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Typical and Dyslexic Development in Learning to Read Chinese

Hua Shu and Hong Li
Beijing Normal University, China

1. Introduction

Compared with research on alphabetic languages, research on reading acquisition and impairment in Chinese has a relatively short history. However, this field has attracted more and more attention, and increasing number of findings have been reported in recent years. In the present chapter, we will firstly describe some important features of the Chinese language, and how these features influence reading acquisition of normal Chinese children. Then, we will summarize a series of studies of dyslexic development in learning to read Chinese, in which the critical deficits for Chinese dyslexic children were identified. Finally, several longitudinal studies will be reviewed, in which the early predictors and developmental trajectories of reading acquisition and impairment in Chinese children were explored.

2. Properties of the Chinese language and the cognitive correlates in reading acquisition of Chinese children

It has long been recognized that phonological skills are highly correlated with reading ability in alphabetic languages (Bradley & Bryant, 1983; Wagner & Torgesen, 1987; Ziegler & Goswami, 2005). In recent years, increasing research evidence has been reported that the contribution of the cognitive skills on reading acquisition is also related to the nature of the orthographies. For example, naming speed (Wimmer et al., 2000) and letter knowledge (Gallagher, Frith, & Snowling, 2000) have been identified to be also the important cognitive correlates of reading acquisition in transparent orthographies.

Chinese is a logographic writing system. The basic units of written Chinese are characters. More than 80% of modern Chinese characters are phonetic compound characters and consist of sub-character components or radicals arranged under the orthographic rules. For example, a compound character (e.g., 盯, /ding1/, *stare*) consists of two parts: one component is called semantic radical (e.g., 目, *eye*), which carries the meaning information of a character, and another component called phonetic radical (丁, /ding1/), which provides the information about pronunciation of a character. The corpus study by Shu, Chen, Anderson, Wu, and Xuan (2003) showed that, in all of the characters taught in elementary schools, about 88% of the compound characters are semantic transparent (e.g. the character妈 (*mother*) is with a female radical “女”) or semi-transparent (e.g. the character猎

(*hunting*) is with an animal radical "犭"). However, only about 39% of the compound characters are regular in pronunciation (e.g., the character 逗 /dou4/ is with the phonetic radical "豆" /dou4/).

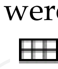
The semantic and phonetic radicals may be further divided into about 600 subcomponents (e.g. 十, 口) which have fixed internal structures. The components or subcomponents are combined to form thousands of characters. Many of the radicals or components have their legal positions within the characters, although others can occur on flexible positions. For example, some components can appear only on the left (e.g. 扌), on the right (e.g. 刂), on the top (艹) or on the bottom (灬) of characters. Awareness of inter-structure and position of components within characters are important in character recognition and it makes relatively greater demands on basic visual or orthographic analysis in Chinese reading. Previous studies have demonstrated that visual skill and orthographic awareness (e.g. Huang & Hanley, 1995; Ho & Bryant, 1997; Ho, Chan, Lee, Tsang, & Luan, 2004; Li, Peng, & Shu, 2006; Li, Shu, McBride-Chang, Liu, & Peng, in press) play significant roles in Chinese reading development. The brain mechanism of orthographic processing in Chinese reading were also reported in the fMRI studies (Liu, Zhang, Tang, Mai, Chen, Tardif & Luo, 2008; Tan, Liu, Perfetti, Spinks, Fox, & Gao, 2001; Wang, Yang, Shu & Zevin, 2011)

The unit of interface between the written word and spoken language in Chinese is *morpheme*. A character corresponds with one syllable and usually represents one morpheme. It makes morphological awareness potentially important in Chinese reading. Morphological awareness in Chinese is suggested to consist of three types of knowledge related to reading (Wu, Packard, & Shu, 2009). First, the fact that there are about 7,000 morphemes but only 1,200 syllables in Mandarin Chinese suggesting that more than five morphemes or characters share one syllable. Therefore the knowledge of homophones becomes important when reading Chinese, in which a reader is required to distinguish the homophone characters which share the same syllable (e.g. /yi4/) but with different morphemes (e.g. 义 *'meaning'*, 易*'easy'*, 亿 *'a hundred million'*, 宜 *'appropriate'*, 益 *'benefit'*, 艺 *'art'*, 议 *'discuss'*, and so on. The second is knowledge of homographs which requires a reader to be aware that a single written character (e.g. 草) may represent different morphemes ('grass' or 'careless'). The different morphemes contribute to the word's meaning when they are in different compound words (e.g. *'grass'* in 草地 *'lawn'* or *'careless'* in 草率 *'cursory'*). The third is knowledge of the morphemic structure of compound words which requires the awareness of the contribution of the individual morphemes (e.g. 飞 *'fly'* and 机 *'machine'*) to the meaning of the whole word (e.g. 飞机, *'airplane'*) . Because of the central role played by the morpheme in Chinese orthography, sensitivity to morphological knowledge is especially important in the development of oral and written vocabulary in Chinese. Morphological awareness is critically important for children learning to read and write, and emerges early and develops with age in preschool children (Chen, Hao, Geva, Zhu, & Shu, 2009; McBride-Chang, Shu, Zhou, Wat, & Wagner, 2003).

