Behavioural Self-regulation and its Contribution to Reading Among Chinese Poor Readers

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Abstract

This study investigated to which behavioural self-regulation and language skills could discriminate Hong Kong Chinese poor from adequate readers. A total of 78 Chinese first graders with 39 poor readers and 39 adequate readers participated and they were matched on age, parents' education levels and nonverbal intelligence (IQ). The two groups were tested on the measures of behavioral self-regulation (the Head-Toes-Knees-Shoulders; HTKS), vocabulary definition, phonological awareness, morphological construction, rapid digit naming, and sentence comprehension. Results showed that the poor readers performed less well than the adequate readers in all cognitive-linguistic and reading comprehension measures. Among these measures, the HTKS, morphological construction, and rapid digit naming showed the greatest power in discriminating poor and adequate readers. Self-regulation skills accounted for significant amount of unique variance in reading comprehension after controlling for the effects of age and IQ. Together, these findings highlight the potential importance of the process of learning to read in Chinese for shaping one's self-regulation skills.

Keywords: Behavioural self-regulation, phonological awareness, morphological awareness, rapid digit naming, and poor readers

INTRODUCTION

Although most children develop reading proficiency with appropriate education, some individuals may fail to acquire reading skills. Estimates indicate that between 5-10% of the school population may suffer from reading difficulties (e.g., Shaywitz, Shaywitz, Fletcher, Escobar, 1990). Reading acquisition is regarded as a multifaceted process and relies on the development of different cognitive-linguistic skills. Extensive research has investigated deficits in decoding skills, e.g., phonological awareness, letter-sound knowledge, rapid naming that may lead to reading problems (Goswami & Bryant, 1990; Storch & Whitehurst, 2002). More recently, behavioral self-regulation has been put forward as another important skill for reading acquisition (e.g., McClelland, et al., 2014; von Suchodoletz, 2013).

Self-regulation refers to the capacity of individuals to apply cognitive skills like cognitive flexibility (or attention), working memory, and inhibitory control to behavior. However, at the same time, deficits in these skills can be the possible cause of reading difficulties.

So far fewer attempts have been made to examine the relationships between self-regulation and other cognitive-linguistic skills in explaining individual differences in reading given that reading is viewed as the execution and integration of multiple cognitive-linguistic skills (Kendeou & Trevors, 2012; van den Broek & Espin, 2012). This is consistent with the simple view of reading (Gough & Tunmer, 1986; Hoover & Gough, 1990; Shaywitz, 2003) which posits that decoding, e.g. phonological skills, is coupled with a broad range of cognitive-linguistic skills. Thus, the present study is to investigate the contributions of cognitive-linguistic skills: self-regulation, phonological awareness, morphological awareness, vocabulary knowledge, and rapid naming in distinguishing between poor readers and competent readers of Chinese and to examine their contributions to reading comprehension.

SELF-REGULATION SKILLS

Although behavioral self-regulation skills can be viewed as an individual's capability to regulate emotion, cognition, and behavior (Calkins, 2007), these skills are defined as the behavioral manifestation of the integration of cognitive flexibility, working memory, and inhibitory control (Wanless, McClelland, Tominey, & Acock, 2011).

These self-regulation skills, which may stem from executive functioning, have been found to be associated with academic achievement (McClelland, Acock, &

Morrison, 2006; Ponitz, McClelland, Matthews, & Morrison, 2009). For example, previous studies (e.g., Blair & Razza, 2007) have found that the ability to focus attention has a strong influence on children's academic outcomes. Cognitive flexibility often involves processes of shifting attention between sets of tasks or rules without distraction (Diamond, 2006).

Similarly, working memory, which refers to the capacity of an individual to hold and manipulate information over a short period of time (Baddeley, 2000), plays a vital role in the storage of information into long-term memory and the acquisition of reading-related skills. Working memory has been linked to the individual's reading attainment and has been found to make significant contributions to word reading and reading comprehension (Engel de Abreu & Gathercole, 2012; Swanson & Berninger, 1995). Individual differences in inhibitory control also explain variability in academic achievement (e.g., Clark, Pritchard, & Woodward, 2010).

Inhibitory control often includes the ability to focus attention and suppress irrelevant information in order to act appropriately (Diamond, 2006; Moutier, Plagne-Cayeux, Melot, & Houdé, 2006). Given that reading involves multiple cognitive-linguistic skills, self-regulation skills can be considered to be essential for reading acquisition and failure. Indeed, recent studies (e.g., Chung & McBride-Chang, 2011; Peng, Sha, & Beilei, 2013) have found that both components of working memory and inhibitory control uniquely predict reading variability in Chinese. Because Chinese orthography has many different graphic units and orthographic rules, and because thousands of characters and cognitive-linguistic skills are required to be learned (Chung & McBride-Chang, 2011), children may take all their elementary school years to learn and acquire these units, rules, knowledge, and skills to read Chinese. At the same time, however, children who fall behind in their development of self-regulation skills or exhibit poor self-regulation skills, are at greater risk of reading difficulties.

