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Chinese Language and Remediation Support for Children with Dyslexia in Singapore

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Abstract

The research presented here is targeted towards a better understanding of how students with dyslexia learn Chinese language as a second language. The research and development consisted of a preliminary survey and two studies, to identify difficulties that are unique to dyslexia in learning Chinese and develop an effective intervention programme that caters to the needs of students. The first study identified significant impairments in visual processing in children at high risk of dyslexia, associated with significant deficits in phonetic decoding, in a sample of 45 nine-year-old children including students drawn from the Dyslexia Association of Singapore (DAS) and matched controls. The insights from this study were used to develop an intervention programme in the second study, where significant improvements in targeted skills were found for 16 children aged six to twelve. Implications for further development are discussed.

INTRODUCTION

Dyslexia and Chinese language

Dyslexia is believed to be a universal language learning disability that varies across different languages, depending on the diversity of the writing systems. Most of the studies on dyslexia and reading development derive from English speakers with attempts to generalise these findings and theories or models to other alphabetic languages (Brunswick, 2010). Some researchers have found that dyslexia varies across languages and the differences can be due to different characteristics of the languages (Cell Press, 2009; Hu et al., 2010). Goswami

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(2010) indicated that many cross-language studies show more similarities in phonological awareness because of the psycholinguistic grain-size theory – whereby the grain size of syllable and onset-rime were found to be similar universally, while the grain size of phoneme was found to be dependent on the language-specific orthographic effects on reading acquisition. Alphabetic writing systems such as Italian, German and English represent phonemes more consistently than others, as there is more direct mapping of letters to speech sounds, compared to logographic or syllabic writing systems that have larger phonological granularity, such as Japanese, Korean and Chinese. Therefore, dyslexics in all languages seem to experience phonological deficits – a common neuro-anatomical origin, and the extent to which language acquisition is impacted depends on the depth of the orthographies, because they also tend to have difficulty with the written forms of words – orthography (Brunswick, 2010).

While there is an universal large-to-small phonological development across languages seemingly shaped by the orthographic structure of the native language (Duncan, 2010), Hu et al. (2010) found that both Chinese and English dyslexics have notably similar areas of brain activation which are responsible for semantic processing of orthography and these activations are culturally independent. This shows that there is a common pattern in the neural mechanism impacting their phonological, verbal and/or visuo-spatial working memory processes. They further found that the slight difference in brain activation for both groups of normal readers indicated that Chinese language processing require greater reliance on visuo-spatial memory – a neural processing of perceptual information uniquely for Chinese language learners.

Additionally, Cell Press (2009) cited researchers, Siok and Tan, that the visual cognitive system is activated to perform a fine-grained visuo-spatial analysis on the Chinese characters' phonological and semantic information. Thus, Chinese dyslexics may have disordered phonological processing that commonly coexists with abnormal visuo-spatial processing ability, as compared to English dyslexics. Ho and Fong (2005) found high concomitance of reading difficulties in both Chinese and English languages, with phonological deficit (especially phonemic awareness) more specific to English reading and visual-orthographic deficits more specific to Chinese reading and rapid naming deficit as a common cause in both languages. Similarly, Chung and Ho (2010) found that Chinese-English learners with dyslexia generally have weak rapid-naming, visual-orthographic knowledge, and phonological and morphological awareness in both languages, with phonological difficulties relating less to Chinese language than English language. Furthermore, their results also suggested that naming speed is a general form of processing skill common for any language script but other metalinguistic processes may be specific for each language acquisition. However, in both studies, the transference of processes was investigated on Chinese as a first language and English as a second language, and thus, one might question whether such transference is bidirectional.

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Variation between languages was found by Comeau, Cormier, Grandmaison and Lacroix (1999) who developed a model of three intercorrelated domains of phonological awareness, phonological access in lexical entry and phonological processing in verbal working memory. Although the Chinese language is not an alphabetic language, their findings provided evidence for cross-language transfer of phonological awareness, suggesting that phonological awareness in the native language is strongly related to successful acquisition of second language. McBride-Chang (2011) highlighted the similarities and differences in language transfer between native language and second languages, and found that the overlap of metalinguistic skills between Chinese-English learners was roughly 32-37% while Spanish-English learners was roughly 50% or more. That means, although metalinguistic skills transfer across languages, variations in the transfer are difficult to estimate due to the diversity in the orthographic nature of different languages (Koda, 2011). Therefore, with a deficit of phonological cognitive processing, dyslexics would very likely face difficulties in language learning in general.

Although it has been claimed that incidence of dyslexia will be low in languages which are transparent and with coarse granularity in their phonology (Brunswick, 2010), the challenge faced by dyslexics to overcome language difficulties is much greater and more complex for opaque languages regardless of coarse or fine phonological granularity (i.e. English and Chinese). English is an atonal alphabetic language and its letter-sound relationship makes pronunciation of visual words possible. By contrast, Chinese is a tonal language that contains single or multiple syllables in a single or multiple morphemic characters in a morphographic script (Yin & Weekes, 2004). English language adopts an alphabetic writing system (i.e. 'sounding out' of individual letters) while Chinese language adopts a logographic writing system where most of the characters contain a semantic element to provide the meaning and a phonetic element to provide the pronunciation. Thus the Chinese language is linguistically more opaque than the English language, despite both having deep orthographies (Brunswick, McDougall & de Mornay Davies, 2010). The Chinese language is also considered to have a morphosyllabic writing system because the majority of the characters can be represented as a morpheme – the smallest pronounceable unit is also associated with meaning, making the script morphographic (Shu, Meng, Chen, Luan & Cao, 2005).

The characters in the Chinese language have been classified into six kinds (McNaughton & Li, 1999; Lee, 2008; Han, 2008). The simpler form of Chinese characters derived from the objects they describe (Ning, 2001), such as "人" which looks like a stick drawing of "man", then followed by Chinese characters in symbolic forms (McNaughton & Li, 1999), such as "一、二、三" for "one, two, three". The other four are meaning-compounds such as "日" [sun] + "月" [moon] = "明" [bright], phonetic-loans such as "足" /zú/ which has both meanings of "feet" and "sufficient", semantic-phonetic-compounds such as "女" [girl] + "家" [house] = "嫁" [being

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married], and mutually-interpretive forms such as "乐" which means "music" and "enjoyment".