Chinese has a relatively simple syllable structure: a syllable consists of an onset and a rime and the combination is regular in spelling; mapping from spelling to sound is syllable-based. However, numerous studies on Chinese children's reading development and impairment have demonstrated that phonological skills, including syllable awareness, onset awareness and rime awareness, are associated with Chinese character recognition (e.g.

Chow, McBride-Chang, & Burgess, 2005; Siok & Fletcher, 2001; Ho, Law, & Ng, 2000). Lexical tone is a fundamental feature of Chinese spoken language in which four tones are used to distinguish meanings that are not differentiated by segmental information. Studies showed that different levels of phonological awareness in Chinese emerge as the results of age or experience. Syllable and rhyme awareness appear to develop naturally with age in preschool children. However, onset and tone awareness appear to depend upon school instruction (Shu, Peng, & McBride-Chang, 2008).

Rapid Automatized Naming (RAN) refers to tasks that require readers to name a list of familiar stimuli as rapidly as possible. RAN tasks were suggested to predict reading better in transparent orthographies than in opaque orthographies. However, recent studies have suggested RAN to be a consistent predictor of Chinese reading development, in which linking printed information with a given phonological representation arbitrarily is important. It predicts reading fluency and accuracy in both typically developing children and dyslexics (Ho & Lai, 1999; Ho et al., 2000; Shu, McBride-Chang, Wu, & Liu, 2006; Lei, Pan, Liu, McBride-Chang, Li, Zhang, Chen, Tardif, Liang, Zhang, & Shu, 2011; Pan, McBride-Chang, Shu, Liu, Zhang, & Li. in press).

To summarize, studies have reported a strong link between phonological awareness and character recognition in Chinese children (e.g., Siok & Fletcher, 2001; Shu et al., 2008). The role of morphological awareness, visual-orthographic skills, and rapid automatized naming in reading acquisition and impairment has also been demonstrated (e.g., Ho et al., 2004; Shu et al., 2006). What assessments can best examine those cognitive skills and are most sensitive to differences in reading ability at different stages of development? Li et al., (in press) administered 184 kindergarten children at age 5 to 6, and 273 primary school children at age 7 to 9 from Beijing with a comprehensive battery of tasks, including those for visual-orthographic, phonological, morphological skills, rapid automatized naming abilities, and Chinese character recognition skills, in order to explore the cognitive correlates which can better predict Chinese reading acquisition across preschool and early grade levels. Visual Spatial Relationships and Visual Memory subtests were administered to test children's visual skills. An orthographic judgment task was created to measure orthographic awareness of Chinese children, in which children were asked to judge 4 types of critical items, including black and white line drawings (e.g. ), ill-formed structure with radicals in the illegal positions (e.g. ) , ill-formed components (e.g. ), and well-formed structure pseudo-characters items (e.g. ). Phonological awareness contained syllable deletion, rime detection, and phoneme deletion. Three tasks were designed for measurement of morphological awareness, specifically for knowledge of compound words, knowledge of homophones, and knowledge of homographs. The morphological construction task aims to test if children are able to decompose a compound word (大红花, *big red flower*) into morphemes (大 *big,* 红 *red,* 花*flower*) and construct a new compound word based on the new morphemes (e.g. "If a big flower that is red in color is called "大红花, *big red flower*", what should we call the big flower that is blue?" The correct answer is "大蓝花, *big blue flower*"). The homophone judgment task aims to test if children can distinguish the morphemes with the same sound but different meanings based on the compound word context. For example, the second syllable of the words "蛋(*egg*)糕(*cake*), /dan4-gao1/, *cake*" and "跳(jump)高(high), /tiao4-gao1/, *high jump*" share the same sound /gao1/ but with different meanings "糕, *cake*" and "高, *high*". Children were asked to judge "If the compound words 蛋糕 /*dan4 gao1*/ and 跳高 /*tiao4 gao1*/ share the same morpheme /gao1/?" The correct answer is "No". Morpheme production task aimed to test if children can distinguish homographs, that is, the morphemes with same character and same sound, but with different meanings based on the compound word context. For example, the morpheme "明"in word "明(next)天(day), /*ming2 tian1*/, *tomorrow*" and"明(bright)亮(light), /*ming2 liang4*/, *brighten*" share the same character and same sound, but with the different meanings 'next' and *'bright'*. In the task, the experimenter spoke a word (e.g. "明(next)天(day), /*ming2 tian1*/, *tomorrow'*) to children. Children were asked to produce two compound words containing the same character and sound but with different morphemes (homograph). The possible correct words are 明(next)年(year) /*ming2 nian2*/*'next year'* with the morpheme *'next'* and 明(bright)亮(light) /*ming2 liang4*/, '*brightness'* with the morpheme *'bright'*).