Perhaps poor self-regulation skills are also linked to weaknesses in other previously established cognitive-linguistic skills, namely phonological awareness, morphological awareness, vocabulary knowledge, and rapid naming. This may in turn affect reading performance in poor readers. However, neither the present research on English nor studies on Chinese have examined such self-regulation skills in relation to other previously established cognitive-linguistic skills in explaining reading. Poor self-regulation may be another marker for children with reading difficulties. Thus, the measure of self-regulation skills was included in the present study.

PHONOLOGICAL SKILLS

Phonological awareness, which includes the ability to recognize spoken words, break down the words into sound units, and reflect upon and manipulate these units, has been recognized as an important predictor of children's reading achievement in English and Chinese as it facilitates awareness of the relationship between the sound and the printed word (Gottardo, Stanovich & Siegel, 1996; Muter & Snowling, 1998).

Previous studies concede that phonological awareness is a good predictor of word reading and reading comprehension, and is causally related to reading outcomes (e.g., Blachman, 1997; Muter & Snowling, 1998; Vellutino, Fletcher, Snowling, & Scanlon, 2004). Across a variety of languages, phonological awareness skills tend to develop by advancing from larger units of sound e.g., words and syllables to smaller units of sound e.g., onsets, rimes, and phonemes (Lonigan, Burgess, & Anthony, 2000). Because English differs from Chinese in some broad aspects of phonology, in that grapheme–phoneme mapping is involved in English, whereas whole-character to whole-syllable mapping is stressed in Chinese, syllable and onset–rime level awareness tend to be the most important aspect of phonological awareness in Chinese.

In Chinese, the syllable is the basic phonological unit of speech, and each syllable can represent a morpheme. Most Chinese characters are ideophonetic compounds consisting of a semantic and a phonetic component (or radical). For example, in a character (such as [dang1] 'lamp'), a semantic radical indicates the semantic category (fire) of the character (as one needed fire to light an oil lamp in the olden days), whereas the phonetic radical [dang1] 'climb' signifies the sound cues of the character. Such phonetic information tend to be encoded at the syllable and onset–rime level in Chinese rather than being assembled at the phonemic levels as in English. Therefore, Chinese children with reading problems sometimes manifest difficulties in processing phonological information (Ho, Leung, & Cheung, 2011; McBride-Chang, Tong, Shu, Wong, Leung, & Tardif, 2008c). However, other studies of dyslexia have revealed that deficits in phonological awareness are less prominent in Chinese readers (e.g., Chung, Ho, Chan, Tsang, & Lee, 2010, Ho, Chan, Tsang, & Lee, 2002, Shu, McBride-Chang, Wu, & Liu, 2006).

Therefore, it is necessary to consider further the influence of phonological skills on children's reading ability. In the present study, we included a measure of phonological awareness as these skills could be used to distinguish between the good and poor readers and to predict reading performance.

MORPHOLOGICAL SKILLS

Morphological awareness is another skill that could be used to distinguish between readers of differing ability. Morphological skills include the ability to reflect upon and manipulate morphemes, and apply word formation rules (Carlisle, 1995). Across different languages morphological skills are associated with word reading and reading comprehension in English (e.g., Carlisle, 2000; Deacon & Kirby, 2004; Nagy, Berninger, Abbott, Vaughan, & Vermeulen, 2003; Roman, Kirby, Parrila, Wade-Woolley, & Deacon, 2009) and in Chinese (e.g., McBride-Chang, Shu, Zhou, Wat, & Wagner, 2003; Wang, Yang, & Chen, 2009). Unlike English, Chinese is a morphosyllabic writing system with a rich morphological structure and many words consist of multiple morphemes by combining different morphemes. More than 75 % of Chinese words are formed through lexical compounding, which is an essential way of forming complex words.

Many words may therefore share the same morpheme. For example, 電話/din6 waa2/(tele-phone), 電報/din6 bou3/(tele-graph), 電視/din6 si6/(tele-vision). All of these words sharing the morpheme 電/din6/(tele) are semantically related as indicated by this morpheme. Also, Chinese contains a vast number of syllables that have more than one homophone, and every syllable has a different meaning (e.g., Packard, 2000; Zhou, Zhuang, & Yu, 2002). For instance, the syllable "san" has different meanings, e.g., [san1] 'new' (新), [san1] 'stretch' (伸), [san1] 'body' (身) and [san1] 'hard' (辛). Consequently, the ability to comprehend and use morphologically complex forms may be particularly vital for reading in Chinese.

