R'SPM-CR). The SPM was developed by Raven and colleagues (Raven 1958; Raven et al. 1998) to measure non-verbal intelligence and was revised in China (Zhang and Wang 1985, 1989). R'SPM-CR had a split-half correlated coefficient of .95 and test-retest reliability of .82 (Zhang and Wang 1989). The criterion-related validity with Chinese version of Wechsler tests was .71 (Zhang and Wang 1989).

The dictation test and R'SPM-CR were administered first. The reading test was administered 2 days later. Participants with R'SPM-CR percentile rank lower than 25% were excluded. Participants' descriptive characteristics are presented in Table 1. The *t*-tests showed that the two groups did not differed significantly in reading accuracy. However, children with dictation difficulties showed significantly greater discrepancy between reading and dictation abilities. The inclusion criteria of dictation difficulties were met.

Materials

Experimental materials included target stimuli and cue stimuli. Target stimuli were selected based on reading and dictation tests used in participant screening. For each participant, the Chinese characters that he or she could read correctly in the reading test, but failed to write correctly in the dictation test, were chosen as his or her target stimuli. Each participant was therefore presented with a unique set of target stimuli. Same target stimuli design was adopted by Yang et al. (2009a). These stimuli, as well as their associated words or idioms, were read in *Putonghua* and voice-recorded by an adult female who possessed a First-level, Class B *Putonghua* level certification. The format of the voice recording for each target stimulus was as follows: 爬山的爬. The Chinese character "爬/pa2/ (climb)" was the target stimulus, and the word "爬山/pa2 shan1/ (climb mountain)" helped to locate the meaning of the target character.

Table 1 Descriptive characteristics of the two groups

	Dictation difficulties		Control		
	M	SD	M	SD	t-value
Age (years)	10.68	1.17	10.53	1.31	.37
SPM	39.90	5.46	39.22	5.16	.39
Reading accuracy	.82	.079	.85	.29	−1.56
Dictation accuracy	.40	.14	.58	.11	−4.63
Discrepancy between reading and dictation	.52	.14	.34	.11	4.52***

R'SPM-CR=Raven's standard progressive matrices-Chinese revised

Target stimuli were distributed evenly into three sub-sets for each participant. Characters sharing the same radicals, pronunciations, or both radicals and pronunciations with the target stimuli were selected as cue stimuli for each sub-set, respectively (see Table 2). Chinese characters sharing the same radical of target stimuli provided grapheme information for target stimuli and were thus used in the grapheme cue condition. For example, the two characters "抓/zhua1/" and "爬/pa2/" had the same radical "爪", but they had no common on pronunciation. Characters sharing the same pronunciation provided syllable cues for target stimuli and were thus used in syllable cue condition. For example, the two characters "茅/mao2/" and "毛/mao2/" had the same pronunciation, but they have no common on grapheme characteristics. Characters sharing the same radical and pronunciation provided both grapheme and syllable cues for target stimuli and thus were used in grapheme-syllable cue condition. For example, the two characters "浑/hun2/" and "混/hun2/" not only had the same radical "氵", but also had the same pronunciation. All cue stimuli were chosen from the Chinese test book for Grade 1 and 2 primary students and were checked with the Chinese teachers to guarantee the cue stimuli were familiar and simple enough for the participants. The linguistic characteristics of the target and cue stimuli were presented in Table 3, target stroke, cue stroke, and the ratio of the number of same radical(s) shared by the cue and target, over the total number of targets' number of radicals were included. Results of the independent *t*-tests revealed no significant difference between the two groups on these linguistic characteristics.