Regression analyses indicated that only syllable deletion, morphological construction, and speed number-naming were unique correlates of Chinese character recognition in kindergarten children. Among primary school children, the independent correlates of character recognition were rime detection, homophone judgment, morpheme production, orthographic knowledge, and speed number-naming. Results confirmed that phonological awareness, morphological awareness and speed naming are important in explaining character recognition for both kindergarten and lower grade primary school children. Orthographic awareness becomes significant to character recognition of school children as they learn to read. It is important to choose tasks which are suitable for the age of children that are being tested, since some tasks are sensitive to a wide range of ages, while others are more age-specific.

3. Chinese children with dyslexia and its early prediction

3.1 The characteristics and core deficits of Chinese children with dyslexia

About 5%-10% of school-aged children, in any language, have a persistent difficulty in learning to read that could not be explained by sensory deficits, low general intelligence, poor educational opportunity, or lack of motivation (Fisher, DeFries, 2002; Shaywitz, Shaywitz, Fletcher, Escobar, 1990). However, for a long time developmental dyslexia was believed to be a problem that exists only in western languages, since the strong assumption that phonological awareness has a major impact on the acquisition of literacy only in alphabetic languages. Since Stevenson, Stigler, Lucker, Lee, Hsu, and Kitamura (1982) first found that the prevalence of dyslexia among American, Japanese and Chinese children is comparable, a great number of studies in Hong Kong, Taiwan and Mainland China have congruously reported that between 5% and 10% of school-aged children in Chinese were dyslexic in the past years (Zhang, Zhang, Yin, Zhou, & Chang, 1996; Yin and Weekes, 2003). Research has revealed that, just like in alphabetic languages, dyslexic children in Chinese mainly suffered from the accuracy and speed of word reading and spelling, so that reading measures widely used in distinguishing dyslexic from normal children are single character or word recognition measures ((Ho, et. al, 2002, 2004; Meng, Shu & Zhou, 1999; Shu, Wu, McBride-Chang, 2006).

According to the dual-route model of reading, mapping from print to sound is achieved through at least two pathways, a lexical semantic route and a nonsematic GPC route (Coltheart, Rastle, Perry, Langdon & Ziegler, 2001). Yin and Weekes (2003) proposed a framework for understanding acquired and developmental dyslexia in Chinese derived from a cognitive neuropsychological account of reading and writing Chinese. Their model assumes that normal oral reading in Chinese depends on a division of labor between the lexical semantic pathway and a nonsemantic pathway. Impairment to the lexical semantic pathway will result in acquired surface dyslexia, while impairment to the nonsemantic pathway results in deep dyslexia. In a case study, Shu, Meng, Chen, Luan, and Cao, (2005) reported two types of dyslexic children, surface and deep, who showed the impairment in different pathways. Two dyslexic children, Child-L and Child-J, were tested by a word recognition task, in which they were asked to name a character and then to compose a compound word based on the target character. It was found that Child-L, identified as 'surface dyslexic', could correctly pronounce many of regular characters but made many regularization errors in irregular character naming. And Child-L also made many homophone errors when he composed a compound word based on the target character. According to Hillis and Caramazza (1995), the information from semantic-lexical and OPC routes integrate to provide the constraint for the selection of word pronunciation. For a Chinese reader, a compound character 拦 /lan2/*'obstruct'*may active a set of homophone characters /lan2/, and also active the characters with the meaning related with *'obstruct'*. The correct pronunciation and meaning of the character will be accessed with the two pathways. However, Child-L could correctly pronounce a target character (e.g. 拦 /lan2/) based on its phonetic cue (e.g. 兰 /lan2/), but he could not access the semantic information of the character. Then he composed a wrong compound word 篮子 /lan2 zi/, *'basket'* with a homophone character 篮 /lan2/, as illustrated in Figure 1. It suggests that as a surface dyslexic, Child-L normally developed the nonsemantic or sublexical route so that he could utilize phonetic radical information in character naming. But his semantic pathway was developmentally delayed or deficient.

