THE JOURNAL OF
CHILD PSYCHOLOGY AND PSYCHIATRY

Journal of Child Psychology and Psychiatry 49:2 (2008), pp 211–218 doi:10.1111/j.1469-7610.2007.01837.x

Word recognition and cognitive profiles of Chinese pre-school children at risk for dyslexia through language delay or familial history of dyslexia

Catherine McBride-Chang,[1] Fanny Lam,[2] Catherine Lam,[2] Sylvia Doo,[2] Simpson W.L. Wong,[1] and Yvonne Y.Y. Chow[1]

[1]The Chinese University of Hong Kong; [2]Child Assessment Service, Department of Health, Hong Kong

Background: This study sought to identify cognitive abilities that might distinguish Hong Kong Chinese kindergarten children at risk for dyslexia through either language delay or familial history of dyslexia from children who were not at risk and to examine how these abilities were associated with Chinese word recognition. The cognitive skills of interest were syllable awareness, tone detection, rapid automatised naming, visual skill, and morphological awareness. **Method:** We recruited 36 children whose sibling had been previously diagnosed with dyslexia (familial risk group) and 36 children who were initially reported to have difficulties in preschool literacy acquisition by either teachers or parents and subsequently found to demonstrate clinical at-risk factors in aspects of language by paediatricians (language delayed group); the mean age of these groups was approximately 61 months. Thirty-six children with no such risk factors were matched by age, IQ, and parents' education to the at-risk groups. All children were tested on cognitive skills and Chinese word recognition. **Results:** Compared to the controls, children in the language delayed group scored significantly lower on all measures, whereas children in the familial risk group performed significantly worse only on tone detection, morphological awareness, and Chinese word recognition. In regression analyses, word recognition was best explained by morphological awareness, tone detection and visual skill. **Conclusions:** Language-related measures are strongly associated with early reading development and impairment in Hong Kong Chinese children. Tests of tone detection and morphological awareness may be important clinical tools for diagnosing risk for reading problems in young Chinese children. In contrast, Chinese language delay may be associated with broader cognitive impairments as found previously in various Indo-European languages (e.g., Bishop & Snowling, 2004). **Keywords:** Language impairment, genetic risk, dyslexia, Chinese children, lexical tone.

Early intervention is potentially more cost-effective than later intervention, both for dyslexia (e.g., Adams, 1990; Snow, Burns, & Griffin, 1998) and language delay (Beeghly, 2006). In many countries, however, early diagnosis of such difficulties is difficult. For example, children with dyslexia cannot be identified until they have clearly fallen behind their peers in reading, a process that may take several years to establish (Fawcett, Singleton, & Peer, 1998). Variability in typical language development may also make early diagnosis of language delay challenging (Beeghly, 2006). The goal of the present study was to identify cognitive abilities that might distinguish Chinese children at risk for dyslexia from those with a language disability and from typically developing children at a relatively young age (X = 61 months), as well as to examine how these abilities are associated with early word recognition in Chinese.

Among English-speaking children, a wide range of language-related difficulties have been tested as markers of dyslexia and language delay (e.g., Bishop & Snowling, 2004; Fawcett & Nicolson, 1994), diagnoses that may show strong overlap (Catts, Fey, Tomblin, & Zhang, 2002). For example, in studies of children learning alphabetic orthographies, 40–75% of those with early language impairment later developed reading difficulties (Aram & Hall, 1989; Bashir & Scavuzzo, 1992). However, the manifestations of reading problems experienced by children with language impairment or dyslexia are not necessarily the same, either at a cognitive or genetic level (Bishop & Snowling, 2004). For example, children with classic dyslexia in English are most likely to show phonological deficits, whereas those with language impairment often show both phonological and nonphonological language (e.g., inference-making) deficits (Bishop & Snowling, 2004).

Because our primary interest in the present study was in identifying potential early markers of reading difficulties, we drew from previous work on cognitive deficits in Chinese developmental dyslexia (Ho, Chan, Lee, Tsang, & Luan, 2004; Ho, Chan, Tsang, & Lee, 2002; Shu, McBride-Chang, Wu, & Liu, 2006) to tap three areas. These areas were phonological processing, including both phonological awareness and

Conflict of interest statement: No conflicts declared.

Published by Blackwell Publishing, 9600 Garsington Road, Oxford OX4 2DQ, UK and 350 Main Street, Malden, MA 02148, USA

speeded naming (e.g., Wagner & Torgesen, 1987), visual processing, and morphological awareness, as outlined below.