Indeed, studies on Chinese have found that morphological awareness in the form of lexical compounding is a precursor to reading ability (e.g., Tong, McBride-Chang, Shu, & Wong, 2009) and a reliable discriminator for Chinese children with and without reading difficulties (e.g., McBride-Chang, Lam, Lam, Doo, Wong, & Chow, 2008; Shu et al., 2006). Thus, the present study tested the extent to which morphological awareness could distinguish between the good and poor readers, and predict reading ability.

VOCABULARY KNOWLEDGE

Previous studies have examined the relationship between vocabulary knowledge, particularly the use of oral word definitions and synonyms, and reading acquisition and impairment (e.g. Liu et al., 2010; McBride-Chang & Ho,

2005). For example, research conducted with English readers showed that vocabulary knowledge was a significant correlate of reading performance, and it continued an important predictor after controlling other cognitive-linguistic skills (Landi, 2010; Ouellette, 2006; Ricketts, Nation, & Bishop, 2007; Wise, Sevcil, Morris, Lovett, & Wolf, 2007). A similar association has also been found in Chinese (e.g., Liu et al., 2010; Zhou et al., 2014). Wang, Cheng and Chen (2006) was one of the few studies that investigated oral vocabulary together with phonological awareness, working memory and other reading-related skills. Oral vocabulary was found to be one of the best precursors for word reading in Chinese.

Similarly, studies conducted by Greenberg, Pae, Morris, Calhoon, & Nanda (2009) and Liu et al. (2010) found that many poor readers possess poor vocabulary knowledge and tended to fall behind their typically developing peers in vocabulary development. However, these studies have not usually examined such vocabulary knowledge in relation to other cognitive-linguistic skills in explaining variability in reading. Vocabulary knowledge measure was therefore included in the present study.

RAPID NAMING

Finally, rapid naming is also an important correlate of reading acquisition and impairment across a variety of scripts, including English (Wagner et al., 1997), German (Wimmer, Mayringer, & Landerl, 2000), Dutch (de Jong & van der Leij, 1999) and Chinese (Chung & McBride-Chang, 2011). The most commonly used measure of rapid naming is one in which readers are asked to name a series of stimuli e.g., numbers, letters, colours or objects as quickly as possible. Rapid naming is likely to tap into a number of skills, including phonological processing, involved in accessing and retrieving phonological representations from memory, visual sequencing and symbol processing (e.g., Wagner & Torgesen, 1987; Wolf & Bowers, 1999).

Moreover, as noted in a study by Manis, Seidenberg, and Doi (1999), Chinese character recognition is relatively 'arbitrary' and a rapid naming measure may tap into the ability to learn arbitrary links between print and sound. For example, in the rapid digit naming task, phonological codes can be directly derived from visual input i.e., digits thereby tapping into a highly arbitrary print to sound conversion. Chinese may be a writing system that is particularly strongly associated with a rapid naming measure. Previous studies have consistently shown that rapid naming predicts reading development in Chinese from preschool (Chow, McBride-Chang, & Burgess, 2005), continuing to late childhood (Pan, McBride-Chang, Shu, Liu, Zhang, & Li, 2011). It also predicts

dyslexia perhaps because Chinese dyslexic readers tend to be less efficient in the naming process involved in arbitrary print to sound conversion and associated with poor quality of phonological representations of speech sounds and poor articulatory speed (Chung, Ho, Chan, Tsang, & Lee, 2011; Shu, et al., 2006).

Thus, in the present study, we extended our investigation to examine rapid naming in relation to the self-regulation and other cognitive-linguistic skills in order to obtain a fuller picture of the importance of rapid naming for reading performance.

THE PRESENT STUDY

Although the five cognitive-linguistic skills, namely self-regulation, phonological awareness, morphological awareness, vocabulary knowledge, and rapid naming are linked with reading ability, relatively little investigation to date has examined the concurrent influence of multiple skills that may affect reading performance in Chinese readers, particularly in poor readers.

The purpose of this study has been twofold and is conducted in Hong Kong with Chinese speaking children in the first grade of primary school. We tested both for group differences in self-regulation and for associations of the four cognitive-linguistic skills with reading comprehension. The first aim of this study was to examine whether poor readers would display difficulties in self-regulation along with problems in phonological awareness, morphological awareness, vocabulary knowledge, and rapid naming.

It was anticipated that poor readers would perform less well than the competent readers on tests of the five cognitive-linguistic skills. The second aim was also to examine whether self-regulation would make a contribution to reading performance, sentence comprehension independent of phonological awareness, morphological awareness, vocabulary knowledge, and rapid naming. It was expected that self-regulation could explain unique variance in sentence comprehension beyond these other established cognitive-linguistic skills.