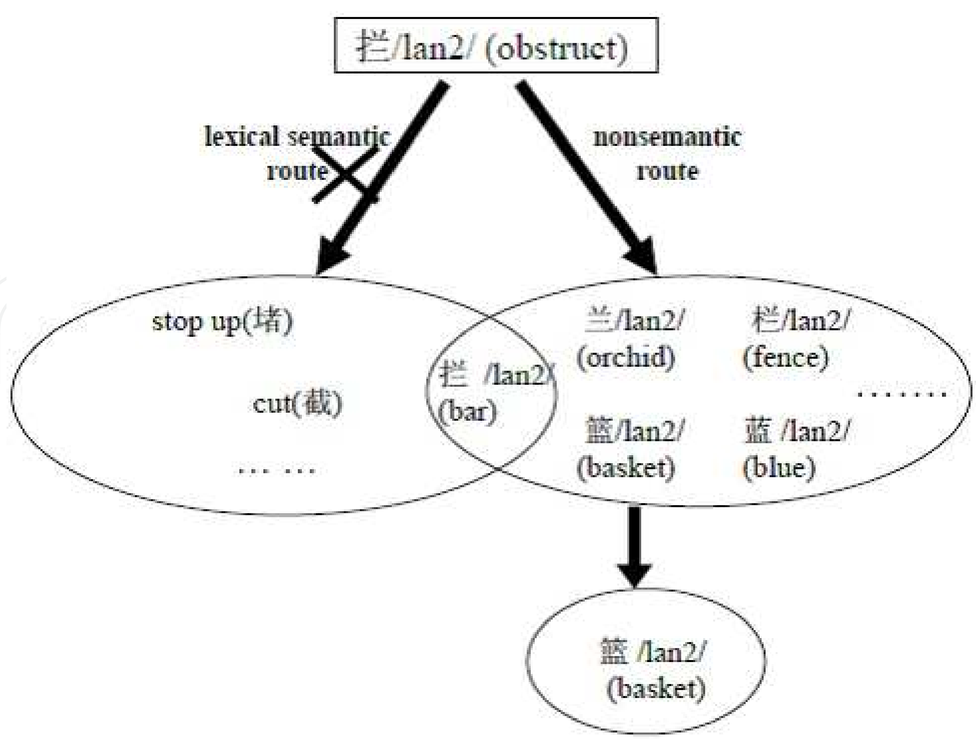


Fig. 1. An example of reading model for surface dyslexic Child L

In contrast, Child-J, identified as 'deep dyslexic', made a relatively large percentage of semantic related errors (26%) in pronunciation. For example, he named the character 煎 /jian1/ *'fry'*, which is with the phonetic 前 /qan2/, as 炖 /dun4/ *'braise'*, a character which is semantically related with the target character煎*'fry'*, but with the phonetic 屯 /tun2/. He composed a compound word炖肉 /dun4-rou4/ *'stew'*, (see Figure 2). It is clear that he ignored the phonological information provided by the phonetic 前 /qan2/ of the target character煎 /jian1/, but accessed the meaning of the target 煎*'fry'* and also the characters with the meanings related with *'fry'* were activated. Child-J's performance showed the characteristics of deep dyslexia. That is, his nonsemantic pathway was developmentally delayed or deficient, but his semantic pathway was relatively normal.