A hallmark of dyslexia in some alphabetic orthographies (e.g., Dutch: de Jong & van der Leij, 2003; English: Bryant & Bradley, 1985; Italian: Cossu, Shankweiler, Liberman, Katz, & Tola, 1988), phonological processing, focused on accessing and manipulating speech segments, is one deficit that is also manifested by some primary school children with dyslexia in Hong Kong (Ho et al., 2002, 2004). For example, Ho, Law, and Ng (2000) found that Chinese children with dyslexia performed significantly worse than children without dyslexia on tasks tapping phonological awareness. One of the strongest predictors of Chinese word recognition in previous research on typically developing Chinese kindergartners is syllable deletion (Chow, McBride-Chang, & Burgess, 2005; McBride-Chang & Ho, 2000; McBride-Chang & Kail, 2002), because each Chinese character has a direct correspondence to a single syllable and morpheme. Given that the ability to manipulate syllables in language may be an important skill in mapping language onto Chinese script, syllable awareness was included as one phonological processing skill in the present study.

Another aspect of phonological processing that may be useful in early reading development among Chinese children is sensitivity to lexical tones. Each Chinese character is represented by a syllable that is marked by a given lexical tone. If this tone is misrepresented, the character will be pronounced incorrectly and may be misidentified as a different word. Given the importance of lexical tone for Chinese character acquisition in children (e.g., Chen et al., 2004; Fu & Huang, 2000; Hu & Catts, 1998; Leong, Cheng, & Tan, 2005), in the present study, we tested tone detection as well.

A third aspect of phonological processing, rapid automatised naming (RAN), strongly distinguishes children with dyslexia from those without dyslexia across a variety of alphabetic orthographies (e.g., Wolf & Bowers, 1999). Indeed, RAN, tapped by the speed with which children orally identify a series of common symbols or objects presented multiple times, is among the best markers of reading disability across languages (e.g., German: Wimmer & Hummer, 1990; Dutch: Yap & van der Leij, 1993, 1994; Finnish: Korhonen, 1995; Spanish: Novoa & Wolf, 1984), including Chinese (e.g., Ho & Lai, 1999; Ho et al., 2004; Shu, Meng, & Lai, 2003). The present study, therefore, included a measure of RAN as a potential predictor of reading disability.

In addition to the above-mentioned aspects of phonological processing, we included a measure of visual skill. Visual skills tap children's processing of visual information unrelated to print. Chinese character recognition may make use of visual skills as children begin the process of reading because of the remarkable visual complexity of Chinese characters, which contain a much greater amount of visual information than do alphabetic scripts (Chen, Song, Lau, Wong, & Tang, 2003). Furthermore, although Chinese and English reading are associated with similar activation across regions of the brain, the peak brain activation in the left lateral middle frontal cortex, a region that mediates visual-spatial skills, is found in Chinese reading only, perhaps an indication that the logographic structure of Chinese characters may demand special visual-spatial processing (Tan et al., 2001). Indeed, visual skills distinguish Chinese children with and without dyslexia in some profiling studies (Ho et al., 2002). Moreover, several studies of Chinese children have demonstrated some association of pure visual and orthographic processing (e.g., Huang & Hanley, 1995; Lee, Stigler, & Stevenson, 1986; McBride-Chang & Chang, 1995; Siok & Fletcher, 2001), suggesting that early visual skills may subsequently influence orthographic skills and, thus, reading development.

A final cognitive ability tapped in the present study was morphological awareness, recently demonstrated to distinguish dyslexic from nondyslexic Chinese fifth and sixth grade readers (Shu et al., 2006). One aspect of morphological awareness involves understanding how morphemes in a word can be combined within a language. For example, recent studies of children at risk for reading disability in both Dutch (Alphen et al., 2004) and Finnish (Lyytinen & Lyytinen, 2004) showed that inflectional morphology was relatively weak in those young children subsequently diagnosed as at risk for dyslexia as compared to those who were not. Although there is relatively little inflectional morphology for children to master in Chinese, another aspect of early morphological development, lexical compounding, is fundamental to Chinese, for which there are many more multi-morphemic words to learn to read and spell from the beginning of reading acquisition, as compared to English (e.g., McBride-Chang et al., 2005). Morphological awareness in the form of lexical compounding has been shown to be a strong and independent correlate of Chinese word recognition in both kindergartners and second graders from Hong Kong (McBride-Chang, Shu, Zhou, Wat, & Wagner, 2003), as well as second graders in Beijing (McBride-Chang et al., 2005).