METHOD

Participants

The children for the present study came from a sample of 210 Hong Kong Chinese-speaking children recruited for a longitudinal study (112 boys, 98 girls) at age 5. The sample was fairly representative of different locations within Hong

Kong city. In the present study, seventy-eight first grade students were selected based on the standardized Chinese word reading subtest of the Hong Kong Test of Specific Learning Difficulties in Reading and Writing (HKT-SpLD); Ho, Chan, Tsang & Lee, 2000). Local norms are available from 6 years 1 month to 10 years 6 months. The reliability coefficients of this subtest range from 0.92 to 0.99 across various age groups. Details of this test are further discussed in the Measures section.

The HKT-SpLD is commonly used to assess Hong Kong primary school children with literacy difficulties. The children were administered this test at around age 7. Thirty-nine children (22 boys and 17 girls) were selected as poor readers who scored at or below the 25th percentile in the Chinese Word Reading test. Another 39 children (16 boys and 23 girls) with average or above performance who scored at or above the 50th percentile in the test were selected as the control group.

In order to control for the possible effects of age, intelligence, and social economic status, the average readers were matched to the poor readers on age, parents' educational level, and nonverbal intelligence (Raven's Standard Progressive Matrices). Fathers' and mothers' education levels were also gathered based on a 7-point scale ranging 1 (lower than third grade), 2 (fourth to sixth grade education), 3 (junior high school), 4 (senior high school), 5 (some college), 6 (college graduate), and 7 (graduate education). Thus, the children in both poor readers and average readers groups did not differ in age or intelligence or parents' educational level (all $Fs<2.83$, all $ps>.05$). No emotional and behavioral problems such as autism or hyperactivity, and uncorrected sensory impairment were reported in either group.

MEASURES

GENERAL INTELLECTUAL ABILITY (IQ)

Raven's Standard Progressive Matrices was used to measure the children's nonverbal reasoning ability. This standardized test consisted of five sets of 12 items with a total of 60 items. For each item, participants were asked to select the best option from six or eight alternatives to fill in the missing part of the target matrix. Scoring was based on the local norm established by the Education Department of the Hong Kong Government in 1986.

WORD READING

The word reading measure was taken from the Chinese Word Reading subtest of the Hong Kong Test of Specific Learning Difficulties in Reading and Writing (HKT-

SpLD) (Ho, Chan, Tsang & Lee, 2000). The HKT-SpLD is a standardized assessment battery developed for Hong Kong primary school children, and items in the Chinese Word Reading task are common two-character words used by Grade 1 to Grade 6 students. The Chinese Word Reading measure consisted of 150 two-character Chinese words arranged in increasing difficulty. In this task, children were asked to read aloud from the beginning of this task and stopped when they failed to read 15 consecutive items. One point was given for each word correctly read. Scoring was based on the established local norm. The reported reliability of this standardized measure among participants with ages ranging from 6 years 1 month to 12 years 6 months was (r = .92 to .99).

BEHAVIORAL SELF-REGULATION

The Head–Toes–Knees–Shoulders task (HTKS) was used to measure behavioral regulation by tapping in on cognitive flexibility, working memory, and inhibitory control (McClelland & Cameron, 2012). This measure was adapted from studies (e.g., Cameron Ponitz et al., 2008; Cameron Ponitz, et al., 2009; Becker, McClelland, Loprinzi, & Trost, 2014) to assess participants' behavioral regulation. A total of 30 test items and 4 practice items was used. There were two forms of the HTKS which includes Form A with two commands: head–toes commands (e.g., "touch your head" and "touch your toes") and Form B with additional commands: knees–shoulders commands (e.g., "touch your shoulders" and "touch your knees"). Form B, therefore consisted of commands to touch all four body parts. In this task, children were asked to perform the opposite of a response to different oral commands. For example, if the experimenters said, "touch your head," the correct response would be for the children to touch their toes.

Children were asked to respond to these commands as fast as they could. During the practice trials, the experimenters modeled the commands with actions, and feedback was also given. Each item was scored with 0 for an incorrect response (e.g., touching his or her head when requested to touch his or her head), 1 for a self-corrected response (e.g., firstly responding incorrectly, but correcting himself or herself), or 2 for a correct response (e.g., touching his or her toes when asked to touch his or her head). T

hus, the total scores ranged from 0 to 60. In order to assess inter-rater reliability, a random sample of children (n = 25) was videotaped whilst being administered the HTKS task. Videotapes were observed and marked by two experimenters who had not administered the HTKS task to the participants. Children's responses were rated by the two experimenters (interrater reliability=0.90), and the Cronbach's alpha of the measure was 0.91.

PHONOLOGICAL AWARENESS

The phonological awareness task was designed similar to the Comprehensive Test of Phonological Processing (CTOPP; Wagner, Torgesen & Rashotte, 1999) in that it tapped into different phonological units with increasing difficulty. This measure was used in previous studies (Cheung, Chung, Wong, McBride-Chang, Penney, & Ho, 2010; Chung, McBride-Chang, Cheung, & Wong, 2013). In this task, syllable deletion, onset deletion, and rhyme production were used and were presented orally. For the syllable deletion, there were 15 three-syllable real and 14 pseudoword items.