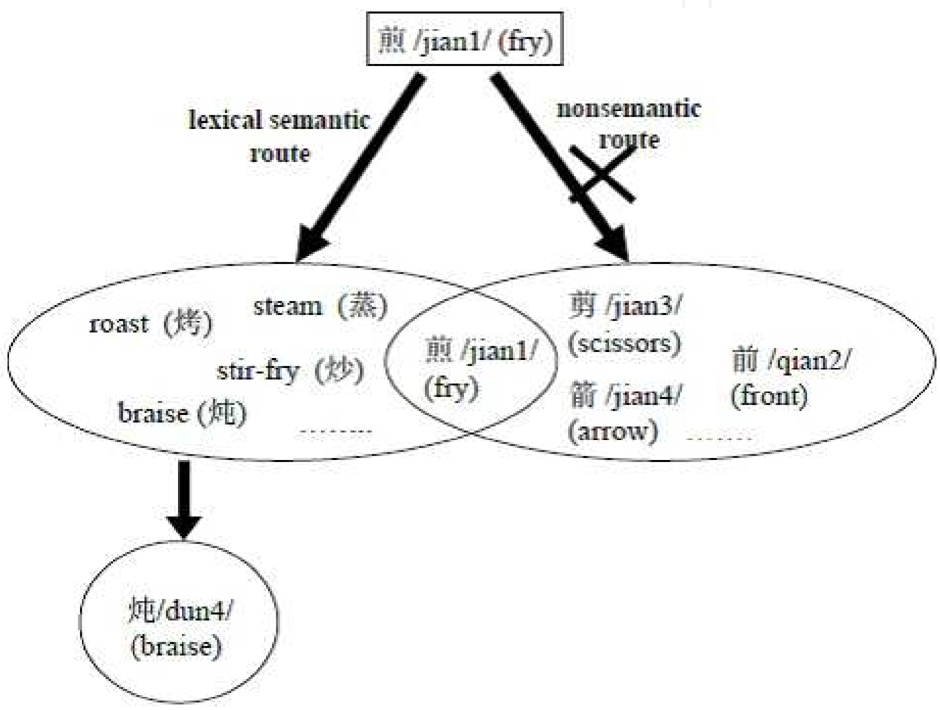


Fig. 2. An example of reading model for deep dyslexic Child J

The resulting patterns of the two children support the framework proposed by Yin and Weekes (2003) that surface dyslexia (Child-L) may be explained by developmental delay or deficit in the *semantic* pathway and deep dyslexia (Child J) can be explained by delay or deficit in the *nonsemantic* pathway in reading acquisition. The impairment in different pathways could explain the fact that child L could not distinguish the target from homophone characters, and child J could not utilize sublexical phonetic information in pronunciation. The response patterns of the dyslexic children were simulated and confirmed by the results from a triangle model in Chinese (Yang, McCandliss, Shu, & Zevin, 2008).

Phonological deficit has been treated as the main cause of developmental dyslexia and sufficient to explain poor reading performance in alphabetic languages (Bradley & Bryant, 1983; Ramus, 2003; Snowling, 2000; Ziegler, Bertrand, Tórth, Csépe, Reis, Faísca, Saine, Lyytinen, Vaessen, & Blomert, 2010). However, the important links of cognitive skills with reading success and failure vary across orthographies (Ziegler & Goswami, 2005; Lyytinen, Erskine, Tolvanen, Torppa, Poikkeus, & Lyytinen, 2006). What are the core deficits for dyslexic children in Chinese?

Research has revealed that phonological, naming-speed and orthographic deficits are important features in Chinese dyslexic children. Testing 147 Hong Kong children with dyslexia on a number of literacy and cognitive tasks, Ho, et al. (2004) found that rapid naming deficit (57%) and orthographic deficit (42%) were the most dominant types of cognitive deficits in Chinese developmental dyslexia, while the relatively small proportion of dyslexic children has phonological deficits (29%) and visual deficits (27%).

Shu, et al. (2006) specifically examined the role of morphological skills in Chinese dyslexia besides other cognitive skills. Comparing 75 dyslexic with 77 normal children from primary schools in Beijing, the study systematically examined their literacy skills (character naming, reading comprehension, and dictation), linguistic and nonlinguistic cognitive skills with morphological awareness, rapid naming, phonological awareness, verbal short-term memory, lexical vocabulary, visual spatial test, articulatory rate, visual attention and nonverbal short-term memory tasks. In the logistic regression analysis, dyslexic children were found to be best distinguished from age-matched controls with tasks of morphological awareness, speeded number naming and vocabulary skills, while performance on tasks of visual skills and phonological awareness failed to distinguish the two groups. Path analysis revealed that phonological awareness, morphological awareness and rapid naming were all uniquely associated with the three literacy tasks: character recognition, reading comprehension and dictation. Based on the same data, Wu (2004) further found that, compared with phonological (53%) and speed (45%) problems, the largest proportion (96%) of dyslexic children had morphological problems. Figure 3 shows all the children with dyslexia grouped by their deviant performance on the different tasks.