Procedure

The experiment was run using E-prime 1.1 software. Participants sat in front of computers with eyes leveled with the screen and with earphones worn. The experimental procedures and requirements were introduced to participants prior to beginning. After 10 practice trials, participants were instructed to enter the experiment. The experiment consisted of three blocks: the grapheme cue condition, the syllable cue condition, and the grapheme-syllable cue condition. In each trial, a fixation was presented in the center of the screen for 500 ms, followed by a cue stimulus lasting for 3000 ms. Under the grapheme cue condition, the character with the same radical with the target stimulus was presented. Under the syllable cue condition, character with the same pronunciation with the target stimulus was presented. Under the grapheme-

Table 2 Samples of target and cue stimuli from one participant

	Target stimuli		Cue stimuli	
Cue Condition	Shape	Pronunciation	Shape	Pronunciation
Grapheme cue	爬	/pa2/	抓	/zhua1/
Syllable cue	茅	/mao2/	毛	/mao2/
Grapheme-syllable cue	络	/luo4/	落	/luo4/

Table 3 Linguistic characteristics of the two groups

	Dictation difficulties		Control		
	M	SD	M	SD	t-value
Target stroke	10.24	.33	10.41	.30	−1.57
Cue stroke	8.04	.48	7.99	.52	.28
Ratio of shared radical(s)	.54	.04	.54	.04	−.12

syllable cue condition, character with the same radical and pronunciation with the target stimulus was presented. Participants were instructed to fix their eyesight on the cue stimulus to pay attention to its orthographic characteristics, including the structure, radicals, and strokes. Meanwhile, they were required to read out the cue stimulus aloud. Upon the disappearance of the cue stimulus, a fixation was presented on the screen for 500 ms, followed by a blank screen, with dictation voice-recorded dictation of the target stimulus played via the earphone and repeated twice. After the voice recording, participants were instructed to write down the target stimulus on a paper, and then press the "F" on the keyboard to enter the next trial. The presentation format of each trial under the three cue conditions was showed in Figs. 3, 4, and 5.

Participants were required to complete dictation tasks under all three cue conditions. The order of the three cue conditions was counterbalanced among participants. Participants were rewarded with a thank-you card and a pencil upon the completion of the experiment.

Data Analysis

Dictation accuracy was calculated as the proportion of the correctly written target stimuli and was used for data analysis. The effects of the cue conditions and group

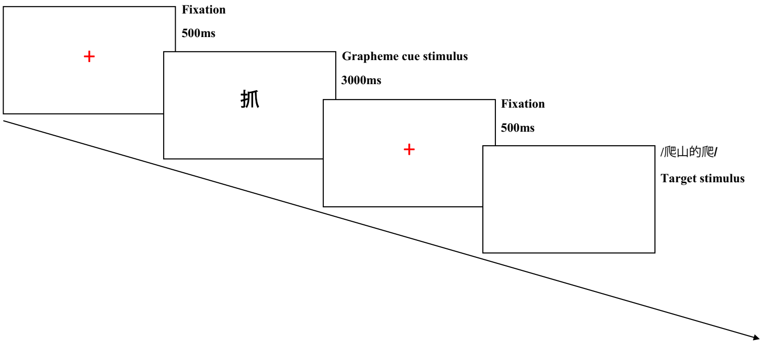

Fig. 3 Presentation format of each trial under the grapheme cue condition

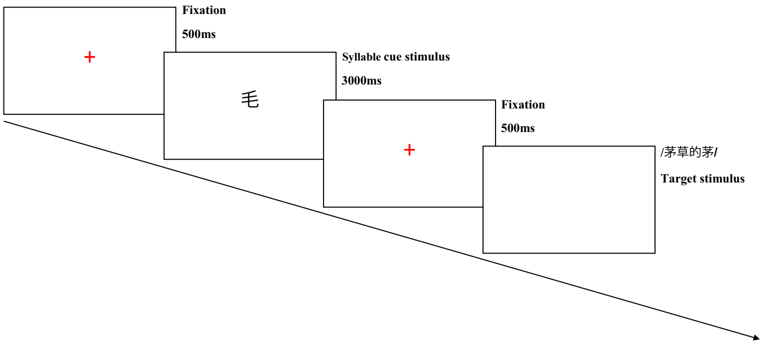

Fig. 4 Presentation format of each trial under the syllable cue condition

on dictation accuracy were explored using analysis of variance (ANOVA), with the group (dictation difficulties vs. controls) as the between-subjects factor and the cue condition (grapheme cue vs. syllable cue vs. grapheme-syllable cue) as the within-subjects factor.