With Chinese language being a logographic and morphosyllabic language, unlike the English alphabetic language, it is believed that other cognitive abilities than phonological deficits would affect language acquisition, especially visual perceptual skills. The Chinese script can have many homophones that are visually-dissimilar, as well as visually-similar characters that are not homophonous, which can be difficult to know if a radical is phonetic or semantic (Su, Klingebiel & Weekes, 2010). Knowing how to read a Chinese character correctly requires a learner to know the pronunciation as a whole, and knowing how to write a Chinese character correctly requires a more complicated set of processes to understand both phonetic and semantic information to differentiate the characters.

Ho (2003) investigated the cognitive deficits in Chinese dyslexics which provided more clues to the cognitive processes underlying reading and writing Chinese language, namely visual skills, phonological skills, phonological awareness, phonological memory, and phonological retrieval. There have been greater emphases on the phonological aspects of Chinese language which affect reading accuracy (e.g. Ho & Lai, 1999; Ho & Ma, 1999; Meng et al., 2005). Studies have demonstrated that training in phonological strategies did show improvement in Chinese dyslexic children's character reading skills, but only for phonologically regular characters, not the irregular ones (Ho & Ma, 1999; Ho, 2003). Phonologically regular characters contain phonetic radicals to give a clue on how to pronounce it, but phonologically irregular characters do not produce sounds that are similar to their phonetic radicals (e.g. "理" /lǐ/ is pronounced the same as "里" /lǐ/ in it, but "埋" /mái/ is pronounced differently). Additionally, although there have been many fewer brain studies on Chinese dyslexics, there has been evidence of lower activation in brain areas responsible for lexical and phonological processes, similar to English dyslexics (Cao, 2011).

McBride-Chang et al. (2011) have demonstrated a broad array of metalinguistic and cognitive skills that are important for learning Chinese language and proposed that although phonological sensitivity is developmentally vital for learning to read Chinese characters, because of the unreliable phonological cues to Chinese words, it may be essential to look at other indicators of reading acquisition, such as morphological awareness and visual skills. Morphological awareness is seen as important for learning Chinese as a heritage language, because many characters are formed by two or more graphic components and can be combined to form new words (Koda, 2011). McBride-Chang (2004) discussed how morphological awareness and morphological instruction may help children in learning to read, especially in languages that have orthographic patterns, like Chinese. Children with dyslexia are also found to perform poorly on tone detection, morphological awareness and word recognition, and tests of tone detection and morphological

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awareness are proposed to be the clinical assessment tools to detect children who are at risk of reading problems in Chinese (McBride-Chang et al., 2008). However, this proposal and discussion are based on traditional Chinese script that contains more complex visual features and stroke patterns but with greater retention of semantic association. Thus, McBride-Chang (2004) also concluded the importance of visual and orthographic skills in reading and writing Chinese characters, whereby serial visual memorisation may be required to focus on visual details and shape constancy of stroke patterns. McBride-Chang et al. (2010) suggested the possibility of simplified script making greater demands on basic visual attention and perception in beginning readers when another study showed that mainland Chinese students were stronger than those from Hong Kong in terms of their visual skills (McBride-Chang, Chow, Zhong, Burgess and Hayward, 2005). This could be because characters in the simplified script have less strokes, resulting in less points of distinction.

Other studies, though comparatively fewer, investigated visual skills in relation to reading and dyslexia, and suggested the importance of visual skills in successful Chinese language acquisition (e.g. Woo & Hoosain, 1984; Huang & Hanley, 1995; Ho & Bryant, 1999; Siok & Fletcher, 2001). Because graphic componential complexity is the distinct feature in Chinese characters, visual recognition of the character components for analysis and identification as a phonetic and semantic function is found to be of great importance (Feldman & Siok, 1997). Ho and Bryant (1999) examined three different visual skills in reading of English and Chinese words, due to the presence of differential processing demands on different orthographies, and found visual constancy of shape to be the strongest predictor of Chinese reading performance while visual figure ground and visual-spatial skills reliably predicted English reading performance. McBride-Chang, et al. (2005) also investigated three visual skills (i.e. visual discrimination, visual-spatial and visual closure) in reading two different Chinese scripts and found visual-spatial skill to have the strongest association with both scripts. According to their findings, visual-spatial skill is a good predictor of Chinese reading acquisition in inexperienced Chinese readers, such as dyslexics and second language learners.

For orthographic structure awareness, Yeh and Li (2002) considered three aspects of Chinese character which are the radical, the phonetic and the structure, and for structure, they specified three main types which are horizontal, vertical d bounded. For example, the structures can be in the shapes of  ,  ,  ,  and  (谢, 2002). The most dominant orthographic structure of Chinese characters in the Chinese language was found to be the semantic-phonetic horizontal-type structure (Bai & Schreuder, 2011). However, within the structure, there is a need for visual recognition and orthographic knowledge to identify the types of radicals in order to process the Chinese character. Semantic radicals provide the meaning information of the character that represents and phonetic radicals provide

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the pronunciation needed to read the character, which could be similar to the grapheme-phoneme correspondences applied in alphabetic languages, such as English (Zhou & Marslen-Wilson, 1999).

Ho, Chan, Tsang and Lee (2002b), and Ho, Chan, Tsang and Lee (2004) demonstrated a subgroup of Chinese dyslexics who had greater visual-orthographic difficulties than phonological processing deficits, and Chung et al. (2008) found that visual temporal processing is likely to be associated with Chinese character recognition. Similarly to Ho et al. (2002b) and Ho et al. (2004), Chung, Ho, Chan, Tsang and Lee (2009) found five reading-related cognitive skills that could be necessary for Chinese language acquisition, in their comparison study on Chinese dyslexics and normal readers: (1) visual-orthographic awareness, the most predominant characteristic, on the knowledge of orthographic structure and implicit knowledge of radical positions in Chinese characters, (2) rapid naming, the second most dominant skill, reflecting abilities in phonological representations, automatic processes of extraction and induction of orthographic patterns, and lexical access, (3) morphological awareness, the third dominant skill, in morphemic identification, discrimination, manipulation and generalisation based on understanding of radial roles and morphological relations, (4) verbal memory for short-term storing of phonological information and making associations between visual symbols, speech sounds and meaning, and (5) phonological awareness, being the least common, due to the lack of a phonemic coding system in the Chinese language.