Children were asked to take away either the first, second or third syllable and say aloud what was left. For example, participants were asked to say /hap6/ /coeng3/ /go1/ (合唱歌) without /hap6/ (合). The correct answer is /coeng3/ /go1/ (唱歌). In the onset deletion, 10 real and 12 pseudo one-syllable words were used. Participants were requested to delete the first consonant of each item and say aloud what was left. For example, say /coi3/ (菜) without the initial sound would be /oi3/ (愛). These stimuli strictly measured onset deletion only, rather than phoneme deletion more globally, because in Cantonese there are no consonant clusters and only few final consonants to consider. For the rhyme production, there were 16 items which consisted of three reference syllables sharing the same rhyme and tone on each item. The children were required to come up with and say aloud a Cantonese syllable having the same rhyme and tone as the references. For example, 'say a Chinese syllable which shared the same rhyme and tone as "書" (/syu1/ meaning "book"). One acceptable answer would be "豬" (/zyu1/ meaning "pig")'. A composite phonological awareness score was calculated by summing the scores from the three tasks. The maximum composite score was 67 and Cronbach's alpha of the measure was 0.86.

MORPHOLOGICAL AWARENESS

Morphological construction task was employed to assess morphological awareness, as done in previous work on Cantonese-speaking children (Cheung et al., 2010; Chow, McBride-Chang & Cheung, 2010). This measure was administered at graded difficulty levels. Twenty-seven test items were organized into five subsets of varying difficulties. For each item, a scenario was presented orally by the experimenter, and the children were asked to construct words for the novel objects or concepts based on the scenarios given. For example, one description was "When someone eats more than is good for, this is called overeat. What could we call when someone drinks excessively?" The target response was overdrink. A target answer was awarded two points, and a partially correct answer was awarded one point. The Cronbach's alpha was 0.82.

RAPID NAMING

The rapid digit naming task consisted of 8 rows of 5 digits (2, 4, 6, 7, and 9) that were printed on a piece of white A4 sheet (Chung, McBride-Chang, Wong, Cheung, Penny, & Ho, 2008). These digits were arranged in random order. Prior to formal testing, children were asked to name each of the five digits individually to make sure that they could read them. The participants were then asked to name all digits on the sheet from left to right and from top to bottom as accurately and quickly as possible. This test was administered twice in order to obtain a test–retest reliability, and the average time was recorded. The test-retest reliability was 0.91.

VOCABULARY KNOWLEDGE

The vocabulary definition adapted from studies (e.g., Cheung et al., 2010; McBride-Chang et al., 2008) was used to assess participants' vocabulary knowledge. This test comprised 53 vocabulary items. In this task, children were orally presented with a word representing an object or concept and asked to explain or define this word. Each response was scored on a 3-point scale (from 0 to 2) for completeness. For instance, when "teacher" was given to the children, if she or he explained it as 'a person who teaches', two points would be given, whereas if she or he defined it as 'a person at school', one point would be awarded. The test was terminated if the children scored zero on five consecutive items. The Cronbach's alpha for this measure was 0.89.

READING COMPREHENSION

The sentence comprehension was developed and based on the studies (Chik, et al., 2012; Yeung, et al., 2011). There were 14 cloze sentences in which a noun, a verb or an adjective was missing. Children were requested to choose, from four choices, the word that best completed each sentence. The four choices were of the same word class but had different meaning and usage. One point was given for the correct answer in each sentence. The Cronbach's alpha for this measure was 0.81.

PROCEDURE

Head–Toes–Knees–Shoulders task (HTKS), rapid digit naming, morphological construction, vocabulary definition, phonological awareness, and word reading tasks were administered individually except for Raven's Standard Progressive Matrices. The parents' or guardians' consents for students' participation were obtained before testing. The children were given from 2 to 4 practice items for the cognitive-linguistic tasks before the formal testing. All assessments were conducted by trained experimenters.

RESULTS

Group Comparisons of Reading, Behavioural Self-Regulation, and Cognitive-Linguistic Measures

The poor readers were matched with the average readers as control readers as in Table 1 showing the means, standard deviations, ranges, *t* and Cohen's d values for all tests for reading, self-regulation and cognitive-linguistic measures. There were no significant differences in age, parents' educational levels, and Raven's scores as nonverbal intelligence (IQ) between the groups. The effect sizes (Cohen's d; Cohen, 1988) of all significant differences in sentence comprehension, behavioural regulation, and cognitive-linguistic measures between the poor reader group and control group were medium to large, as seen in Table 1.