To summarise, the present study examined the extent to which five cognitive abilities would distinguish young Chinese children who were at risk for dyslexia by virtue of either genetic risk or clinically identified preschool language delay as compared to those who were not at risk for dyslexia. Children with a relative with dyslexia tend to have a higher than normal probability of developing reading difficulties (e.g., Gilger, Pennington, & DeFries, 1991; Scarborough, 1990; Vogler, DeFries, & Decker, 1985), so the genetic risk group consisted of those with a sibling already diagnosed as having dyslexia. According to the multiple deficits hypothesis, the number of cognitive deficits manifested by a child is strongly related to the severity of his or her reading disabilities (Badian, 1997; Ho et al., 2002). Thus, we expected that children with difficulties across a wider range of cognitive tasks, as has been demonstrated previously in some studies of children with language delay (e.g., Bishop & Snowling, 2004), might also demonstrate greater reading difficulties. The tasks administered were syllable deletion, tone detection, rapid automatised number naming, visual skill, and morphological awareness. We also examined how all five of these were associated with early Chinese word recognition itself in these groups.

Method

Participants

All participating children included in the present study with parental consent were in their second year of kindergarten. In Hong Kong, kindergarten is a separate 3-year school that all children attend from the ages of 3 to 6 years old. Hong Kong Chinese children are expected to have mastered approximately 200 Chinese characters by the end of kindergarten, and they typically begin training in reading from the second semester of their first year in kindergarten (at roughly 3.5 years of age).

All 72 children in each of the two at-risk groups had been referred by paediatricians from the Child Assessment Service (a division of the Department of Health in Hong Kong). Of these, 36 (21 boys, 15 girls, mean age = 61.06 months, SD = 3.37 months) were in the familial risk group because their sibling had been diagnosed with dyslexia. Another 36 (24 boys, 12 girls, mean age = 60.83 months, SD = 3.82 months) had been reported to have had difficulties in word recognition by parents or teachers and had been subsequently tested by paediatricians to estimate their general intellectual abilities, using the Griffiths Mental Developmental Scale (Griffiths, 1984). They had also been evaluated for oral language skills using either the Reynell Developmental Language Scale (Reynell & Huntley, 1985) or the Preschool Language Scale 3 (Zimmerman, Steiner, & Pond, 1992), both widely used for evaluation of potential language problems in Hong Kong. These children showed variable impairments in one or more key areas of effective reading, including phonological awareness, lexical skills, receptive and expressive oral language, reading readiness, or letter identification (Snow et al., 1998). Apart from preschool literacy backwardness, the children tended to exhibit one or more language- or literacy-related clinical features, such as phonetic disorder, delay in verbal comprehension and/or expression, colour naming coding difficulties, slow processing speed or graphological errors in writing. However, children with significant behavioural problems such as autism or hyperactivity were excluded from this group. A third group of 36 children (16 boys, 20 girls, mean age = 61.28 months, SD = 3.64 months) matched to these at-risk children based on age, parents' educational levels, and nonverbal intelligence (using the *Coloured Progressive Matrices*; Raven, 1956) were selected as a control group from a larger group of 215 normally-achieving children. These 215 children were participants in an ongoing longitudinal study of language and literacy development under the direction of the first author.

Procedure

All language delayed or familial risk group children were subsequently tested individually at the Hong Kong Child Assessment Centre in the presence of a paediatrician on all tasks described below. All testing was carried out in Cantonese by undergraduate psychology students trained in the procedures. Testing took place during the months of June through July 2006. The children in the control group were tested individually at their homes by trained undergraduate psychology majors as part of a larger study.

Measures

Chinese word recognition. Children were tested on 27 one-character and 34 two-character simple words designed for Hong Kong kindergartners. If the children failed to read aloud 10 consecutive items on this task correctly, testing stopped. For those whose testing was not terminated at this point, the Chinese word reading subtest of the Hong Kong Test of Specific Learning Difficulties in Reading and Writing (Ho, Chan, Tsang, & Lee, 2000) was then orally administered. The internal consistency reliability of this combined measure of Chinese word recognition was .96, and the final score on this task was derived by adding together both portions of the task.

