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Original article

A Cross-sectional Study of the Cognitive Abilities Underlying the Acquisition of Reading in Chinese Speaking Children in Mainland China: The Change of Predictors across Grades

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In this study, we analysed the cognitive abilities that are predictors of reading acquisition in the Chinese language. To this end, the phonological skills, visual skills, naming speed, morphological awareness, vocabulary knowledge, nonverbal intelligence, and reading performance of 672 primary school children in China were assessed. Multiple regression analyses revealed that visual skill and naming speed were significant predictors of word-reading performance for children in lower grades. In contrast, phonological skills and vocabulary knowledge significantly contributed to the reading abilities of children in intermediate and advanced grades. Therefore, our results indicated that the relationship between reading performance and the different cognitive abilities change with age. We suggest that this may be due to the characteristics of the Chinese orthographic system, as well as the instruction method at primary schools in Mainland China.

Key words: Chinese reading acquisition, visual skill, naming speed, phonological skill, vocabulary knowledge

I. Introduction

Phonological processing skills refer to the use of sound structure in a language. Phonological awareness, phonological recoding in lexical access, and verbal short-term memory have been identified as three primary phonological processing skills (Wagner & Torgesen, 1987) that are strongly associated with alphabetic reading ability. However, the deficits of reading development in non-alphabetical languages like Chinese are different from those of alphabetical languages (McBride-Chang, 2016). Therefore, conducting further research on Chinese reading performance and the cognitive abilities of Chinese children can serve to clarify reading development in Chinese orthography.

Each Chinese character represents a syllable as well as a unit of meaning or morpheme. Chinese characters consist of many strokes, which makes them visually complex. Given that Chinese characters are visually distinctive and complex, it is possible that those who have problems with their visual skills will encounter difficulties in Chinese literacy. For example, visual skills have been reported to be involved in detecting and memorising stroke patterns, which are essential for deriving meaning and sound when reading Chinese characters (Ho & Bryant, 1997). A number of findings obtained by previous studies supported this notion (e.g., Ho & Bryant,

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1999; Huang & Hanley, 1995; Siok & Fletcher, 2001; Tan, Spinks, Eden, Perfetti, & Siok, 2005; Lin & Uno, 2015). Visual skills are defined as the skills that are applied to cognitive processes of organizing, interpreting, and storing representations of visual sensory stimuli, as well as their locations (Yang, Guo, Richman, Schmidt, Gerken, & Ding, 2013). In some previous studies, pure copying skills, which were conceptualised as involving attention to visual detail and the ability to use visual-motor skills to represent such detail in print (Kalindi, McBride-Chang, Tong, Wong, Chung, & Lee, 2015), were found to be important for Chinese literacy acquisition (McBride-Chang, Chung, & Tong, 2011; Tan, Spinks, Eden, Perfetti, & Siok, 2005).

Although phonological skills are an important factor for reading development in alphabetical languages (e.g. Hulme, Hatcher, Nation, Brown, Adams, & Stuart, 2002; Share, 1995), there is an ongoing debate regarding the association between phonological skills and the development of reading skills in Chinese. Ho, Law, and Ng (2000) and Ho and Lai (1999) have reported that Hong Kong Chinese children with dyslexia are deficient in phonological awareness and phonological memory. A similar relationship between phonological skills and reading achievement in Chinese has also been reported by researchers across societies (Ho & Bryant, 1997; Hu & Catts, 1998; Siok & Fletcher, 2001). While recognising the general importance of phonological skills for reading acquisition in Chinese and English, other researchers found that phonological awareness skills did not always have a significant contribution to reading development in Chinese (Ho, Chan, Tsang, & Lee, 2002; McBride-Chang, Cho, Liu et al., 2005). Furthermore, phonological memory deficits seem to contribute to dyslexia in some Chinese children; Zhang and Zhang (1997), for example, reported that Chinese children with developmental dyslexia in mainland China performed significantly worse in digit and text memory than normal children of the same age. Given these contradictory conclusions, it is necessary to further examine the influence of phonological skills on reading development in the Chinese context.

Phonological recoding in lexical access, another phonological processing skill defined by Wagner and Torgesen (1987), is most often measured using speeded naming tasks that track the speed and automaticity of symbol recognition (Wolf, Bally, & Morris, 1986). Given that many studies have demonstrated that this ability is linked with reading difficulties in both alphabetic (Mimmer, Mayringer, & Landerl, 2000) and Chinese (Liao, Georgiou, & Parrila, 2008; McBride-Chang et al., 2012; Tan et al., 2005) orthographies, naming speed is of significant interest in the field.

Furthermore, vocabulary has been shown to be an influential predictor of the acquisition of reading skills in Chinese. Shu, McBride-Chang, Wu, and Liu (2006) found that Chinese readers with developmental dyslexia differed from an age-matched control group in terms of their vocabulary skills. Early vocabulary knowledge has also sometimes emerged as an important factor in correlating Chinese reading performance in previous studies (e.g. Liu, McBride-Chang, Wong, Tardif, Stokes, Fletcher, & Shu, 2010; Pan, McBride-Chang, Shu, Liu, Zhang, & Li, 2011).