Furthermore, they have confirmed that developmental dyslexia in Chinese could not be outgrown, just as it has been claimed as a persistent difficulty in all language, but problems in visual-orthographic knowledge and rapid naming might have greater effect than phonological skills on language learning.

Chinese language acquisition in Singapore

Singapore is a culturally diverse and a highly reported multilingual society. The resident population is made up of Chinese (74.2%), Malay (13.3%), Indians (9.1%) and other races (3.3%) (Singapore Department of Statistics, 2013). This makes it the only Asian country outside of China where Chinese is the predominant race (王 & 余, 2007). As a result of the bilingual language policy, Singaporeans grow up in a very diverse linguistic environment with English as an alphabetic language, Chinese as a logographic language, Malay as a Roman alphabetic language and Tamil as a syllabic Brahmi language (Curdt-Christiansen, 2011).

The bilingualism policy, especially with its promotion of Chinese language among Singaporean Chinese, is associated with the rise and success of China that presents many economic opportunities for bilingual Singaporeans (Lee, 2012). Thus, Singapore adopts the same simplified Chinese writing system as China, and 'hanyu pinyin' phonetic symbols in its bilingual educational programme. As such, the medium of instruction in schools became English and their ethnic language was learned as Mother Tongue, a second language, as part of the

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curriculum. The reason for making the learning of mother tongue language mandatory was to preserve ethnic identity, which is characteristic to Singapore.

With English language as the major medium for educational and social communication, Singaporean Chinese children found the Chinese language difficult and less interesting to learn, which in turn decreased their motivation and willingness to learn their 'Mother Tongue' (刘, 吴 & 张, 2006). Thus, in 2007, the Ministry of Education made changes to the Primary School syllabus for Chinese and Higher Chinese subjects, with the main objective of promoting efficiency and practicality in the use of the Chinese language in Singapore (王, 2010). The Chinese Language Curriculum and Pedagogy Review Committee (2004) changed the educational focus on developing listening, speaking and reading skills, so as to facilitate an easier alternative to learning Chinese language and characters (cited in Zhang & Liu, 2005). Currently, Chinese language is taught as either a standard subject or foundation subject to match the varied abilities of the children, and to ensure that all children are given educational access to their 'Mother Tongue' in the curriculum (Ministry of Education [MOE], 2014). Furthermore, it was also found that implementation of student-centered teaching through use of 'hanyu pinyin' in early literacy, technological intervention tools and contextual-based verbal discussions could be a successful approach for children learning Chinese as a second language in Singapore (Zhang & Liu, 2005; 刘 & 赵, 2007).

The learning of mother tongue language begins as early as nursery (three years old) and spans the secondary school years and for some, till the end of their pre-university education. At upper primary school and secondary school levels, students are streamed into three main categories for learning Chinese as a language subject – namely, Standard Chinese, Higher Chinese and Foundational Chinese (MOE, 2014). Students diagnosed with dyslexia are allowed to be exempted from the studying of their mother tongue language upon recommendation of educational psychologists on the basis of their difficulty in learning English (Liew, 2011), the most important language of communication in Singapore. However, some would still cope with two languages in school till upper primary levels because of the societal pressures of living in a multilingual society (Dixon, 2005).

In Singapore, if the child's parents do not speak in Chinese at home with the child, the child only receive six hours of input in Chinese a week from mother tongue lessons. The number of hours of instruction progressively decrease as the child grows older to as low as 2.5 hours per week for students learning the language at the foundational level. Thus, the bilingual education policy adopted in Singapore has put many Chinese children in a very unique position from other Chinese children of countries where Chinese language is the first language, such as China, Taiwan and Hong Kong. Due to the differences in linguistic environment, students in these countries receive much more exposure to the language in daily usage with Chinese the only language spoken in their society. Chinese language

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in Singapore is considered a second language, despite being the native language for Chinese ethnics, while English language is considered the first language and medium for societal communication and school instruction (Lee, 2012). Thus, this has provided our dyslexic Chinese children an even more perplexed situation for acquisition of both languages.

Empirical motivation of the Research

Therefore, the research study covered two phases that aim to investigate whether visual perceptual abilities do play an important role in the learning of Chinese language, especially in Singapore's context and despite the presence of dyslexia as a learning difference. It also hopes to develop a remediation programme for Chinese language that caters to the unique profile of children with dyslexia learning Chinese language as a second language in Singapore. As there have not been any literacy assessments for or literature on Chinese literacy skills of Chinese children in Singapore, this would be also be another interesting exploration of the appropriateness of newly created or adapted Chinese literacy assessments for Singaporean bilingual children in assessing their literacy skills. Thus, it is also an exploratory study to validate this battery of tests of Chinese literacy skills to examine differences in Chinese literacy skills between dyslexic and non-dyslexic children, as well as to profile literacy needs of dyslexic children when learning Chinese language.

Preliminary Survey

In 2009, the team conducted a preliminary survey with over 400 parents of our dyslexic students at the DAS. The survey aimed to find out more about the struggles of our students as well as the kind of support they are receiving, before conducting the research study. A random sample of the surveys (n = 160) showed that almost half of our students had no support or remediation in Chinese, about 85% of them did not speak Mandarin as Home Language and about 75% of the parents were interested in Chinese classes. At the same time, the survey showed that our students had difficulties across most aspects of the language, including basic reading and spelling of Chinese characters, as well as comprehension of Chinese passages and oral skills. Some parents also provided feedback that their children lack interest and/or motivation in learning Chinese.

With the survey results in mind, the team conducted a research study in 2010 and 2011 with the aim to better understand the difficulties our dyslexic students face in learning Chinese and whether visual perceptual ability affects the learning of Chinese characters. The study was conducted with 95 Primary Four students, from the DAS as well as mainstream primary schools. The study included a selection stage where students were screened using the LUCID Rapid dyslexia screening test and the Test of Visual Perceptual Skills. The selection stage was necessary because the purpose of the study was to find out whether difficulties faced by DAS students in learning the language are unique to dyslexia.