Syllable deletion. In this task, which has also been used in previous studies (McBride-Chang & Ho, 2000; McBride-Chang & Kail, 2002), across trials, children were asked to take away one syllable from a three-syllable phrase presented orally in Cantonese (e.g., say /din6 daan1 ce1/ without /din6/ would be /daan1 ce1/). There were 13 items requiring the deletion of the first syllable, last syllable, or middle syllable. The internal consistency reliability of this task was .85.

Tone detection. We adapted the tone detection task from a study previously done by Ciocca and Lui (2003). The stimuli used in this task were derived from two monosyllables /ji/ and /fu/, and were divided into two sets of six Cantonese tones. The stimuli of the monosyllable /ji/ included /ji1/ 衣 (clothing), /ji2/ 椅 (chair), /ji3/ 意 (first character of spaghetti), /ji4/ 兒 (son), /ji5/ 耳 (ear), and /ji6/ 二 (two), and those of the monosyllable /fu/ were /fu1/ 膚 (skin), /fu2/ 虎 (tiger), /fu3/ 褲 (trousers), /fu4/ 符 (symbol), /fu5/ 婦 (woman), and /fu6/ 父 (father). This task has two phases, learning and testing. In the learning phase, children were taught to identify 12 pictures that were associated with a corresponding Cantonese syllable mentioned above. All stimuli were played for the children on a Sony mini-disc player. In the testing phase, the participants were then given a booklet of 3 trial items and 36 test items, with all the items presented in pictures. Each picture represented a previously-learnt Cantonese syllable. In each trial, children were asked to identify and select the correct picture from among two choices that represented the syllable played by the mini-disc player. The internal consistency reliability for this task was .64.

Rapid number naming. Prior to testing, children were asked to name, untimed, each of five digits (5, 4, 3, 1, 8) to ensure that all of these stimuli were familiar to them. Children were then presented with a sheet of paper containing all five digits each across five rows, all in different orders. Children were instructed to name all the digits accurately at their fastest speed, and two trials were given to obtain the average time used. Times were measured by the experimenter using a stop-watch. The test–retest reliability for this task was .88.

Visual skill. This skill was assessed using the Visual-Spatial Relationships subtest of Gardner's (1996) Test of Visual-Perceptual Skills (non-motor) Revised. All participants were asked to identify from a set of five figures the figure with a different orientation from the other four. The test consisted of one practice item and 16 test items. Testing stopped when the child missed four out of five items consecutively. The internal consistency reliability for this task was .87.

Morphological awareness. This task, used in previous studies (e.g., McBride-Chang et al., 2003; McBride-Chang et al., 2005), required children to combine familiar morphemes in new ways to form new structurally legal multi-morphemic nonwords. The 2 trial items and 15 test items included in this task were each tested within the framework of a two-sentence scenario. The trial items and the first three test items were accompanied by pictures in order to make them as comprehensible as possible. An example of an item tapping this ability is the following: *If we see a web that is made by a spider, we call it a spider web. What should we call a web made by an ant?* (the correct answer should be *ant web*). The internal consistency reliability of this task was .79.

Results

The data were analysed in two steps. First, a 3 (group) × 5 (task) MANCOVA controlling for age, nonverbal IQ and parents' education revealed that there was a main effect for group (F [2, 102] = 3.37, $p < .01$). Second, post hoc least significant difference (LSD) tests across cognitive tasks were carried out in separate ANCOVAs, as shown in Table 1. Compared to the control group, children in the language delayed group performed significantly worse across all tasks, whereas the familial risk group performed significantly worse only on Chinese word recognition, tone detection, and morphological awareness. Furthermore, for tone detection and morphological awareness only, the at-risk groups did not differ from one another in performance. For all other tasks, the familial risk group outperformed the language delayed group.

Table 2 shows intercorrelations among all measures partialling the effects of age, nonverbal IQ and parents' education. Chinese word recognition was significantly and moderately associated with all cognitive measures. As shown in Table 3, in a multiple regression analysis, only the final beta weights of the visual-spatial relationships, morphological awareness, and tone detection were uniquely associated with Chinese word recognition in the equations. We further explored the unique contributions of each of these variables in a series of hierarchical regression analyses, shown in Table 4, with all other variables statistically controlled. When morphological awareness, tone detection, and visual-spatial relationships were each entered in the last step of the equation, they still explained a statistically significant proportion of unique variance in Chinese word recognition (5%, 3%, and 3%, respectively).