Additionally, a growing body of research has shown converging evidence on the importance of morphological awareness when reading Chinese, which is defined as awareness of, and access to, morphemes in words (Shu et al., 2006). In previous studies, morphological awareness was found to contribute uniquely to Chinese character recognition, character writing, reading fluency, and reading comprehension (McBride-Chang, Shu, Zhou, Wat, & Wagner, 2003; Shu et al., 2006; Tong, McBride-Chang, Wong, Shu, Reitsma, & Rispens, 2011). All these findings emphasise morphological awareness as a unique, important metalinguistic awareness skill in Chinese literacy acquisition.

However, most of the abovementioned studies conducted their research on reading acquisition in relation to various cognitive constructs in Hong Kong and Taiwan (Ho & Bryant, 1997; Hu & Catts, 1998; Ho & Lai, 1999; Ho et al., 2000). In terms of literacy instruction methods, spoken languages, and script, there are several differences between children from mainland China and those from Taiwan and Hong Kong (Cheung & Ng, 2003). Given the wide diversity of Chinese learning environments, Chinese literacy development between Hong Kong, Taiwan, and Mainland China may vary. Yet, few studies have examined the significant predictors of Chinese word reading across all elementary grades. The fact that the majority of studies were conducted among children of a particular age range, and few measures were employed for the potentially important skills, makes it difficult to draw conclusions regarding the relative predictive power of each reading related skill in Chinese word reading across different grades. It is therefore necessary to examine cross-sectional reading development, especially in Mainland China, for primary school children in grades 1 to 6 to ascertain the developmental trajectory of Chinese reading acquisition. Thus, the aim of the current study is to determine the cognitive abilities that exert a unique influence on the acquisition of reading in Chinese, and determine whether they remain influential at different developmental stages.

II. Methods

1. Participants

A total of 672 native Chinese children from two primary schools (located in A Province) participated in our study from 2018 to 2019. There were 128 children in grade 1, 102 in grade 2, 103 in grade 3, 101 in grade 4, 119 in grade 5, and 119 in grade 6. Participants that took all of the tests and had Raven Coloured Progressive Matrices (RCPM) (Raven, Court, & Raven, 1995) of more than -1.5 SD of the mean score were included in the analysis.

2. Measures

(1) Word Reading test:

The word reading test in grade 1 consisted of 40 word stimuli, which included 20 one-character and 20 two-character stimuli in Chinese. The word reading test in grade 2 consisted of 20 word stimuli, which included 10 one-character and 10 two-character stimuli. From grades 3 to 6, the word reading test only included 10 two-character stimuli. The stimuli were printed on two A4 size sheets, and the participants were required to read them aloud. All of the word stimuli were selected from textbooks that had already been studied by the participants and were different across grades. The stimuli of word reading tests varied in different grades in order to prevent floor and ceiling effects.

(2) Phonological tests:

a. Phoneme deletion and phoneme production.

An onset deletion (Onset) task and a rime deletion (Rime) task were administered to first and second graders, while an onset production task and a rime production task were administered to the children from grades 3 to 6. The phoneme deletion tests were modified from the phonological tests administered by Lin and Uno (2015). The testing methods and scoring procedures were same as their tasks, while the stimuli were different from those used in their study. In the phoneme deletion tasks, the participants were required to delete the onset or rime from the syllables and answer orally. In the phoneme production tasks, children were asked to say a different syllable that has the same onset or rime as the presented syllables. Each sub-task included five items, making a total of 10 real syllables. Each participant's score for the deletion or production tasks was the number of correct answers he/she gave out of the 10 items. Different levels of phonological awareness tasks were included in the phonological tests in order to prevent floor and ceiling effects when the same measures were given across a wide range of children's ages.

b. Non-word repetition tests (NonwordRep).

In two practice runs and ten trials, the participants were asked to complete non-word repetition tests (nonwordRep) in which the stimuli consisted of three to nine syllables that were ordered in terms of the ascending length. This measure was modified form the phonological memory task used in the study of Chan et al. (2006). The testing method was same as their task, while the stimuli were different from those used in their study. The participants were required to listen to each non-word and then repeat them. Each participant's score was the number of correctly pronounced non-words out of the 10 items.

c. Non-word backward span (NonwordBackSpan).

The stimuli were five non-words with two to five syllables. This measure was adapted from the backward digit span task used in the study of Liu et al. (2019), in which the participants were asked to repeat digit strings arranged in order of increasing length. The testing method and scoring procedure of the current study were also same as Liu et al.'s (2019). We used non-word syllables replacing digit strings as the stimuli in our study in order to be consistent with the non-word repetition tests. For each trial, the children were asked to listen to a non-word carefully and then repeat it. After the children repeated the non-word correctly, they were asked to repeat it in reverse. The number of correct responses was calculated.

(3) Visual skill tests:

Visual skill tests included copy drawing, immediate recall, and delayed recall tasks. For copy drawing, participants were required to copy a complicated figure (FigureCopy), after which they were required to draw the figure again without the target stimulus for reference (FigureImm). After about 30 minutes, the children were asked to draw the figure for a third time (FigureDel). The Rey-Osterrieth Complex Figure Test was administered for children from grades 2 to 6, while the Three Figures (Inomata, Uno, & Haruhara, 2013) were administered for first graders. A different visual skill test was selected for children in grade 1 in order to prevent the floor effect.