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STUDY 1

Methodology

The research phase adopted a quantitative two-way research design. A total of 45 students from DAS and other mainstream primary schools voluntarily participated in the study. 19 DAS students (13 boys and 6 girls) and 26 non-DAS students (18 boys and 8 girls) were selected through the use of Lucid Rapid Screening test (LUCID Research Ltd, 2010) and respectively categorised into 'at-risk' and 'low-risk' groups. The third edition of Test of Visual Perceptual Skills (non-motor) (TVPS-3) (Martin, 2006) and newly developed or adapted battery of Chinese literacy tests were used in assessing the students for statistical comparison and correlational analyses. The mean ages of DAS students (experimental group) and mainstream primary students (control group) were 9.85 years (S.D. = 0.29 years) and 9.84 years (S.D. = 0.43 years) respectively. The purpose of having the control group is to confirm the hypothesis that poor visual perceptual skills affect Chinese literacy performance, is not confined to dyslexic children.

The second edition of 'The Hong Kong Test of Specific Learning Difficulties in Reading and Writing' (Ho et al., 2007) and 'The Hong Kong Specific Learning Difficulties Behaviour Checklist (For Primary One Pupils)' (Ho, Chan, Tsang & Lee, 2002a) are currently utilised and conducted in 'Cantonese' for diagnosing Hong Kong Children with dyslexia. Other assessment tools in Chinese were also found available in China and Taiwan (King-May Psychological Assessment, 2010; Psychological Publishing Co., Ltd., 2006), such as the Chinese-grade literacy scale (中文年级认字量表) (黄, 2001), the Comprehensive test of basic reading and writing words (基本读写字综合测验) (洪, 张, 陈, 李 & 陈, 2003) and the Written language ability diagnostic test for children – second edition (国小儿童书写语文能力诊断测验 - 第二版) (杨, 李, 张 & 吴, 2003). As the assessment tools were developed according to the norms of the respective countries, the Chinese language used in these tools is in traditional script and 'zhuyin fuhao' was used to denote the phonetic symbols for pronunciation of Chinese characters, instead of 'hanyu pinyin'. For example, traditional script uses "糸" while simplified script uses "纟" for one of the semantic radicals. Nonetheless, these existing assessment tools serve as a good reference for new test development and other test adaptation of the battery of Chinese literacy tests to the local context in this research phase.

Therefore, a battery of Chinese literacy tests that consists of three tests was developed and adapted:

1. Chinese character structure awareness test (中文字形结构识别能力测验)
   Most parts of this test were newly developed and based on the Ministry of Education (MOE) Primary School syllabus for Chinese and Higher Chinese subjects (2007). This is so that the Chinese characters or radicals are appropriate for the students at primary school level and their performance in this test could relate to their academic learning in

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mainstream primary schools. The test items in the subtests were developed with greater relation to visual perceptual skills in terms of Chinese character orthographic structure, radicals and shapes.

2. Reading of single Chinese characters (中文年级认字量表)
   The list of Chinese characters was adapted with reference to the MOE Primary School syllabus for Chinese and Higher Chinese subjects (2007), MOE Chinese character lists for Primary and Secondary Schools (2002), as well as the character frequency distribution analysis by 王 and 余 (2007), in order to match the local context of Singapore and so as to ensure that they are appropriate for the language proficiency level of the Singaporean students.

3. Comprehensive test of basic reading/writing words (基本读写字综合测验)
   This test was adapted to assess the students' spelling ability (counter measured with aural and phonetic symbols – 'hanyu pinyin') and copying skills with regards to visual perception.

As the battery of Chinese literacy tests was not standardised and had no standard set of scores, inter-scorer agreement was reached to derive inter-scorer reliability, so as to ensure consistency in scoring between the team members. In addition, training was given to all team members to ensure that the administration of tests and derivation of test scores was undertaken in a systematic, efficient and consistent way.

Results

To determine students with high and low visual perceptual skills, a median split was conducted on the overall scores of the TVPS assessment test. Students who scored lower than the median was categorized as 'low visual perceptual skills', and those who scored higher than the median was categorised as 'high visual perceptual skills'. This resulted in 21 students being categorized as 'low visual perceptual skills' and 24 students being categorised as 'high visual perceptual skills'. The number of 'low-risk' and 'at-risk' students categorised by their visual perceptual skills is summarized in Table 1.

Table 1. 'Low-risk' and 'At-risk' Students Categorised by Visual Perceptual Skills

	Low Visual Perceptual Skills	High Visual Perceptual Skills
Low-risk for dyslexia	7	19
At-risk for dyslexia	14	5

To compare performance on different assessment tests between the 'low-risk' and 'at-risk' groups based on their visual perceptual skills, 2 x 2 randomised ANOVA with Student Group (low-risk vs. at -risk) and Visual Perceptual Skills (low vs.

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high) as the independent variables (IV) were conducted on the Chinese Literacy tests. Further comparison was also conducted on the subtests of the Lucid Rapid screening assessment.

For the Literacy assessment test, the mean scores of the 'low-risk' students was higher than 'at-risk' students, $F(1, 41) = 46.51$, $p < .001$. However, there was no difference in the mean scores between students of low and high visual perceptual skills, $F(1, 41) = 0.70$, $p = .41$. The interaction effect between Student Group and Visual Perceptual Skills was also not significant, $F(1, 41) = 0.0017$, $p = .97$.

As a secondary analysis to further understand the performance of students with high and low visual skills on the Lucid screening assessment, 2 x 2 randomised ANOVA with Student Group (low-risk vs. at -risk) and Visual Perceptual Skills (low vs. high) as the independent variables (IV) were also conducted on subtests of the Lucid Rapid screening assessment.