The performance of the poor reader group was significantly lower than the performance of the control group on all the cognitive-linguistic measures: morphological construction [$t(76) = -7.18$, $p < .001$], phonological awareness [$t(76) = -8.37$, $p < .001$], vocabulary definition [$t(76) = -6.04$, $p < .001$], Head-Toes-Knees-Shoulders task [$t(76) = -8.08$, $p < .001$], rapid digit naming [$t(76) = 5.35$, $p < .001$], and sentence comprehension [$t(76) = -10.36$, $p < .001$].

Distinguishing Between Poor Readers and Average Readers

To examine the extent to which self-regulation and cognitive-linguistic measures could best distinguish the poor and good readers, logistic regression analyses were used to investigate the four cognitive-linguistic and self-regulation measures, taking each area into consideration once. In the logistic regression analyses, age and IQ were entered into the first step. When the five measures were entered simultaneously into the second step, the three final significant predictors were Head-Toes-Knees-Shoulders task $\chi^2(1, N=78) = 28.70$, $p < .001$, morphological construction, $\chi^2(1, N=78) = 12.85$, $p < .001$, and rapid digit naming $\chi^2(1, N=78) = 12.49$, $p < .001$.

With these three measures included in the analysis, an overall hit rate was 96.2%, with accuracy rates of both the poor readers group (97.4%) and control group (94.9%) being very similar to one another (see Table 3). The Head-Toes-Knees-Shoulders task, morphological construction, and rapid digit naming were found to be important indicators of poor readers.

Table 1. Descriptive statistics and t-test results for all measures

Task	Poor Readers (n = 39)			Average Readers (n = 39)				Effect size
	M	SD	Range	M	SD	Range	t	(Cohen's d)
Age	86.49	3.61	79.00 - 94.00	85.77	4.23	79.00 - 96.00	0.81	0.18
Parents' Educational Level	5.72	1.02	4.00 - 7.00	5.92	0.96	4.00 - 7.00	-0.91	-0.20
Nonverbal IQ	29.44	9.63	11.00 - 45.00	29.79	7.81	12.00- 45.00	-0.18	-0.04
Head-Toes-Knees-Shoulders task	26.05	6.61	15.00- 38.00	38.13	6.59	25.00 - 47.00	-8.08	-1.83
Rapid Digit Naming	26.28	6.82	16.42 - 41.12	19.40	4.23	13.74 - 29.62	5.35	1.21
Morphological Construction	10.82	3.90	3.00 -18.00	18.03	4.91	6.00 - 27.00	-7.18	-1.63
Vocabulary Definition	25.67	4.90	18.00 - 37.00	34.26	7.40	21.00 - 50.00	-6.04	-1.37
Phonological Awareness	20.26	7.53	7.00- 37.00	35.74	8.76	21.00 - 52.00	-8.37	-1.90
Sentence Comprehension	8.10	1.43	5.00 -10.00	12.05	1.90	8.00 - 14.00	-10.36	-2.35

Table 2. Logistic regression analyses for distinguishing between poor and good readers (N=78)

Model No. 1 Model / Predictor	$\chi 2$	Nagel-kerke R^2	Correctly identified poor readers	Correctly identified average readers	Overall accuracy	β	Odds ratio	Wald
Forward stepwise	91.20	0.92	97.4%	94.9%	96.2%			
Age						-0.15	0.87	0.65
Nonverbal IQ						-0.13	0.87	1.80
Head-Toes-Knees-Shoulders task						0.47	1.60	6.48*
Morphological Construction						0.56	1.75	7.18**
Rapid Digit Naming						-0.38	0.68	4.80*

***p<0.001, **p<0.01, *p<0.05

Correlations Between Reading, Behavioural Self-Regulation, and Cognitive-Linguistic Measures

Table 2 presents the correlations among performance on the morphological construction, phonological awareness, vocabulary definition, rapid digit naming, and self-regulation, sentence comprehension for the whole sample (n=78) after controlling for age and IQ. Most of the cognitive-linguistic measures (morphological construction, phonological awareness, vocabulary definition, and rapid digit naming) were significantly correlated with each other. Among these measures, the rapid digit naming was not significantly correlated with the morphological construction and self-regulation, possibly due to our relatively small sample size. The self-regulation measure was significantly correlated with the cognitive-linguistic measures (morphological construction, phonological awareness, and vocabulary definition). All the correlations between cognitive-linguistic measures, self-regulation, and sentence comprehension measures were significant.