(4) Rapid automatized naming (RAN):

RAN tests, which were developed by Kaneko et al. (2004), were also administered. The children were asked to name drawings of objects and digits that were printed in rows on A4 size paper as fast as possible. The RAN tests consisted of one practice run and three trials. The time used to name all the stimuli was also accounted for in each trial, and the average duration of the three trials was used as the participants' score in the analyses.

(5) Vocabulary tests:

a. Standardised Comprehension Test of Abstract Words (SCTAW).

The SCTAW, a standardised test developed in Japan (Uno, Haruhara, & Kaneko, 2002), was conducted in order to test the participants' receptive vocabulary knowledge. As the test was originally conducted in Japanese, the Chinese target words were translated from those used in the study of Lin and Uno (2015). Each participant's score was the number of correct answers that he/she gave.

b. Expressive vocabulary (KABC).

This task was adapted from the expressive vocabulary test in the Japanese version of the Kaufman Assessment Battery for Children (KABC-II, 2013) to measure children's vocabulary knowledge. Coloured pictures of some objects were presented to the children, and they were instructed to name the objects one by one. Scoring procedures of this task were based on the local norm established by the Japanese version of the KABC-II. Each word that was matched to the picture was equal to one mark.

(6) Morphological awareness tests:

a. Morphology judgement (MorphologyJud).

This measure was modified from the morpheme judgment task administered by Wei et al. (2014). The testing method was same as their task while the stimuli were different from those used in their study.

In this task, the experimenter orally presented the child with two-morpheme Chinese words. In each word pair, there was a syllable that shared the same sound and the written form (e.g. a shared syllable '友' in '朋友' meaning 'friend' and '友情' meaning 'friendship'). For each word pair, children were asked to judge whether a shared syllable had a similar or different meaning to the other words.

b. Morphology production (MorphologyProd).

Following the previous study (Shu et al., 2006), we conducted a morphology production task to the older Chinese school children in order to prevent the ceiling effect of morphology judgement task. This measure was modified from the morpheme production task used in the study of Shu et al. (2006). The testing method and scoring procedure were same as their task while the stimuli were different from those used in their study. The experimenter orally presented a two-character Chinese word and a target constituent character of this word to each child. Children were asked to say two words that had the target character. When answering, children were required to produce a word whose target character shared the same meaning as that of the presented word, as well as a word whose target character had a different meaning from the character of the presented word. For example, the word '花朵' meaning 'flower' with the target character '花' was presented. Two possible answers are '鲜花', meaning 'fresh flower', and '花钱', meaning 'to spend money'. This task had five trials, and it was administered to children in grades 3 to 6.

3. Procedures

For the word-reading task, phonological tests, RAN tests, expressive vocabulary task, morphology production task, each child was tested individually, and the examiners recorded errors. Each child's responses were also audiotaped for later verification. In the group tests' sessions, RCPM, SCTAW, visual skill tests and morphology judgement task, were administered to participants. The individual tests were administered in quiet rooms at the participants' school, while the group tests were administered in their classrooms. The individual sessions lasted approximately 15-20 min, while the group sessions lasted 35-40 min. This study was approved by the Ethics Committee of the University.

III. Results

Pearson's correlation analyses were conducted on cognitive test scores and word-reading performance. Table 1 presents the results of Pearson's correlation.

1. Grades 1 and 2

RAN (grade1: r=-0.21, p<0.05; grade2: r=-0.23, p<0.05), Onset (grade1: r=0.23, p<0.05; grade 2: r=0.25, p<0.05), NonwordRep (grade1: r=0.18, p<0.05; grade2: r=0.38, p<0.001) and Nonword BackSpan (grade1: r=0.19, p<0.05; grade2: r=0.28, p<0.01) were significantly related to word reading in grades 1 and 2. The correlation analyses showed that FigureCopy (r=0.28, p<0.01), FigureImm (r=0.35, p<0.001), FigureDel (r=0.19, p<0.05), and Rime (r=0.23, p<0.05) were correlated with grade 1 but not with grade 2, whereas KABC (r=0.34, p<0.001) was related to grade 2 but not grade 1.

We tested whether there are significant interactions between grade and each test performance correlating with reading performance of either grade 1 or grade 2 through a series of model comparisons. It was revealed that the scores in FigureImm had a significant interaction with grade, because there was a change in model fit when the interaction was excluded from the regression model with the interaction and main effect (p<0.05); the following regression models in the multiple regression analysis did not combine grade 1 and grade 2.

a. Results of multiple regression analysis in grade 1.