For the Lucid Rapid Phonological Processing (PHP) subtest, the mean scores of the 'low-risk' students were higher than 'at-risk' students, $F(1, 41) = 69.39$, $p < .001$. However, there was no difference in the mean scores between students of low and high visual perceptual skills, $F(1, 41) = 0.82$, $p = .37$. The interaction effect between Student Group and Visual Perceptual Skills was also not significant, $F(1, 41) = 3.07$, $p = .08$.

For the Lucid Rapid Auditory Sequential Memory (ASM) subtest, the mean scores of the 'low-risk' students were higher than 'at-risk' students, $F(1, 41) = 21.08$, $p < .001$. However, there was no difference in the mean scores between students of low and high visual perceptual skills, $F(1, 41) = 1.15$, $p = .29$. The interaction effect between Student Group and Visual Perceptual Skills was also not significant, $F(1, 41) = 0.0093$, $p = .92$.

For the Lucid Rapid Phonetic Decoding Skill (PDS) subtest, the mean scores of the 'low-risk' students were higher than 'at-risk' students, $F(1, 41) = 30.29$, $p < .001$. However, there was no difference in the mean scores between students of low and high visual perceptual abilities, $F(1, 41) = 0.035$, $p = .85$. The interaction effect between Student Group and Visual Perceptual Skills was significant, $F(1, 41) = 5.70$, $p < .03$. Further simple effects analysis demonstrated that for students of low visual perceptual skills, 'low-risk' students scored higher than 'at-risk' students, $t(19) = 6.46$, $p < .001$, and that for students of high visual skills, there was no difference between 'low-risk' and 'at-risk' groups, $t(22) = 1.41$, $p = .17$.

In order to compare the performance of the TVPS-3 assessment test between the 'low-risk' and the 'at-risk' groups, a randomized sample t test was performed on the overall score of the TVPS-3 assessment test. The 'at-risk' group had lower mean scores for the TVPS-3 assessment test (mean = 94.7, s.d = 2.76) compared to the 'low-risk' group (mean = 105.2, s.d. = 2.18), $t(44) = 53.16$, $p < .001$. This suggested that the 'at-risk' group performed worse on the assessment test compared to the 'low-risk' group.

Overall, for the mean scores of the different assessment tests, 'low-risk'

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students scored higher than 'at-risk' students. The difference in visual perceptual skills did not affect the scores for most of the assessment tests, with the exception of the Lucid Rapid PDS subtest, where it suggested that 'at-risk' students of low visual perceptual skills performed poorer in phonetic decoding than 'low-risk' student of low visual perceptual skills.

In order to compare the mean scores of each Chinese literacy test and subtest, an independent sample t-test was conducted. There was a significant difference in the *Chinese Character Structure Awareness Test (中文字形结构识别能力测验)* scores for the 'low-risk' group (mean = 210.31, s.d. = 15.75) and the 'at-risk' group (mean = 190.47, s.d. = 20.095); t(43) = 3.71, $p < 0.01$. For its subtests, there were also significant differences in the *Character shape and structure matching task (部件组合形式)* scores; $t(43) = 2.39$, $p < 0.05$, *Orthographic structure recognition task (识别汉字结构)* scores; $t(43) = 2.34$, $p < 0.05$, and *Character learning and retrieval task (提取新学单词)* scores; $t(43) = 3.71$, $p < 0.01$. There was no significant difference in the *Strokes and radical copying task (基本笔画与部件抄写)* scores, $p > 0.05$.

For the *Reading of Single Chinese Characters (中文年级认字量表),* there was a significant difference in the scores for the 'low-risk' group (mean = 102.85, s.d. = 29.261) and the 'at-risk' group (mean = 53.95, s.d. = 20.805); $t(43) = 6.22$, $p < 0.001$. For the *Comprehensive Test of Basic Reading and Writing Words (基本读写字综合测验),* there was a significant difference in the scores for the 'low-risk' group (mean = 198.65, s.d. = 25.371) and the 'at-risk' group (mean = 132.95, s.d. = 38.895); $t(43) = 6.86$, $p < 0.001$. For its subtests, there were also significant differences in the *Multiple choice task (找出正确的字)* scores; $t(43) = 7.47$, $p < 0.001$, *Spelling of single words task (听/看汉语拼音写单字)* scores; $t(43) = 6.40$, $p < 0.001$, Far-distance copying task (远端抄写) scores; $t(43) = 5.12$, $p < 0.001$, *Near-distance copying task (近端抄写)* scores; $t(43) = 3.76$, $p < 0.01$, and *Short passage copying task (短文抄写)* scores; $t(43) = 4.32$, $p < 0.001$.

The above results suggested that the 'at-risk' group performed worse in most of the Chinese literacy tests and subtests than the 'low-risk' group, except for copying of strokes and radicals, implying that the 'at-risk' group are poorer in most of the Chinese literacy skills as compared to the 'low-risk' group. A graphic representation of the means comparisons for each Chinese literacy tests and subtests between both groups is shown in Figure 1.

In order to compare the mean scores of each reading error miscue, an independent sample t-test was also conducted. There was a significant difference in the *visually-similar errors* for the 'low-risk' group (mean = 11.31, s.d. = 6.632) and the 'at-risk' group (mean = 7.05, s.d. = 4.743); $t(43) = 2.38$, $p < 0.05$, especially for its subtype, *same-radical characters;* $t(43) = 3.23$, $p < 0.01$. This suggests that 'at-risk' students tend to make less visually-similar and phonetically-similar errors than 'low-risk' students, especially with characters that contain the same radicals when making