Results

Mean scores and standard deviations of dictation accuracy across the three cue conditions for the dictation difficulty and control groups were shown in Table 4.

The mixed ANOVA results revealed a significant main effect of the group ($F(1, 36) = 8.19$, $p < .01$, $\eta^2 = .19$), indicating that dictation accuracy was significantly higher among controls than in children with dictation difficulties. The cue condition also showed a significant main effect ($F(2, 72) = 56.55$, $p < .01$, $\eta^2 = .61$). The interaction effect between the group and cue condition was significant ($F(2, 72) = 3.46$, $p < .05$, $\eta^2 = .09$). Further simple effect analysis suggested that dictation accuracy did not differ

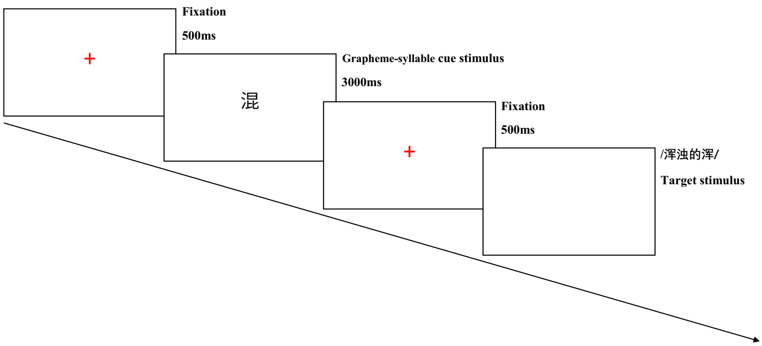

Fig. 5 Presentation format of each trial under the grapheme-syllable cue condition

Table 4 Mean (SD) dictation accuracy (proportion correct) under three cue conditions

	Dictation difficulties		Control	
	M	SD	M	SD
Grapheme cue	.49	.15	.51	.19
Syllable cue	.23	.11	.32	.15
Grapheme-syllable cue	.51	.19	.70	.14

significantly between the two groups under the grapheme cue condition; however, the dictation accuracy of children with dictation difficulties was significantly lower than controls under both the syllable cue ($p < .05$) and the grapheme-syllable cue conditions ($p < .01$). For the dictation difficulty group, the differences between the grapheme and syllable conditions and between the syllable and the grapheme-syllable cue conditions were significant ($p < .01$); the differences between the grapheme and grapheme-syllable cue condition was not significant. For the control group, differences between the grapheme and syllable cue conditions, grapheme and the grapheme-syllable cue conditions, and syllable and grapheme-syllable cue conditions were all significant ($p < .01$).

Discussion

This study explored whether different types of cues (i.e., grapheme cue, syllable cue, and grapheme-syllable cue) affected dictation performance in children with and without dictation difficulties. Results of this study supported our expectations: under the grapheme cue condition, differences in dictation accuracy were not significant between the two groups; under the syllable cue and the grapheme-syllable cue conditions, dictation accuracy in children with dictation difficulties was significantly lower than in children without such difficulties.

The finding on the grapheme cue condition indicated that grapheme cues facilitate the recall of learned Chinese characters in both children with and without dictation difficulties and thus improving their dictation accuracy. Previous studies observed significant facilitation of grapheme cues on normally mental represented orthographics. For example, Ding et al. (2004) found that primes with the same radical or component with targets significantly facilitate Chinese character reorganization in normally developed participants. In their study, grapheme cues also facilitated the output of children with dictation difficulties, revealing a similar facilitation with normally developed participants. Thus, the claim that mental orthographic representation of Chinese characters in children with dictation difficulties is impaired was not supported in this study.