Table 3. Correlations among measures after controlling age and IQ

	1	2	3	4	5	6
1.Head-Toes-Knees-Shoulders task	-					
2. Phonological Awareness	0.41***	-				
3. Morphological Construction	0.36**	0.56***	-			
4. Vocabulary Definition	0.26*	0.44***	0.37**	-		
5. Rapid Digit Naming	-0.22	-0.35**	-0.22	-0.36**	-	
6. Sentence Comprehension	0.54***	0.56***	0.58***	0.43***	-0.35**	-

*p<0.05, **p<0.01, ***p<0.001

Table 4. Summary of hierarchical multiple regression for variables predicting sentence comprehension from behavioral self-regulation and cognitive-linguistic measures after controls for age and IQ (N=78)

Step	Predictor	R	R^2	ΔR^2	*Final step*		
					B	*SE B*	β
1	Age	.17	.03	.03	-0.05	0.06	-0.07
1	Nonverbal IQ				0.00	0.03	0.01
2	Vocabulary Definition	.46	.21	.18***	0.04	0.03	0.12
3	Rapid Digit Naming	.50	.25	.04*	-0.04	0.04	-0.11
4	Phonological Awareness	.62	.38	.13***	0.04	0.03	0.17
5	Morphological Construction	.68	.47	.08**	0.14	0.05	0.30**
6	Head-Toes-Knees-Shoulders task	.74	.54	.07**	0.09	0.03	0.31**

*p<.05, **p<.01, ***p<.001

Predicting Reading from Behavioural Self-Regulation, and Cognitive-Linguistic Measures

As shown in Table 4, hierarchical multiple regression analyses were performed on the combined data from all of the poor and average reader group given that the general patterns of results were similar in both groups, thereby enhancing statistical power. These analyses examine the extent to which the morphological construction, phonological awareness, vocabulary definition, rapid digit naming, and self-regulation measures explained variability in sentence comprehension.

In the regression analyses, age and IQ as the control variables were entered in the first step. The measures of the vocabulary definition, rapid digit naming, phonological awareness, morphological construction, and self-regulation were then entered in the second, third, fourth, fifth, and sixth steps. Vocabulary definition, rapid digit naming, phonological awareness, morphological construction, and self-regulation each made unique contribution to sentence comprehension. These significant predictors together accounted for 18.1%, $F(3, 74) = 6.51$, $p < .01$; 4.1%, $F(4, 73) = 6.09$, $p < .001$; 13.3%, $F(5, 72) = 8.96$, $p < .001$; 8.3%, $F(6, 71) = 10.34$, $p < .001$, and 7.3%, $F(7, 70) = 11.72$, $p < .001$ of the variance in sentence comprehension.

DISCUSSION

The present study represents a first attempt to investigate the cognitive-linguistic skills of behavioral self-regulation, phonological awareness, morphological awareness, vocabulary knowledge, and rapid naming in Chinese poor readers. We also examined the relation between these skills and reading comprehension. The children with reading difficulties exhibited significantly impaired performance on the Head–Toes–Knees–Shoulders task (HTKS), phonological awareness, morphological construction, vocabulary definition, rapid digit naming and sentence comprehension measures, relative to the control group who were matched on age, IQ, and parent's education level.

In the logistic regression analyses, self-regulation along with rapid naming and morphological awareness significantly distinguished poor from adequate Chinese readers. Furthermore, self-regulation explained unique variance in reading comprehension beyond phonological awareness, morphological awareness, vocabulary knowledge, and rapid naming. Our findings are consistent with the simple view of reading (Gough & Tunmer, 1986; Hoover & Gough, 1990), which proposes that reading acquisition and impairment may depend on the orchestration of interconnected, cognitive-linguistic skills. These results were further discussed below.

In the present study, self-regulation skills distinguished children with reading difficulties as compared to those without such difficulties. In particular, the poor readers showed pronounced deficits in the area of cognitive flexibility, working memory, and inhibitory control. Deficits in self-regulation skills may be closely linked with their deficits in cognitive-linguistic skills, which are the primary skills required by readers, and with which most poor readers struggle (Ho, Chan, Lee, Tsang, & Luan, 2004; Shu, Meng, & Lai, 2003).

As mentioned previously, Chinese orthography has numerous different graphic patterns and orthographic rules, and thousand of characters are required to be learned. For those readers who have not yet fully mastered the process of learning to read, each character may be learned individually as a kind of logograph or unique symbol. This may in turn place extra demands on the individual's cognitive flexibility, working memory, and inhibitory control. Furthermore, many poor readers may have difficulty concentrating on some aspects of linguistic information (e.g., pronunciation and meaning) and suppressing irrelevant information given the vast number of homophones and homographs in Chinese.

At the same time, these readers could have problems processing and recalling a large number of characters needed to develop strong character-semantic skills to discriminate different homophones and homographs in order to comprehend meaningful sentences and passage. Consistent with the research study on Chinese children (Chung & McBride-Chang, 2011; Peng et al., 2013), which found that at least both working memory and inhibitory control contribute to reading development and failure, a similar finding was found in our sample of poor readers. Poor self-regulation may be another possible marker for children with reading difficulties and dyslexia.