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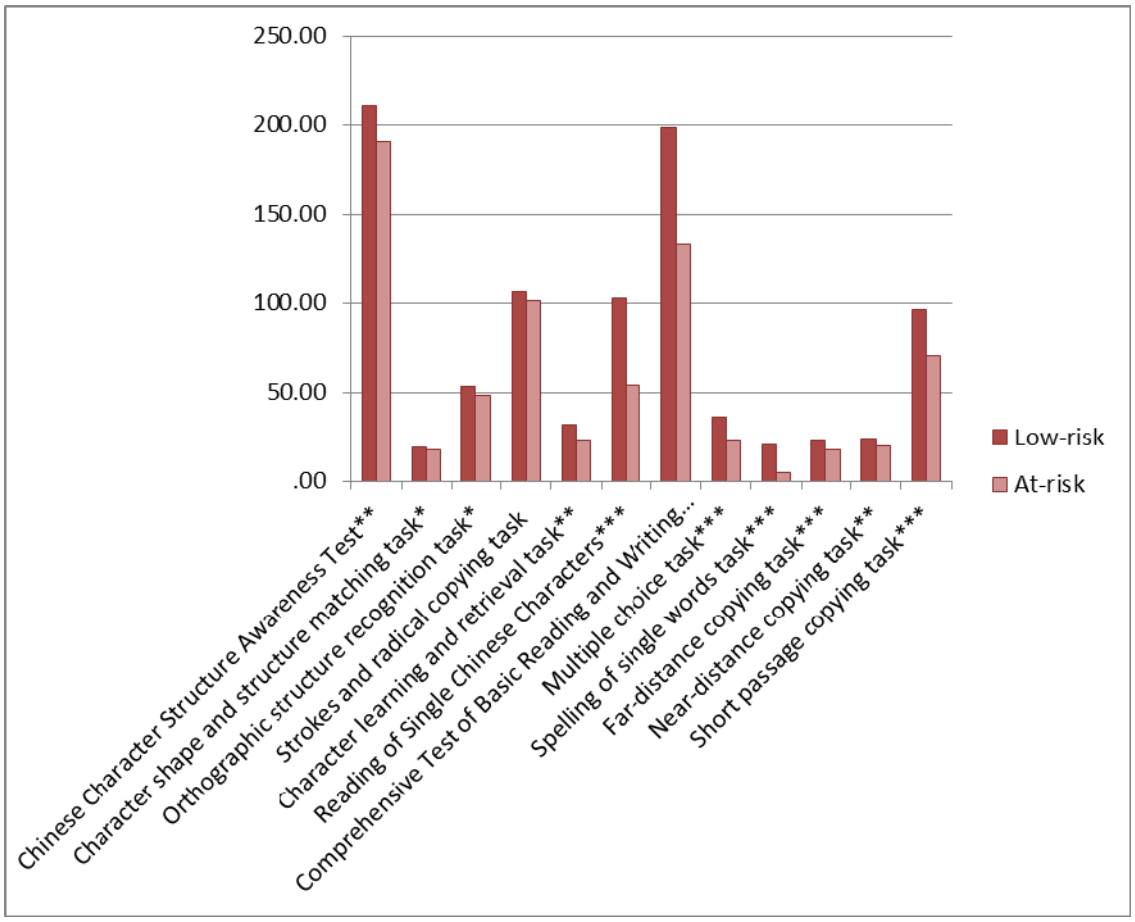

*p < 0.05, **p < 0.01, ***p < 0.001

Figure 1. Comparison of means on 'Chinese literacy' between 'risk of dyslexia'

visually-similar errors. There was also significant difference in *unknown errors* between 'low-risk' group (mean = 73.38, s.d. = 36.057) and the 'at-risk' group (mean = 127.37, s.d. = 29.934); t(43) = -5.32, p < 0.001. This suggests that 'at-risk' students make more unknown errors than 'low-risk' group when reading Chinese characters. There was no other significant difference in the rest of the error miscues, p > 0.05.

In order to compare the mean scores of each spelling/writing error miscue, an independent sample t-test was also conducted. There was a significant difference in *wrongly written characters* for the 'low-risk' group (mean = 11.08, s.d. = 5.932) and the 'at-risk' group (mean = 17.21, s.d. = 10.266); t(43) = -2.53, p < 0.05, especially for its subtype, *structure errors*; t(43) = -3.76, p < 0.01. This suggests that 'at-risk' students tend to write characters that are non-existent in

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the Chinese language, especially with regards to the orthographic structure and position of radicals within a character. There was also a significant difference in *incorrect characters* for the 'low-risk' group (mean = 11.08, s.d. = 5.932) and the 'at-risk' group (mean = 17.21, s.d. = 10.266); $t(43) = -6.94$, $p < 0.001$. For its subtypes, there were significant differences for *visually-similar-phonetically-different characters;* $t(43) = -3.28$, $p < 0.01$, *visually-different-phonetically-similar characters*; $t(43) = -2.297$, $p < 0.05$, *visually-different-phonetically-same characters*; $t(43) = -3.82$, $p < 0.001$, *similar-semantic-different-phonetic characters*; $t(43) = -5.10$, $p < 0.001$, and *visual-semantic-phonetic confusion*; $t(43) = -3.47$, $p < 0.01$. This suggests that 'at-risk' students tend to write more incorrect characters that are mainly homophones or irregular characters, and semantically related characters, as compared to 'low-risk' students.

There was significant difference in *incomplete response* for the 'low-risk' group (mean = 15.23, s.d. = 13.776) and the 'at-risk' group (mean = 29.26, s.d. = 32.978); $t(43) = -2.86$, $p < 0.05$. There was also significant difference in *unknown errors* for the 'low-risk' group (mean = 8.77, s.d.=10.727) and the 'at-risk' group (mean = 37.84, s.d. = 19.828); $t(43) = -4.92$, $p < 0.05$. This suggests that 'at-risk' students tend to be unable to complete writing a Chinese character or make more unknown errors than 'low-risk' group when reading Chinese characters. There were no other significant differences in the rest of the error miscues, $p > 0.05$.

In view of the insignificant interaction results, correlational analyses were conducted for all subtests of different assessment tests as an exploratory study to understand the possible relationships between different visual perceptual skills, phonological processing, auditory sequential memory and phonetic decoding skills, with different Chinese literacy skills.