The multiple regression analysis in grade 1 was carried out with variables from ten cognitive abilities tests, including RAN, FigureCopy, FigureImm, SCTAW, KABC, Onset, Rime, NonwordRep, NonwordBackSpan and MorphologyJud. The

Table 1 Results of the Pearson Correlation Analysis between Scores of Cognitive Ability measures and the Word Reading Test

Variable	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Grade 6
RAN	**-0.206***	**-0.225***	-0.188	**-0.390****	-0.132	-0.174
FigureCopy	**0.277****	0.098	0.134	-0.037	0.118	0.10
FigureImm	**0.347*****	0.024	0.110	-0.076	-0.002	-0.054
FigureDel	**0.19***	-0.042	0.088	-0.021	0.121	0.030
SCTAW	-0.145	0.053	0.083	**0.302****	**0.365****	0.175
KABC	0.078	**0.337*****	0.186	0.020	**0.339****	**0.297****
Onset	**0.229***	**0.253***	-0.148	0.107	0.136	**0.300****
Rime	**0.225***	0.193	**0.247***	**0.257***	**0.244***	**0.306****
NonwordRep	**0.182***	**0.378*****	**0.357****	**0.212***	**0.289****	0.083
NonwordBackSpan	**0.189***	**0.28****	**0.297****	**0.342****	**0.329****	**0.264****
MorphologyProd			0.029	0.078	**0.338****	0.178
MorphologyJud	0.153	0.171	-0.077	-0.117	-0.071	0.170

Note. *: $p < 0.05$ **: $p < 0.01$ ***: $p < 0.001$

regression model consisted of the z-scores on the word reading test of grade 1 as the dependent variable, and those ten cognitive tests z-scores as the independent variables. For children in grade 1, word-reading performance was significantly predicted by the scores in FigureImm (β=0.31, t=2.91, p<0.01), RAN (β=-0.19, t=-2.15, p<0.05) and SCTAW (β= -0.21, t=-2.33, p<0.05). Even when FigureDel, together with other ten cognitive tests, were entered into the multiple regression analysis simultaneously, word reading performance in grade 1 was still significantly predicted by the same variables as the FigureDel was excluded.

b. Results of multiple regression analysis in grade 2.

The multiple regression analysis in grade 2 was carried out with variables from ten cognitive abilities tests, including RAN, FigureCopy, FigureImm (or FigureDel), SCTAW, KABC, Onset, Rime, NonwordRep, NonwordBackSpan and MorphologyJud. The regression model consisted of the z-scores on the word reading test of grade 2 as the dependent variable and those ten cognitive tests z-scores as the independent variables. Word reading performance was significantly predicted by the scores on the KABC (β=0.27, t=2.74, p<0.01) and NonwordRep (β=0.35, t=3.72, p<0.001). When FigureDel, replacing FigureImm, was entered into the multiple regression analysis, word reading performance in grade 2 was significantly predicted by the same variables.

2. Grades 3 and 4

Rime (grade3: r=0.25, p<0.05; grade4: r=0.26, p<0.05), NonwordRep (grade3: r=0.36, p<0.01; grade 4: r=0.21, p<0.05), and NonwordBackSpan (grade3: r=0.3, p<0.01; grade4: r=0.34, p<0.01) were significantly related to word-reading scores in both grades 3 and 4. The correlation analysis also showed that the RAN (r=-0.39, p<0.01) and SCTAW (r=0.3, p<0.01) were correlated with grade 4 but not with grade 3. The comparisons between a model with only main effects and a model consisting of main effects and the interaction revealed that none of scores on RAN or SCTAW had a significant interaction with grade, due to no significant change in model fit (p>0.1). Therefore, the remaining regression models in the multiple regression analysis combined grades 3 and 4.

The multiple regression analysis was carried out with variables from ten cognitive abilities tests, including RAN, FigureCopy, FigureImm (or FigureDel), SCTAW, KABC, Onset, Rime, NonwordRep, NonwordBackSpan, and Morphology Pro (or MorphologyJud). The regression model consisted of the z-scores on the word reading test of grades 3 and 4 as the dependent variable and those ten cognitive tests z-scores as the independent variables. As for intermediate graders, word-reading performance were significantly predicted by the scores on the SCTAW (β=0.19, t=2.62, p<0.05), NonwordRep (β=0.15, t=2.09, p<0.05), and NonwordBackSpan (β=0.2, t=2.54, p<0.05). When FigureImm was replaced by FigureDel, or MorphologyPro was replaced by MorphologyJud, to enter into the multiple regression analysis, word reading performance of intermediate graders were significantly predicted by the same variables.

3. Grades 5 and 6

KABC (grade5: r=0.34, p<0.01; grade6: r=0.3, p<0.01), Rime (grade5; r=0.24, p<0.05; grade6: r=0.31, p<0.01), and NonwordBackSpan (grade5: r=0.33, p<0.01; grade6: r=0.26, p<0.01) were significantly related to word-reading scores in both grades 5 and 6. The correlation analysis also showed that the SCTAW (r=0.37, p<0.01), NonwordRep (r=0.29, p<0.01), and MorphologyProd (r=0.34, p<0.01) were correlated with grade 5 but not with grade 6, while Onset (r=0.3, p<0.01) was correlated with grade 6 but not with grade 5. The comparisons between a model with only main effects and a model consisting of main effects and the interaction revealed that none of scores on SCTAW, Onset, NonwordRep and MorphologyProd had a significant interaction with grade, due to no significant change in model fit (SCTAW×grade: p=0.068; Onset×grade: p>0.1; NonwordRep×grade:p>0.1;MorphologyProd×grade: p=0.069). Therefore, the remaining regression models in the multiple regression analysis combined grades 5 and 6.