Phonological skills also discriminated the poor readers from adequate readers in the present study. The results showed that children with reading difficulties performed worse than the competent readers in all the phonological tasks. Thus phonological awareness deficits in the children with reading difficulties may reflect the lesser quality of phonological presentations of morphemes thereby possibly causing some problems in mapping from graphs to syllabic morphemes. As with the previous studies (e.g., Liberman, Shankweiler, & Liberman, 1989; Stanovich & Siegel, 1994), the current results have also shown that phonological awareness uniquely contributes to reading acquisition and impairment in a variety of languages. Deficits in phonological awareness were also found in poor readers and children with dyslexia (e.g., Liu et al., 2010).

Morphological skills in addition to phonological skills consistently distinguished the poor from the adequate readers. As in the previous studies (Chung et al.,

2010; McBride-Chang et al., 2008a; McBride-Chang et al., 2008b), the children with reading difficulties in the present study also performed at a lower level than their typically developing peers on the morphological compounding measure. It may be that poor readers have not fully integrated the morphological unit and the structure of a word, so that their representations and organization of morphological units have yet to develop in order to discriminate morphemes, manipulate morphemic structures and generalize morpheme meaning. Consistent with the studies (Chung et al., 2010; Shu et al., 2006; Yeung, Ho, Chan, & Chung, 2014) morphological awareness was the best method to distinguish children with and without reading difficulties and dyslexia.

Apart from morphological skills, the poor readers also exhibited deficits in vocabulary knowledge. The vocabulary definition used in the present study required the children to define or explain the meaning of the words given. Perhaps the poor readers have relatively limited vocabularies or words in their mental lexicon so that they may have difficulty in recognizing and explaining the word meanings and/or understanding the words sufficiently well to be able to apply them in appropriate context. It is equally possible that an impoverished vocabulary may restrain the haste with which words could be mapped to print (e.g., Liu et al., 2010; McBride-Chang, Liu, Wong, Wong, & Shu, 2012). Therefore, collectively, these findings suggest that poor vocabulary knowledge may be an important cognitive indicator of reading difficulties not only for alphabetic languages but also for Chinese (Landi, 2010; Liu et al., 2010; Ouellette, 2006)

The children with reading difficulties in the present study showed significantly lessened performance on the rapid digit naming task relative to the average readers. These findings may reflect difficulties with generally weak phonological representations, less automatic processes of extraction and induction of orthographic patterns, less efficient lexical access and hence mirror one underlying cause of poor reading given that Chinese script has relatively arbitrary associations between print and sound. Deficits in rapid naming seem to suggest that, like those results for dyslexia in alphabetic languages such as English and German (e.g., Snowling, 2000; Wolf, Bowers, & Biddle, 2000), this cognitive deficit may be an impairment in children with reading difficulties and good indicator of dyslexia in Chinese (e.g., Chung et al., 2010; Ho et al., 2004).

In the present study, logistic regression analyses revealed that self-regulation, morphological awareness, and rapid naming were found to be the strongest cognitive-linguistic skills distinguishing poor readers from competent readers. These three skills could adequately be used to predict group membership of poor and average readers with an overall correct classification rate of 97.4%. Furthermore, digit rapid naming, vocabulary knowledge, phonological awareness, morphological awareness, and self-regulation were linked to

reading comprehension when all these cognitive-linguistic skills were included in regression equations, supplying additional evidence of the potential importance of the sentence comprehension. Therefore, perhaps measures of the Head–Toes –Knees–Shoulders task (HTKS), morphological awareness, and rapid digit naming could be considered to be used for screening readers at risk of reading difficulties.

While the present findings provide a broader understanding of cognitive-linguistic skills relative to reading difficulties in Chinese, these results point to several new directions for future research. Given the paucity of studies that investigate the relationships among self-regulation, phonological awareness, morphological awareness, vocabulary knowledge, and rapid naming, additional longitudinal studies are needed to replicate the present findings both at the group and at the individual level. Future studies conducted with a large sample of readers are therefore necessary to examine whether any causal link stands between different cognitive-linguistic skills such as self-regulation, syntactic, discourse, and pragmatic skills, and different degrees of reading difficulties. Moreover, studies with experimental manipulations and longitudinal studies tapping these skills over time relative to different sets of literacy skills such as text writing abilities will be essential for the future.

To conclude, the current study has demonstrated the potential importance of five cognitive-linguistic skills: self-regulation, phonological awareness, morphological awareness, vocabulary knowledge, and rapid naming, and these skills are strong correlates of reading comprehension in children learning to read in Chinese. Our findings also suggest that weaknesses in self-regulation, morphological awareness, and rapid naming are important markers of word reading difficulties among Chinese readers. Such findings may help to develop tools for the diagnosis and teaching strategies of this group of poor readers, and enhance the public awareness of children with reading difficulties.

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