As visual perceptual skills are the main interest of this research study on Chinese characters, Spearman correlation analyses were performed between the scores of the TVPS-3 assessment subtests with the Chinese Literacy tests scores. There was a significant correlation between the scores on the TVPS-3 Visual Memory subtest with the Literacy assessment test, $r_s = .33$, $n = 46$, $p < .03$. No other significant correlation was found between the other TVPS-3 subtests (i.e. other visual perceptual skills) with the Chinese Literacy tests scores. In order to better understand the relationship between the Chinese Literacy subtests with the TVPS-3 Visual Memory subtest, further Spearman correlation analyses were conducted with all the subtests of the Literacy assessment test and the TVPS-3 Visual Memory subtest. the TVPS-3 Visual Memory subtest score is positively correlated with most of the subtests in *Chinese Character Structure Awareness Test (中文字形结构识别能力测验),* with the exception of the *Orthographic structure recognition task (识别汉字结构)* subtest, the number of correct sequence of strokes in the subtest of *Strokes and radical copying task (基本笔画与部件抄写)* and the *Character learning and retrieval task (提取新学单词)* subtest. The TVPS-3 Visual Memory subtest score is not correlated

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with the test of *Reading of Single Chinese Characters (中文年级认字量表).* This suggested that visual memory played a role in the students' structure awareness of Chinese characters. For the cluster of subtests in *Comprehensive Test of Basic Reading and Writing Words (基本读写字综合测验),* the TVPS-3 Visual Memory subtest score *is* positively correlated with the *Multiple choice task (找出正确的字)* subtest and the *Short passage copying task (短文抄写)* subtest. This could suggest an interesting relationship between visual memory and accurate identification of Chinese characters, and copying of more meaningful text than single characters.

Additionally, Spearman correlation analysis tests were also performed on the scores of the Lucid Rapid screening subtests with the Chinese Literacy tests. There was a significant correlation between the scores on Lucid PHP with the scores on the Chinese Literacy tests, r_s = .54, n = 46, p < .001, between the scores on Lucid ASM with the scores on the Chinese Literacy tests, r_s = .63, n = 46, p < .001, and between the scores on Lucid PDS with the scores on the Chinese Literacy tests, r_s = .43, n = 46, p < .001. This suggested that students who scored well on the Chinese Literacy tests tend to score well on the Lucid Rapid subtests.

Discussion

The results have revealed that 'low-risk' students have better Chinese literacy skills than 'at-risk' students, showing the probable effect of dyslexia on Chinese language acquisition. Moreover, results also have shown that visual perceptual skills differ between these two groups, with 'low-risk' students having better visual perceptual skills than 'at-risk' students, further suggesting probable effect of dyslexia on other cognitive abilities such as visual perceptual skills, on top of its main effect on phonological processing abilities. However, the 2-way ANOVA has found no significant difference in Chinese literacy skills regardless of high or low visual perceptual skills with the presence of dyslexia. This shows that despite the existence of different cognitive profiles of dyslexia, the interaction effect of visual perceptual skills on Chinese literacy skills with dyslexia were not substantiated in this research study. Furthermore, the sample size may seem too small for any significant effects to be found, after the median split.

Studies that involved indirect links between visual skills and reading ability on Chinese dyslexic children (Huang & Hanley, 1997; Huang et al., 2008; Li et al., 2009) have shown that dyslexics and poor readers have weaker visual skills as compared with normal readers. Similar findings had also emerged from this research study, but had not demonstrated differing visual skills within each group on literacy skills. Therefore, this may imply that the visual aspect of individualistic cognitive profiles of dyslexia is not one of the main factors in coping with Chinese language and/or characters.

On the other hand, at a further look into the interaction between visual perceptual skills and phonological awareness for both 'low-risk' and 'at-risk' children, an interesting interactive effect on phonetic decoding skills was discovered in the comparison between both 'low-risk' and

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'at-risk' groups of students who have low visual perceptual skills. As dyslexia is generally characterised by phonological deficits in cognitive processing of languages (Lyon et al., 2003; The International Dyslexia Association, 2007; Dyslexia Association of Singapore, 2009) and phonetic decoding skills is a higher order phonological awareness (Adams, 1990), it seems that this finding is in agreement with other researchers that visual perceptual skills are not a major predictive factor for learning difficulties (Huang & Hanley, 1997; Amitay, Ben-Yehudag, Banai & Ahissar, 2003; Martin, 2006) and that poor visual aspects in cognitive processing could just be one of the effects of dyslexia. This further implies that visual perceptual skills tend to be lower with the presence of dyslexia which may be a partial reason for the learning difficulty in language orthographies.

Furthermore, comparison of means in the Chinese literacy performance to understand the difference in the Chinese literacy skills and error miscues between the two groups of students can begin to create a profile of dyslexia in Singapore. The results have shown that 'at-risk' students are weaker in their orthographic structure awareness (i.e. recognising shapes and structure and radical positional knowledge), learning and retrieval of characters, and even weaker in their reading, spelling and writing abilities, than 'low-risk' students. In fact, this study looks at writing and spelling that involve necessary knowledge of semantic radicals and phonetics that include writing and checking to see if the character looks correct (Ehri, 2000, cited in McBride-Chang, 2004). Therefore, the comparison results suggest that deficits in structural and radical positional knowledge, learning and retrieval ability, reading accuracy, selecting and writing of characters based on orthographic to phonetic and semantic cues, and visual-motor integration (copying) skills are observed with the presence of dyslexia.

Reading and spelling errors that did not fit in any of the categories on error types and non-attempts were all classified under unknown errors. The results have shown that although the 'at-risk' students make more errors than 'low-risk' students based on their Chinese literacy performance, the significant difference in the unknown errors seems to suggest that 'at-risk' students tend to make more errors in their reading generally and skip unfamiliar characters easily, while 'low-risk' students were able to read more accurately and only skip genuinely unfamiliar characters. This also implies that even if unfamiliar characters were analysed and guessed, visual-orthographic skills are needed to recognise the Chinese characters to read as accurately as possible, and the presence of dyslexia makes such processing more difficult. Also, in the process of analysing and guessing, 'low-risk' students tend to make more errors that are visually-similar for characters with the same radicals (e.g. "他" /tā/ read as "地" /dì/) and phonetically-similar in terms of tone, articulation and sound omission or insertion (e.g. "肉" /ròu/ could have been read as /róu/, /lòu /, / rù/ or /riòu/). The latter error could sometimes due to local accent but would be penalised if inconsistency in pronunciation was observed.