The multiple regression analysis was carried out with variables from ten cognitive abilities tests, including RAN, FigureCopy, FigureImm (or FigureDel), SCTAW, KABC, Onset, Rime, NonwordRep, NonwordBackSpan, and Morphology Pro (or MorphologyJud). For higher grades, out of those ten cognitive test performances, word reading performance was significantly predicted by the scores of the SCTAW (β=0.18, t=2.62, p<0.01), KABC (β=0.16, t=2.18, p<0.05), and NonwordBackSpan (β=0.2, t=2.82, p<0.01). When FigureImm was replaced by FigureDel, or MorphologyPro was replaced by MorphologyJud, to enter into the multiple regression analysis, word reading performance of higher graders were significantly predicted by the same variables. Table 2 depicts the results of the multiple regression analyses of word reading for grades 1 to 6.

IV. Discussion

The results of the multiple regression analyses revealed that visual skill, which was measured with Figure immediate recall, was an important predictor of Chinese word reading only in grade 1. Therefore, visual skill was found to be a strong predictor of Chinese literacy performance among younger children, which is consistent with previous findings (Ho & Bryant, 1999; Siok & Fletcher, 2001). This finding gives some indication of the influence of the characteristics of the Chinese writing system, which has more complicated orthographic information than alphabetic orthography. Our visual skills task may have captured something important about the relevance of integrated visual processing in Chinese, including both motor functioning as well as short-term memory. As they are beginners, first grade children are usually taught to focus on the visual configurations of characters, and remember their pronunciation and spelling. Teachers at primary schools in mainland China often employ a drilling approach where Chinese characters are presented, read, and repetitively written by children. Such

Table 2 Results of the Multiple Regression Analysis between Cognitive Abilities and Word Reading Performance

	Grade 1	Grade 2	Grade 3/Grade 4	Grade 5/Grade 6
Variable	(Adj.R^2=0.234)	(Adj.R^2=0.258)	(Adj.R^2=0.172)	(Adj.R^2=0.198)
RAN	**-0.19***	-0.172	-0.13	0.033
FigureCopy	0.053	0.083	0.037	0.067
FigureImm	**0.314****	-0.062	-0.076	-0.129
SCTAW	**-0.206***	0.084	**0.19***	**0.177****
KABC	0.054	**0.271****	0.023	**0.159***
Onset	0.144	-0.045	-0.172	0.062
Rime	0.123	0.131	0.155	0.127
NonwordRep	0.06	**0.347*****	**0.154***	0.045
NonwordBackSpan	0.092	0.128	**0.196***	**0.204****
Morphology	0.11	0.096	-0.067	0.066

Note. *: $p < 0.05$ **: $p < 0.01$ ***: $p < 0.001$

teaching instruction at lower grades enhances children's abilities to differentiate between Chinese characters; it also makes visual-motor skills an integral part of Chinese reading acquisition. As children advance into later grades and the amount of characters and words in textbooks increase significantly, they are taught to remember the orthographic and phonological regularities. Regarding to acquisition of another logographic orthography, the Japanese Kanji, Koyama et al. (2008) found that visual long-term memory significantly contributed to the literacy performance of Kanji words in grade 2 and 4 Japanese children. Contrasting to the finding of Koyama and colleagues, visual memory skill did not predict Chinese word reading performance from grade 2 and above in the present study. This difference may be attributed to the different measures administered to test the visual skill. Furthermore, in Koyama et al.'s study, they did not include vocabulary knowledge as a predictive variable, while vocabulary knowledge was found to be the most important predictor for Japanese Kanji words reading in a later study by Uno et al. (2009). There is a possibility that the significant predictive power of visual memory skills, which was observed by Koyama et al. (2008), would disappear when vocabulary knowledge is included as an independent variable in multiple regression models. In line with our finding, the study of Uno et al. (2009), in which the performance on the visual skill test (measured by ROCFT) and vocabulary knowledge were both included as the predictive variables, found that visual skill was not a significant predictor of Kanji word reading performance of Japanese children from grade 2 to 6.

Additionally, the current study found that naming speed (measured with RAN) only contributed to reading performance of grade 1. This result was in accordance with the previous findings that the relationship between RAN tests and reading accuracy is stronger at the early stages of reading development in English (e.g. Torgesen et al., 1997; Wanger et al., 1997). Our finding indicated that the effects of RAN in reading accuracy weaken in upper grades. In contrast to our result, some studies suggested that the predictive power of RAN was higher for intermediate readers than for beginning readers in Chinese (Liao et al, 2008; Tan et al., 2005). However, children's reading abilities were measured within the limited time, in terms of reading fluency. Taking the findings of our study and the previous studies in Chinese, it is supposed that contribution of naming speed to reading accuracy weakens as the grade goes up, while naming speed continues to contribute to reading fluency even in upper graders. Further research is needed to confirm this.