Discussion

The present study was among the first attempts to establish early measures that might distinguish

Table 1 Estimated mean scores and standard deviations of various tasks controlling for children's age, nonverbal IQ and parents' education of three groups of participants (language delayed, normally-achieving and at familial risk of dyslexia) and the F values for univariate test of group differences

Group/Task	Language delayed $N = 36$	Familial risk $N = 36$	Normally achieving $N = 36$	F (2, 102)	Pairwise comparisons by LSD
Literacy task					
Chinese word recognition (max = 211)	22.22 (3.09)	33.22 (3.15)	51.49 (3.10)	22.96***	NA > LD; NA > FR; LD < FR
Cognitive tasks					
Visual-spatial relationships (max = 16)	7.95 (0.60)	9.73 (0.61)	10.49 (0.60)	4.71*	NA > LD; NA = FR; LD < FR
Syllable deletion (max = 13)	8.42 (0.55)	10.24 (0.56)	11.75 (0.55)	9.27***	NA > LD; NA = FR+; LD < FR
Tone detection (max = 36)	21.99 (0.73)	22.36 (0.74)	24.51 (0.73)	3.53*	NA > LD; NA > FR; LD = FR
Rapid number naming (seconds)	29.73 (1.51)	23.29 (1.53)	19.86 (1.51)	11.10***	NA < LD; NA = FR; LD > FR
Morphological awareness (max = 15)	6.26 (0.54)	6.87 (0.54)	8.91 (0.54)	6.43**	NA > LD; NA > FR; LD = FR

Note. NA = normally achieving group; LD = language delayed group; FR = familial risk group.
$^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$.

Table 2 Partial correlations among different measures partialling for children's age, nonverbal IQ and parents' education

Variables	1	2	3	4	5	6
1. Chinese word recognition	–					
2. Syllable deletion	.43***	–				
3. Tone detection	.38***	.34**	–			
4. Rapid number naming	−.39***	−.46***	−.20*	–		
5. Visual-spatial relationships	.37***	.27**	.16	−.41***	–	
6. Morphological awareness	.46***	.42***	.27**	−.32**	.21*	–

**p* < .05; ***p* < .01; ****p* < .001.

Table 3 Standardised betas for multiple regression equations explaining Chinese word recognition from cognitive variables

Variables	Beta	t
Age	−.09	−1.07
Nonverbal IQ	−.11	−1.23
Parent's education	−.13	−1.54
Syllable deletion	.17	1.54
Tone detection	.22	2.41*
Rapid number naming	−.11	−1.12
Visual-spatial relationships	.23	2.27*
Morphological awareness	.28	3.00**

Note. For equation predicting Chinese word recognition, $R^2 = .40$.
**p* < .05; ***p* < .01.

Table 4 Hierarchical regression explaining Chinese word recognition from unique variables

Step	Variable	R	R^2 change	F change
1.	Variables controlled	.26	.26	7.02***
2.	Visual-spatial relationships	.30	.04	5.86*
3.	Tone detection	.35	.05	7.69**
4.	Morphological awareness	.40	.05	8.94**
1.	Variables controlled	.26	.26	7.02***
2.	Morphological awareness	.33	.07	11.37**
3.	Visual-spatial relationships	.37	.04	5.46*
4.	Tone detection	.40	.03	5.82*
1.	Variables controlled	.26	.26	7.02***
2.	Tone detection	.31	.05	8.13**
3.	Morphological awareness	.37	.06	9.28**
4.	Visual-spatial relationships	.40	.03	5.15*

Note. Variables controlled were children's age, nonverbal IQ and parents' education, syllable deletion and rapid number naming.
**p* < .05; ***p* < .01; ****p* < .001.

Chinese children at risk for reading problems from those not at risk. We included two distinct at-risk groups in the study, one for whom an older sibling had already been diagnosed with dyslexia, and the other a more eclectic group that had been identified using a combination of clinical expertise and performance on standard language tests. Children in the language delayed group, who manifested difficulties across all measures, scored significantly lower on a test of Chinese word reading than did the familial risk group, who showed difficulties only in morphological awareness and tone detection, in addition to reading itself, supporting the multiple deficits hypothesis (Badian, 1997; Ho et al., 2002). Thus, children with dyslexia tend to have more confined difficulties than do language impaired children, even at an early age (e.g., Bishop & Snowling, 2004). For example, children with dyslexia who also manifest some language impairment tend to show more severe and global deficits in sensitivity to morphology, phonology and speech than do children who are reading but not language impaired (e.g., Joanisse, Manis, Keating, & Seidenberg, 2000).