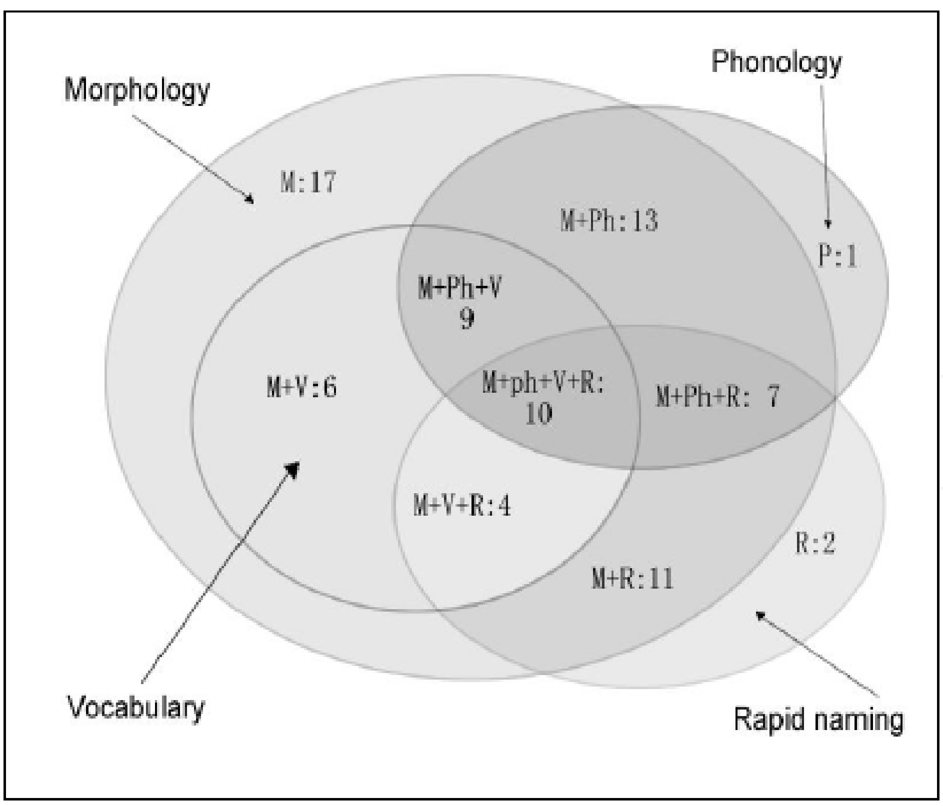


Fig. 3. Classification of dyslexic outliers by morphology, phonology, vocabulary and rapid naming. (from Wu, 2004).

The significance of morphological awareness was supported in a following study in which children with and without dyslexia were tested on the tasks including paired associative learning (visual-visual and visual-verbal PAL), phonological awareness, morphological awareness, rapid naming, verbal short-term memory and character recognition. The logistic regression demonstrated that morphological awareness, rapid naming and visual-verbal PAL uniquely distinguished children with and without dyslexia, even with other metalinguistic skills controlled (Li et al., 2009).

Researchers found that Chinese children with dyslexia tend to possess more than one kind of cognitive deficits. Ho, et al. (2002) reported that 20% of the dyslexic children have only one deficit and about 50% of dyslexic children possess more than two deficits. In Wu, et al. (2009) study, the results further confirmed that 24% of the dyslexic children were found to have only one deficit and about 80% of dyslexic children possessed more than one deficit.