In contrast, phonological skills (measured with non-word repetition or non-word back span) and vocabulary skills (measured by KABC or SCTAW) strongly contributed to word reading performance across grades 2 to 6. Vocabulary and phonological skills seemed to be important for children who were learning to read Chinese words in the older graders. The results of our study revealed that phonological skill, especially phonological memory, was a significant predictor of word reading among children in grades 2 to 6. Phonological short-term memory, which was defined as the ability to maintain phonological information for online processing or storage in the short-term memory (Wanger & Torgesen, 1987), was examined by non-word repetition and non-word back span tasks in this study. As such, our study was in line with the study conducted by Chan et al. (2006), which showed the significance of phonological memory in Chinese word reading among primary grade students. Moreover, in the study of Ramus et al. (2013), the non-word repetition task was also identified as a kind of phonological representation in the factor analysis, because it appears to more directly reflect the precision format of phonological representations. Our findings suggest that precise phonological representation, in addition to phonological memory, might also be related to reading skills in Chinese. The characteristics of languages with different script-sound correspondence or languages that are non-alphabetic, such as Chinese, may contribute to the differences in the types of cognitive deficits experienced by struggling readers (Chan et al., 2006). The phonological deficit hypothesis is widely accepted and received support from previous studies on different languages, including not only alphabetic English but also logographic Chinese (e.g. Goswanmi, 2002; Ho & Brant, 1997; Hu & Catts, 1998; McBride-Chang & Kail, 2002; Siok & Fletcher, 2001). However, we found that phonological memory, rather than phonological awareness, makes a significant contribution to reading development in Chinese. Almost all Chinese characters have only one-to-one correspondence with a single Chinese syllable; expert readers seldom need to analyse the syllable in smaller phonological units (such as onset and rime) when they are in more advanced grades of reading acquisition. Instead, Chinese children need to memorise many grapheme-sound mappings compared to alphabetic readers. Although there are some regularities between phonetic radicals and the pronunciations of compound Chinese characters, the correspondence of phonetic radicals to characters' pronunciation is only 40% (Zhou, 1978). When children enrol in more advanced grades, they tend to encounter more Chinese words and characters than they do in lower grades. Since Chinese orthography does not have grapheme-phoneme correspondence, this may require children to memorise the script-sound associations and extract the sounds of words or characters from memory.

In line with previous findings (e.g. Liu et al., 2010; Pan et al., 2011), the current results also showed that vocabulary contributes to Chinese reading acquisition. Furthermore, the role of vocabulary becomes more important in the later stages of development when it comes to Chinese reading abilities. It seems that vocabulary knowledge facilitates Chinese children's ability to read words and thus helps them become proficient readers. This was also in accordance with the study of Japanese logographic Kanji word reading conducted by Uno et al. (2009). In Uno and colleagues' study (2009), they found that the vocabulary size (measured by SCTAW) was the most important predictor variable in accounting for Kanji word reading performance of

Japanese primary school children from grade 2 to 6, and suggested that an increase in vocabulary size lead to a better performance on Kanji word reading. Compared with alphabetic orthographies, Chinese characters (part of a logographic language) are relatively meaning-based. Knowing the meaning of words may help children master the reading of words that were previously known only from the oral lexicon (Pan et al., 2011). Our results demonstrate that vocabulary development is closely related to performance in older children who are reading Chinese words. Children with large vocabulary sizes could pronounce words efficiently because children in advanced grades tend to be exposed to a large number of new words.

Apart from the above-mentioned findings, the present study had three limitations. The first limitation of the present study, compared to previous studies, is that morphological awareness did not predict word-reading accuracy at any grade in the multiple regression analysis. Some previous research has emphasised the importance of this measure for early Chinese literacy skills (McBride-Change, Wagner, Muse, Chow, & Shu, 2005; Shu et al., 2006). However, we did not find a common association between word reading and morphological awareness among primary school children in our studies, except for a relatively weak correlation with reading ability of children in grade 5. One conjecture for this result could be attributed to the nature of the task used to measure morphological awareness. According to previous studies in Chinese, there are several different aspects of morphological awareness (McBride-Chang et al., 2003; Shu et al., 2006), with lexical compounding awareness (e.g. morpheme construction skills) and homophone awareness being the two most important ones (Liu, McBride-Chang, Wong, Shu & Wong, 2003; McBride-Chang et al., 2003). Homophone awareness reflects the ability to discriminate among homophones with different meanings which was the similar ability tested in the present study. Although the morphological awareness did not significantly contribute to reading performance at the current study, it is still possible that such relationship could be found by using a lexical compounding awareness task in the future work. Second, another unexpected predicting result was related to the receptive vocabulary knowledge (measured by SCTAW) predicting reading performance of children in grade 1 negatively. To examine the relationship between vocabulary knowledge and reading acquisition of Chinese school children in lower grade, a different measure should be developed and tested for mainland Chinese children in the future studies. Third, the results of multiple regression analyses between cognitive abilities and reading performance showed that the model fit of the regression model in different grades were relatively low. Further studies are necessary to develop a set of normative tests suited for mandarin speaking Chinese children.

V. Conclusion

Despite these limitations in measurement, however, the present study has yielded important findings of the relationship between reading performance and these different cognitive skills. According to our findings, visual skills and naming speed contribute to Chinese reading in lower grades of schooling. In contrast with visual skills and naming speed, phonological memory predicted reading ability from grades 2 to 6. In addition, vocabulary knowledge emerged as a relatively important correlate of reading ability across different grades, except in the case of children in grade 1. This may be due to the characteristics of the Chinese orthographic system as well as the instruction method at primary schools in Mainland China.