More importantly, comparisons between results under grapheme and grapheme-syllable cue conditions implied that, on the basis of providing grapheme cues, adding extra syllable cues only promoted dictation accuracy among the controls and did not influence children with dictation difficulties. These results suggested that orthographic and phonological effects in Chinese character writing output are additive for typically developed children, but not children with dictation difficulties. The parallel distributed process (PDP) proposed lexical transformations among orthographic, phonological, and semantic representations are accomplished by interactions among orthographic, phonological, and semantic units as governed by the weighted connections among them (Joanisse and McClelland 2015). In this sense, findings that the non-additive effect of grapheme and syllable cues in children with dictation difficulties might due to their weak weight of the connections between orthographic and phonological units. However, as children with dictation difficulties demonstrated equal reading performance to the controls, the connection from orthographic to phonological information might be at a normal level for them. Hence, the weights of the connections from phonological to orthographic information appeared to be weak for children with dictation difficulties, such that phonological information cannot activate orthographic representation as in typically developed children.

Another important finding of this study was that dictation performance between the two groups differed significantly under the syllable cue condition, which indicated that syllable cues can facilitate the recall of the grapheme of learned Chinese characters in typically developed children. This finding was aligned with previous studies. Yang et al. (2008) used phonetic radicals to manipulate syllable cues to study their promoting effect on dictation performance of children with and without dictation difficulties. They found that when the phonetic radicals shared the same vowel with the character, the promoting effect was significant in children without dictation difficulties, but not in children with dictation difficulties. Moreover, even when phonetic radicals shared the same pronunciation with the whole character, the promoting effect was much stronger in children without dictation difficulties than those with dictation difficulties.

Previous studies found that phonological information facilitated the reaction time and accuracy of Chinese word recognition in normally developed people (Zhang et al. 2009), one explanation was that all lexical codes are mutually connected with each other during lexical processing (Hoshino and Kroll 2008). Following this, the pronunciation of Chinese character may activate the shape of its corresponding homophones, thereby facilitating the output of the target Chinese character. But this facilitation effect was only occurred in children without dictation difficulties.

To conclude, findings of our study supported that the graphemic and phonological representations of Chinese characters are loosely associated in the mental lexicon of children with dictation difficulties. Additionally, our findings contributed to a better understanding of Chinese dictation difficulties. Children with Chinses dictation difficulties manifested a deficit in associating the grapheme and syllable of Chinse characters, which can be a core index of Chinese dictation difficulties. This could have significant implications for diagnosis of children at risk for dictation difficulties. Moreover, our study provided references for teaching or intervention programs targeted at children with dictation difficulties. For example, intervention programs can take into account improving their ability to associate graphemes and syllables of Chinese characters, such as emphasizing the association between graphemes and syllables when teaching Chinese characters.

Finally, this study had several limitations. First, although dictation and reading abilities were measured for participant screening, other interdisciplinary measures can be used to improve the rigor of participant selection. Second, due to the limited number of target stimuli for each participant, we were unable to include an irrelevant cue condition to measure the baseline. Third, because of the varied number of target stimuli across participants, some participants had to proceed more trials whereas others went through fewer, which could induce interference effects. Forth, findings of this study only provided evidence for the representation assumption of dictation difficulties at a behavioral level. In the future, research shall be conducted with more strict participant selection and better control over experimental design. Furthermore, more advanced techniques, such as brain imaging, could be included to obtain more knowledge about Chinese dictation difficulties.

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Compliance with Ethical Standards

Conflict of Interest The authors declare no conflict of interest.

Ethical Approval This study was approved by the Academic Committee of the School of Psychology, Beijing Normal University, China. All procedures performed in this study were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki declaration and its later amendments.

Informed Consent Informed consent was obtained from all the participants included in this study.

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