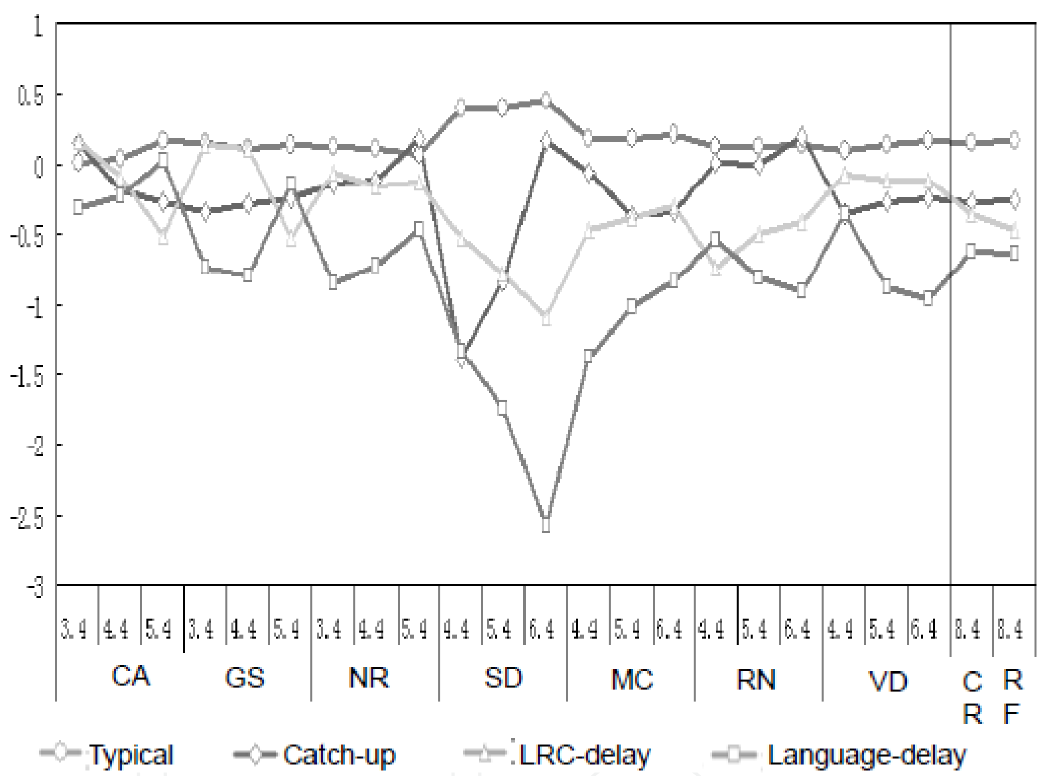
3.2 Early prediction of reading acquisition and impairment

Dyslexia has been defined as a developmental disorder starting at childhood. Many factors interact to shape children's language and reading development before they start school. However, dyslexic children usually are diagnosed after they failed in learning to read at school. Could children with reading difficulties at school be identified at an earlier stage? Longitudinal research provides the best way to understand early prediction of reading acquisition and impairment. Longitudinal studies in alphabetic languages have revealed that slow vocabulary development, language grammatical skills, phonological awareness, rapid naming, and letter knowledge begin to differ between children with and without risk for dyslexia around 3 or 4 years old (Lyytinen et al., 2006). Research even reported that ERP response to speech sound at 6 month discriminated infants with familial risk for reading disorder at age 8 (Leppänen, Richardson, Pihko, Eklund, Guttorm, Aro, & Lyytinen,, 2002). What are the most effective early predictors for reading development and impairment in Chinese? Are we able to identify latent poor readers from early indicators?

In recent years, several studies explored those questions through longitudinal studies. Liu, McBride-Chang, Wong, Tardif, Stokes, Fletcher, and Shu (2009) investigated the extent to which language skills at ages 2 to 4 years could discriminate Hong Kong Chinese poor from adequate readers at age 7. It was found that children's performance at age 2 in vocabulary knowledge, at age 3 in Cantonese articulation, and age 4 receptive grammar skill, sentence imitation, and story comprehension can best predict the word recognition performance between the poor and adequate readers at age 7.

McBride-Chang, Lam, Lam, Doo, Wong, and Chow (2008) found that the group of Hong Kong children with a genetic risk for dyslexia showed particular difficulties in lexical tone detection, morphological awareness, and Chinese word reading, whereas the language delayed group performed more poorly in all tasks administered. Their follow-up study (McBridge-Chang, et al., 2011) further reported that 62% of the children with an early language delay subsequently manifested dyslexia and 50% of those with familial risk become dyslexic at school. The deficits which best distinguish dyslexic from nondyslexic children at age 7 were morphological awareness, rapid automatized naming, and word reading at age 5, suggesting that rapid automatized naming and morphological awareness are relatively strong correlates of developmental dyslexia in Chinese.

Lei et al. (2011) reported a 10-year longitudinal study in Beijing which revealed the dynamic change of reading disabled children and their heterogeneous characteristics in development. 261 children were followed from 3 to 8 years old. They were administered 7 language and cognitive skills (Compound awareness, Grammatical skill, Nonword repetition, Syllable deletion, Morphological construction, Rapid automatized naming, Vocabulary definition) between ages three and six, and then literacy skills (Character recognition, and Reading fluency) were tested at age eight. Individual differences in developmental profiles across tasks were estimated using growth mixture modeling which identified not only the important early predictors but also different subgroups with different developmental trajectories. The results showed that there were four developmental trajectories from ages three to six years and two of them were identified as poor readers (see Figure 4).