That the tone detection and morphological awareness tasks best distinguished the familial risk group from the control group and that the familial risk and language impaired groups had equal difficulties on them suggest that these two tasks should be incorporated by diagnosticians in future work. Neither of these tasks has been regularly included in tests for reading disabilities in alphabetic orthographies. However, both may be particularly important for early word recognition given the structure of Chinese. To detect and decode Chinese words, tone sensitivity is essential. A minor variation in tone implies a different meaning across Chinese syllables. Therefore, detecting differences across tones also likely contributes to the ability to distinguish across characters and to be confident in understanding what characters should be mapped onto what speech segments. Morphological awareness, too, may facilitate early reading in Chinese because one's knowledge of single characters can support reading of many words in which such characters appear. That is, although Chinese words have unique representations in print, these words are typically comprised of two or more Chinese characters, each representing a single morpheme, and each such individual character might appear across a variety of words. Knowing the morphemes comprising words and how such morphemes can be combined within one's language may facilitate reading them in Chinese, just as in English knowing the morpheme *night* might facilitate one's reading of *nightmare* or *goodnight*.

Both tone detection and morphological awareness, in addition to visual skill, were uniquely associated with Chinese word recognition when all cognitive skills were included in a regression equation, providing further evidence of the potential importance of these metalinguistic tasks for early reading in

Chinese. Although this regression analysis oversampled at-risk children, results of an analysis of control group data only were similar, with each of these three cognitive skills explaining between 2 and 7% unique variance in the equation. Furthermore, our results were in line with those of Shu et al. (2006), who demonstrated that both phonological awareness and morphological awareness uniquely explain variability in Chinese word recognition among upper primary grade children with and without dyslexia. The unique association of visual skill to early Chinese word recognition in the present study has also been demonstrated in some previous studies (e.g., Ho & Bryant, 1999; McBride-Chang, Chow, Zhong, Burgess, & Hayward, 2005). Thus, given the results of the present study, it is possible that difficulty in any one of these early cognitive skills, tone detection, morphological awareness, or visual processing, could potentially be associated with reading difficulties in young Chinese children.

There are some aspects of these findings that should be extended and improved upon in future work. For example, this limited and specific set of cognitive skills is likely not comprehensive enough to understand early reading difficulties in Chinese. Other aspects of early reading, such as paired associates learning skill, might be incorporated in future studies. Moreover, our data were collected at a single time point only, making causal associations between cognitive skills and reading impossible to infer. Indeed, it is likely that all of these associations are bidirectional. For example, the association of visual skill with Chinese word recognition may demonstrate in part that Chinese children who show early difficulties in reading Chinese words tend to score relatively low on tasks of visual processing because they show visual processing inexperience attributable to a lack of exposure to print. Future research should examine causal links of all of the cognitive skills included in the present battery to subsequent reading.

Despite these problems of interpretation, however, the present study has demonstrated at least three potentially important aspects of cognitive skills in relation to Chinese word recognition among children at risk for language delay or reading disability. First, although it is clear that a hallmark of reading disorders is a problem with phonological processing (Snowling, 1995), the manifestation of such difficulties may differ in Chinese, involving tone detection, a feature of language that has thus far been underexplored in the literature. Second, morphological awareness may be a core construct in identifying Chinese children at risk for dyslexia, as it is in older children who manifest reading difficulties (Shu et al., 2006). Third, as in other orthographies (Bishop & Adams, 1990), our data suggest that the primary deficits experienced by young Chinese children struggling to learn to read represent, at the core, language-related problems.

Acknowledgement

We are grateful for the support from the Research Grants Council of the Hong Kong Special Administrative Region (project reference 4257/03H) for support of this research.

Correspondence to

Catherine McBride-Chang, Psychology Department, The Chinese University of Hong Kong, Shatin, Hong Kong; Tel: 852-26096576; Email: cmcbride@psy.cuhk.edu.hk

References

Adams, M.J. (1990). *Beginning to read: Thinking and learning about print*. Cambridge, MA: MIT Press.

Alphen, P., van de Bree, E., Gerrits, E., de Jong, J., Wilsenach, C., & Wijnen, F. (2004). Early language development in children with a genetic risk for dyslexia. *Dyslexia*, *10*, 265–288.

Aram, D.M., & Hall, N.C. (1989). Longitudinal follow-up of children with preschool communication disorders: Treatment implications. *School Psychology Review*, *18*, 487–501.

Badian, N.A. (1997). Dyslexia and the double deficit hypothesis. *Annals of Dyslexia*, *47*, 69–87.