References

Chan, D. W., Ho, C. S. H., Tsang, S. M., Lee, S. H. & Chung, K. K. H. (2006) Exploring the reading-writing connection in Chinese children with dyslexia in Hong Kong. *Reading and Writing,* 19, 543-561.

Cheung, H., & Ng, L. (2003) Chinese reading development in some major Chinese societies: An introduction. In: C. McBride-Chang & H.-C. Chen (eds.), Reading development in Chinese children (pp. 3-17). Westport, CT: Praeger Press.

Goswami, U. (2002) In the beginning was the rhyme? A reflection on Hulme, Hatcher, Nation, Brown, Adams & Stuart. *Journal of Experimental Child Psychology*, 82, 47-57.

Ho, C. S.-H, & Bryant, P. (1997) Phonological skills are important in learning to read Chinese. *Developmental Psychology*, 33, 946-951.

Ho, C. S.-H, & Bryant, P. (1999) Different visual skills are important in learning to read English and Chinese. *Educational and Child Psychology*, 16, 4-14.

Ho, C. S.-H., Chan, D. W.-O., Tsang, S.-M., & Lee, S.-H. (2002). The cognitive profile and multiple-deficit hypothesis in Chinese developmental dyslexia. *Developmental Psychology*, 38, 543-553.

Ho, C. S.-H., & Lai, D. N-C. (1999) Naming-speed deficits and phonological memory deficits in Chinese developmental dyslexia. *Learning and Individual Differences*, 11, 173-186.

Ho, C. S.-H., Law, T. P.-S., & Ng, P. M. (2000) The phonological deficit hypothesis in Chinese developmental dyslexia. *Reading and Writing*, 13, 57-79.

Hu, C. F., & Catts, H. W. (1998) The role of phonological processing in early reading ability: What we can learn from Chinese? *Scientific Studies of Reading*, 2, 55-79.

Hulme, C., Hatcher, P. J., Nation, K., Brown, A., Adams, J., & Stuart, G. (2002). Phonemic awareness is a better predictor of early reading skill than onset-rime awareness. *Journal of Experimental Child Psychology,* 82, 2-28.

Inomata, T., Uno, A., & Haruhara, N. (2013) Investigation of cognitive factors affecting reading and spelling abilities of Hiragana characters in Kindergarten children. *The Japanese Journal of Logopedics and Phoniatrics*, 54, 122-128.

Kalindi, S. C., McBride, C., Tong, X., Wong, N. L. Y., Chung, K. H. K., & Lee, C-Y. (2015) Beyond phonological and morphological processing: pure copying as a marker of dyslexia in Chinese but not poor reading of English. *Annals of Dyslexia,* 65, 53-68.

Koyama, M. S., Hansen, P. C., & Stein, J. F. (2008) Logographic Kanji versus phonographic Kana in literacy acquisition. *Annals of the New York Academy of Sciences*, 1145, 41-55.

Liao, C. H., Georgious, G. K., & Partial, R. (2008) Rapid naming speed and Chinese character recognition. *Reading and Writing*, 21, 231-253.

Lin, C. Y., & Uno, A. (2015) Cognitive Abilities Underlying Reading in Chinese: Typical Readers among Third-Grade Children in Taiwan. *The Japanese Journal of Logopedics and Phoniatrics*, 56, 37-42.

Liu, P. D., McBride-Chang, C., Wong, A. M.-Y., Tardif, T., Stokes, S., Fletcher, P., & Shu, H. (2010) Early oral language markers of poor reading performance in Hong Kong Chinese children. *Journal of Learning Disabilities*, 43, 322-331.

Liu, S., Wang, L.-C., & L, D. (2019) Deficits of visual search in Chinese children with dyslexia. *Journal of Research in Reading,* 42, 454-468.

McBride-Chang, C. (2016) Is Chinese special? Four aspects of Chinese literacy acquisition that might distinguish learning Chinese from learning alphabetic orthographies. *Educational Psychology Review,* 28, 523-549.

McBride-Chang, C., Cho, J. R., Liu, H., Wagner, R. K., Shu, H., ...Muse, A. (2005) Changing models across cultures: Associations of phonological awareness and morphological structure awareness with vocabulary and word recognition in second graders from Beijing, Hong Kong, Korea, and the United States. *Journal of Experimental Child Psychology*, 92, 140-160.

McBride-Chang, C., Chung, K. K. H., & Tong, X. (2011) Copying skills in relation to word reading and writing in Chinese children with and without dyslexia. *Journal of Experimental Child Psychology,* 110, 422-433.

McBride-Chang, C., & Kail, R. V. (2002) Cross-cultural similarities in the predictors of reading acquisition. *Child Development,* 73, 1392-1407.

McBride-Chang, C., Liu, P. D., Wong, T., Wong. A., & Shu, H. (2012) Specific reading difficulties in Chinese, English, or both: Longitudinal makers of phonological awareness, morphological awareness, and RAN in Hong Kong Chinese children. *Journal of Learning*

Disabilities, 45, 503-514.

McBride-Chang, C., Shu, H., Zhou, A., Wat, C. P., & Wagner, P. K. (2003) Morphological awareness uniquely predicts young children's Chinese recognition. *Journal of Educational Psychology*, 95, 743-751.