Note: CA-Compound awareness, GS-Grammatical skill, NR-Nonword repetition, SD-Syllable deletion, MC-Morphological construction, RN-Rapid automatized naming, VD-Vocabulary definition, CR-Character recognition, and RF-Reading fluency (from Lei, 2008).

Fig. 4. Subgroup members' average performance in the seven skills and in reading.

The initial level and subsequent growth on three deficits together (phonological awareness, morphological awareness and rapid naming) from age three to six were best to predict their reading difficulties at age eight. Early language deficits in addition to a combination of deficits in phonological awareness, morphological awareness, and rapid naming might lead to more severe reading problems for Chinese children. The results from the longitudinal study support those from dyslexic and control group comparison studies (e.g., Shu et al., 2006), suggesting that phonological awareness, morphological awareness, and rapid naming should be simultaneously considered in Chinese, given the use of broad skills required to learn to read this orthography.

4. Conclusions

In summary, the research confirmed some universal aspects of reading acquisition in alphabetic languages and in Chinese. Just like in alphabetic languages, Chinese children with dyslexia have mainly deficits in the accuracy and speed of character or word recognition. Mastery of a writing system depends upon acquiring an adequate phonological knowledge of the language, especially in early age. Phonological awareness and naming-speed are the two deficits shared by both dyslexic children in Chinese and in alphabetic languages. The specific aspects of reading acquisition in Chinese are related with the characteristic of Chinese language and orthography. It makes morphological and orthographic awareness particularly important to consider in understanding Chinese reading development and dyslexia. Furthermore, most of Chinese children with dyslexia tend to have more than one kind of cognitive deficits. The longitudinal studies reveal that it is possible to identify the school-age poor readers from early stage. The effective predictors include phonological awareness, morphological awareness, rapid naming and oral vocabulary.

In the future, more basic research is needed in order to understand further the cognitive causes of reading failures of Chinese children and the underlying brain mechanism.

Although it has not been discussed in this chapter, systematic work is also needed to explore the role of family and education environment on children's reading acquisition and dyslexia; With family's support and better education environment, more effective assessments could be developed, and early predictors for which children with dyslexia or children at risk for dyslexia could be identified; and in turn better intervention programmes for both preschool and school children could be developed, which could improve dyslexic children's reading ability and reduce the risk of the reading failures.

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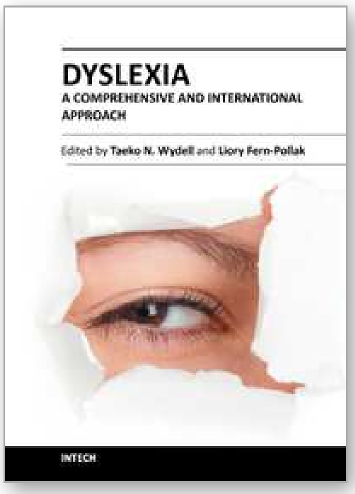

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This book brings together dyslexia research from different perspectives and from different parts of the world, with the aim of providing a valuable source of information to medical professionals specializing in paediatrics, audiology, psychiatry and neurology as well as general practitioners, to psychologists who specialise in developmental psychology, clinical psychology or educational psychology, to other professions such as school health professionals and educators, and to those who may be interested in research into developmental dyslexia. It provides a comprehensive overview of Developmental Dyslexia, its clinical presentation, pathophysiology and epidemiology, as well as detailed descriptions of particular aspects of the condition. It covers all aspects of the field from underlying aetiology to currently available, routinely used diagnostic tests and intervention strategies, and addresses important social, cultural and quality of life issues.

InTech Europe
University Campus STeP Ri
Slavka Krautzeka 83/A
51000 Rijeka, Croatia
Phone: +385 (51) 770 447
Fax: +385 (51) 686 166
www.intechopen.com

InTech China
Unit 405, Office Block, Hotel Equatorial Shanghai
No.65, Yan An Road (West), Shanghai, 200040, China
中国上海市延安西路65号上海国际贵都大饭店办公楼405单元
Phone: +86-21-62489820
Fax: +86-21-62489821