Bashir, A.S., & Scavuzzo, A. (1992). Children with language disorders: Natural history and academic success. *Journal of Learning Disabilities*, *25*, 53–65.

Beeghly, M. (2006). Translational research on early language development: Current challenges and future directions. *Development and Psychopathology*, *18*, 737–757.

Bishop, D.V.M., & Adams, C. (1990). A prospective study of the relationship between specific language impairment, phonological disorders and reading retardation. *Journal of Child Psychology and Psychiatry*, *31*, 1027–1050.

Bishop, D.V.M., & Snowling, M.J. (2004). Developmental dyslexia and specific language impairment: Same or different? *Psychological Bulletin*, *130*, 858–886.

Bryant, P., & Bradley, L. (1985). *Children's reading problems*. London: Basil Blackwell.

Catts, H.W., Fey, M.E., Tomblin, J.B., & Zhang, X. (2002). A longitudinal investigation of reading outcomes in children with language impairments. *Journal of Speech, Language, and Hearing Research*, *45*, 1142–1157.

Chen, X., Anderson, R.C., Li, W.L., Hao, M.L., Wu, X.C., & Shu, H. (2004). Phonological awareness of bilingual and monolingual Chinese Children. *Journal of Educational Psychology*, *96*, 142–151.

Chen, H.-C., Song, H., Lau, W.Y., Wong, K.F.E., & Tang, S.L. (2003). Developmental characteristics of eye movements in reading Chinese. In C. McBride-Chang & H.-C. Chen (Eds.), *Reading development in Chinese children* (pp. 157–169). Westport, CT: Praeger Press.

Chow, B.W.-Y., McBride-Chang, C., & Burgess, S. (2005). Phonological processing skills and early reading abilities in Hong Kong Chinese kindergartners learning to read English as a second language. *Journal of Educational Psychology*, *97*, 81–87.

Ciocca, V., & Lui, J.Y.K. (2003). The development of the perception of Cantonese lexical tones. *Journal of Multilingual Communication Disorders*, *1*, 141–147.

Cossu, G., Shankweiler, D., Liberman, I.Y., Katz, L., & Tola, G. (1988). Awareness of phonological segments and reading ability in Italian children. *Applied Psycholinguistics*, *9*, 1–16.

de Jong, P.F., & van der Leij, A. (2003). Developmental changes in the manifestation of a phonological deficit in dyslexic children learning to read a regular orthography. *Journal of Educational Psychology*, *95*, 22–40.

Fawcett, A.J., & Nicolson, R.I. (Eds.). (1994). *Dyslexia in children: Multidisciplinary perspectives*. London: Harvester Wheatsheaf.

Fawcett, A.J., Singleton, C.H., & Peer, L. (1998). Advances in early years screening for dyslexia in the UK. *Annals of Dyslexia*, *48*, 57–88.

Fu, C.-L., & Huang, H.-S. (2000). The measurement of meta-linguistic awareness and the relationship between meta-linguistic awareness and Chinese character recognition among elementary school students. *Journal of Education and Psychology*, *23*, 383–414.

Gardner, M.F. (1996). *Test of visual-perceptual skills (non-motor)*. Burlingame, CA: Psychological and Educational Publications.

Gilger, J.W., Pennington, B.F., & DeFries, J.C. (1991). Risk for reading disability as a function of parental history in three family studies. *Reading and Writing: An Interdisciplinary Journal*, *3*, 205–217.

Griffiths, R. (1984). *The abilities of young children*. High Wycombe, UK: The Test Agency Ltd.

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, Lee, S.-H., Tsang, S.-M., & Luan, H.V. (2004). Cognitive profiling and preliminary subtyping in Chinese developmental dyslexia. *Cognition*, *91*, 43–75.

Ho, C.S.-H., Chan, D.W.-O., Tsang, S.-M., & Lee, S.-H. (2000). *The Hong Kong Test of Specific Learning Difficulties in Reading and Writing*. Hong Kong: Hong Kong Specific Learning Difficulties Research Team.

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: An Interdisciplinary Journal*, *13*, 57–79.

Huang, H.S., & Hanley, J.R. (1995). Phonological awareness and visual skills in learning to read Chinese and English. *Cognition*, *54*, 73–98.

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.

Joanisse, M., Manis, F.R., Keating, P., & Seidenberg, M.S. (2000). Language deficits in dyslexic children: Speech perception, phonology, and morphology. *Journal of Experimental Child Psychology*, *77*, 30–60.