McBride-Change, C., Wagner, R. K., Muse, A., Chow, B. W. Y., & Shu, H. (2005) The role of morphological awareness in children's vocabulary acquisition in English. *Applied Psycholinguistics*, 26, 415-435.

Wimmer, H., Mayringer, H., & Landerl, K. (2000). The doubt-deficit hypothesis and difficulties in learning to read a regular orthography. *Journal of Educational Psychology*, 92, 668-680.

Pan, J., McBride-Chang, C., Shu, H., Liu, H., Zhang, Y. & Li, H. (2011) What is in the naming? A 5-year longitudinal study of early rapid naming and phonological sensitivity in relation to subsequent reading skills in both native Chinese and English as a second language. *Journal of Educational Psychology*, 103, 897-908.

Raven, J. C., Court, J. H., & Raven, J. (1995) Coloured progressive matrices. Oxford, UK: Oxford Psychologists Press.

Ramus, F., Marshall, C.R., Rosen, S. & van der Lely H. K. (2013) Phonological deficits in specific language impairment and developmental dyslexia: towards a multidimensional model. *Brain*, 136, 630-645.

Share, D.L. (1995) Phonological recoding and self-teaching: Sine qua non of reading acquisition. *Cognition,* 55, 151-218.

Shu, H., McBride-Chang, C., Wu, S., & Liu, H. Y. (2006) Understanding Chinese developmental dyslexia: Morphological awareness as a core cognitive construct. *Journal of Educational Psychology,* 98, 122-133.

Siok, W. T., & Fletcher, P. (2001) The role of phonological awareness and visual-orthographic skills in Chinese reading acquisition. *Developmental Psychology*, 37, 886-899.

Tan, L. H., Spinks, J. A., Eden, G., Perfetti, C. A., & Siok, W. T. (2005) Reading depends on writing, in Chinese. *PNAS*, 102, 8781-8785.

Tong, X., McBride-Chang, C., Wong, A. M.-Y., Shu, H., Reitsma, P., & Rispens, J. (2011) Longitudinal predictors of very early Chinese literacy acquisition. *Journal of Research in Reading*, 34, 315-332.

Torgesen, J. K., Wagner, R. K., Rashotte, C. A., Burgess, S., & Hecht, S. (1997) Contributions of phonological awareness and rapid automatic naming ability to the growth of word-reading skills in second-to fifth-grade children. *Scientific Studies of Reading*, 1, 161-185.

Uno, A., Haruhara, N., & Kaneko, M. (2002) SCTAW-The Standardized Test of Abstract Words. Tokyo: Interuna Publishers.

Uno, A., Wydell, T. N., Haruhara, N., Kaneko, M., & Shinya, N. (2009) Relationship between reading/writing skills and cognitive abilities among Japanese primary-school children: Normal readers versus poor readers (dyslexics). *Reading and Writing*, 22, 755-789.

Wagner, R. K., & Torgesen, J. K. (1987) The nature of phonological processing and its causal role in the acquisition of reading skills. *Psychological Bulletin*, 101, 192-212.

Wagner, R., Torgesen, J., Rashotte, C. A., Hecht, S., Barker, T., Burgess, T., et al. (1997) Changing relations between phonological processing abilities and word-level reading as children develop from beginning to skilled readers: A 5-year longitudinal study. *Developmental Psychology,* 33, 468-479.

Wolf, M., Bally, H., & Morris, R. (1986) Automaticity, retrieval process, and reading: A longitudinal study in average and impaired readers. *Child Development*, 57, 988-1000.

Yang, L.-Y., Guo, J.-P., Richman, L.C., Schmidt, F.L., Gerken, K.C., & Ding, Y. (2013) Visual Skills and Chinese Reading Acquisition: A Meta-analysis of Correlation Evidence. *Educational Psychology Review*, 25, 115-143.

Zhang, C. F., & Zhang, J. H. (1997) A study of cognitive profiles of Chinese learners' reading disabilities. Paper presented at the Second International Chinese Psychologists Conference, Hong Kong. (In Chinese).

Zhou, Y. G. (1978) To what extent are the "phonetics" of present-day Chinese characters still phonetic. *Zhongguo Yuwen*, 146, 172-177.

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中国大陸における中国語話者である児童の音読習得に影響する認知能力に関する横断的研究
― 学年による予測要因の変化について ―

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本研究では、中国語の音読に影響する認知能力を解明するために、中国大陸の児童を対象に単語音読成績を予測する認知能力を検討した。中国のＡ省におけるＡ小学校とＢ小学校の１～６年生672人を対象に、音読検査および認知能力検査（音韻的能力、視覚的能力、呼称速度、形態論的認識力を評価する検査）、語彙力検査、非言語的知能検査を実施した。重回帰分析の結果、視覚的能力と呼称速度は低学年の児童の単語音読成績を予測した。また、語彙力と音韻的能力は２～６年生の単語音読成績を予測した。本研究では、中国語の音読成績に影響する認知能力は児童の発達年齢が上がるにつれて変化することがわかった。それは、中国語の文字体系や中国大陸における音読の指導方法に影響されていると考えられる。

キー・ワード：中国語音読習得　視覚的能力　呼称速度　音韻的能力　語彙力

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