Korhonen, T.T. (1995). The persistence of rapid naming problems in children with reading disabilities: A nine-year follow-up. *Journal of Learning Disabilities*, *28*, 232–239.

Lee, S-Y., Stigler, J.W., & Stevenson, H.W. (1986). Beginning reading in Chinese and English. In B.R. Foorman & A.W. Siegel (Eds.), *Acquisition of reading skills: Cultural constraints and cognitive universals* (pp. 123–150). Hillsdale, NJ: Erlbaum.

Leong, C.K., Cheng, P.W., & Tan, L.H. (2005). The role of sensitivity to rhymes, phonemes, and tones in reading English and Chinese pseudowords. *Reading and Writing: An Interdisciplinary Journal*, *18*, 1–26.

Lyytinen, P., & Lyytinen, H. (2004). Growth and predictive relations of vocabulary and inflectional morphology in children with and without familial risk for dyslexia. *Applied Psycholinguistics*, *25*, 397–411.

McBride-Chang, C., & Chang, L. (1995). Memory, print exposure, and metacognition: Components of reading in Chinese children. *International Journal of Psychology*, *5*, 607–616.

McBride-Chang, C., Cho, J.-R., Liu, H., Wagner, R.K., Shu, H., Zhou, A., Cheuk, C.S.-M., & Muse, A. (2005). Changing models across cultures: Associations of phonological and morphological awareness to reading in Beijing, Hong Kong, Korea, and America. *Journal of Experimental Child Psychology*, *92*, 140–160.

McBride-Chang, C., Chow, B.W.-Y., Zhong, Y.-P., Burgess, S., & Hayward, W. (2005). Chinese character acquisition and visual skills in two Chinese scripts. *Reading and Writing: An Interdisciplinary Journal*, *18*, 99–128.

McBride-Chang, C., & Ho, C.S.-H. (2000). Developmental issues in Chinese children's character acquisition. *Journal of Educational Psychology*, *92*, 50–55.

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

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

Novoa, L., & Wolf, M. (1984). *Word-retrieval and reading in bilingual children*. Paper presented at Boston University Language Conference, Boston, MA.

Raven, J.C. (1956). *Coloured progressive matrices*. Oxford: Psychologists Press.

Reynell, J., & Huntley, M. (1985). *Reynell Developmental Language Scales* (2nd edn, rev.). Windsor, England: NFER-Nelson.

Scarborough, H.S. (1990). Very early language deficits in dyslexic children. *Child Development*, *61*, 1728–1734.

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

Shu, H., Meng, X., & Lai, A. (2003). The lexical representation and processing in Chinese-speaking poor readers. In C. McBride-Chang & H.-C. Chen (Eds.), *Reading development in Chinese children* (pp. 199–214). Westport, CT: Praeger Press.

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

Snow, C.E., Burns, S., & Griffin, P. (Eds.). (1998). *Preventing reading difficulties in young children*. Washington, DC: National Academy Press.

Snowling, M.J. (1995). Phonological processing and developmental dyslexia. *Journal of Research in Reading*, *18*, 132–138.

Tan, L.H., Liu, H.L., Perfetti, C.A., Spinks, J.A., Fox, P.T., & Gao, J.-H. (2001). The neural system underlying Chinese logograph reading. *NeuroImage*, *13*, 836–846.

Vogler, G.P., DeFries, J.C., & Decker, S.N. (1985). Family history as an indicator of risk for reading disability. *Journal of Learning Disabilities*, *18*, 419–421.

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

Wimmer, H., & Hummer, P. (1990). How German speaking first graders read and spell: Doubts on the importance of the logographic stage. *Applied Psycholinguistics*, *11*, 349–368.

Wolf, M., & Bowers, P. (1999). The double-deficit hypothesis for the development dyslexia. *Journal of Educational Psychology*, *91*, 415–438.

Yap, R., & der Leij, A. (1993). Word processing in dyslexics: An automatic decoding deficit? *Reading and Writing: An Interdisciplinary Journal*, *5*, 261–279.

Yap, R., & van der Leij, A. (1994). Testing the automatization deficit hypothesis of dyslexia via a dual-task paradigm. *Journal of Learning Disabilities*, *27*, 660–665.

Zimmerman, I.L., Steiner, V.G., & Pond, R.E. (1992). *PLS-3: Preschool Language Scale-3*. San Antonio, TX: The Psychological Corporation.

Manuscript accepted 6 August 2007