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The results of the spelling/writing error miscue analysis have shown that 'at-risk' students tend to make more errors in spelling and writing as compared to 'low-risk' students and the errors made were varied. The errors include writing non-existent characters, homophones and/or its alikes (visually-different-phonetically-same characters, e.g. "合" /hé/ was written as "和" /hé/, and visually-different-phonetically-similar characters, e.g. "亲" /qīn/ was written as "青" /qīng/), irregular characters (visually-similar-phonetically-different characters, e.g. "具" /jù/ was written as "真" /zhēn/), semantically related characters (similar-semantic-different-phonetic characters, e.g. "课[本]" /běn/ [schoolbook] was written as "书" /shū/ [book]) and also general confusion with characters that are visually, phonetically and semantically similar. McBride-Chang (2004) highlighted the complication of Chinese spelling and possibility of invented spelling by combining various semantics and phonetics to create new pseudo-characters. This shows that these spelling errors are characteristic of dyslexia and not only phonological in nature for Chinese language.

Based on the above interpretation thus far, processing of Chinese language and/or characters includes other cognitive and metalinguistic skills, besides visual perceptual skills. Meng, Cheng-Lai, Zeng, Stein and Zhou (2011) demonstrated the extent to which the impact of visual perception and its underlying neural substrates on Chinese reading development and dyslexia depends partly on orthographic structure awareness in lexical processing of the writing system. Additionally, deficits in temporal processing that are responsible for visual and auditory stimulation were likely to be associated with reading disability (Chung et al., 2008). McBride-Chang (2011) stated that metalinguistic skills do transfer across Chinese and English languages (i.e. phonological awareness, vocabulary and naming speed) but dyslexics were found to have poorer morphological skills for Chinese language. Thus, 'at-risk' students in this study were found to have poorer abilities in orthographic and structural analysis, reading and spelling, visual-motor integration in copying, learning and retrieval.

It is also believed that visual-orthographic skills do play a role in Chinese character reading (Taft & Zhu, 1997; Perfetti & Tan, 1998; Ho et al., 2002b; Ho et al., 2004; Perfetti, Liu & Tan, 2005; Siok & Fletcher, 2001). Therefore, there was an interest to find out which specific aspect of visual perceptual skills play a role in processing Chinese language and/or characters. The correlational study had shown a significant relationship between visual memory and some Chinese literacy skills and visual memory seemed to be involved in the following processes: identifying shapes and structures of Chinese characters (but not the orthographic structure and positions of radicals), copying of strokes and radicals, learning and retrieval of Chinese characters, selecting correct Chinese characters to phonetic cues, and copying of meaningful text (but not single Chinese characters). Furthermore, the results demonstrated relatively stronger relationships between visual memory and

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copying of strokes and radicals, and learning and retrieval of Chinese characters.

Pak et al. (2005) found that visual chunking skills advance over time as children mature gradually from processing of Chinese characters by stroke to semantic and phonetic radicals with the involvement of working memory, so as to facilitate quicker and more accurate copying and reading when they grow older. In other words, chunking of visual features of Chinese characters through the use of working memory could be based on visual memory.

Interestingly, despite the research findings on visual skills and reading ability (Huang & Hanley, 1997; Huang et al., 2008; Li et al., 2009), no relationship between visual memory and reading accuracy was found from this research study. It is highly likely that visual memory does not play a direct role in Chinese character identification and reading accuracy, but other cognitive processes do. Likewise, the Chinese literacy subtest that measures orthographic structure and radical positional awareness did not show any relationship with visual memory as well. Zhang and Simon (1985) had verified that there is some involvement of visual or semantic memory which retains visual chunks (i.e. radicals of a Chinese character) while processing the Chinese character phonologically. Yeh et al. (2003) further concluded that the visual aspect of Chinese characters is more related to the cognitive process in pattern recognition while the orthographic structure aspect is more related to the cognitive linguistic process. Therefore, this probably explains the significant relationship with *Character shape and structure matching task (部件组合形式)* but not in the *Orthographic structure recognition task (识别汉字结构),* implying that other cognitive skills are required in understanding the orthographic structure and radical positions within a Chinese character.

Besides visual memory, there is an overall positive correlation between the LUCID scores and the Chinese literacy scores. With the fact that 'low-risk' students scored higher and make less errors on the Chinese literacy scores compared to 'at-risk' students, it suggested that impairment in language processing for dyslexia is not language specific. That is, bilinguals with dyslexia could do badly across different languages. Moreover, both auditory and phonological awareness were found to be associated with word reading across languages (Chung, Mc-Bride-Chang, Cheung & Wong, 2011). In an fMRI study by Tham et al. (2005), there were several distinct areas of brain activation in both hemispheres for both Chinese and English languages which are mainly for phonological processing. Thus, with dyslexia being characterised with deficits in the phonological component in language processing (Lyon et al., 2003; The International Dyslexia Association, 2007; Dyslexia Association of Singapore, 2009), it is believed that dyslexics would face difficulty in language acquisition in general.

In the correlational analysis for LUCID sub-scores, the generally stronger and more consistent positive relationships between phonological processing and

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auditory sequential memory probably suggested that processing of Chinese language (i.e. reading and writing Chinese characters) does not necessarily involve phonetic decoding skills, unlike English language which uses an alphabetic system with letter-sound correspondence. The linguistic properties of both languages are opposite to each other – Chinese is an analytic, tonal and non-inflected language whereas English is a synthetic, atonal and inflected language (Chung et al., 2011). Studies have shown that Chinese children learning to read Chinese characters need to be sensitive to the phonological components of the lexical processing at the awareness level of syllables with onset and rime, rather than phonemic awareness level (McBride-Chang & Ho, 2000; Siok & Fletcher, 2001; Leong, Cheng and Tan, 2005). A general auditory processing skill was also found to be an underlying factor – a shared phonological skill in onset and rime segmentation, and Chinese tone detection and matching – that links the acquisition of both Chinese and English reading together (Wang, Perfetti and Liu, 2005).

In summary, the study yielded the following findings:

1. Language processing impairment persists across different languages (namely English and Chinese).
2. Literacy skills such as visual-orthographic skills, morphological awareness and visual-motor integration skills, were the observed differences with regard to "risk of dyslexia" in Chinese language acquisition.
3. Some aspects of the processing of the Chinese language require visual memory, which was found to be relatively weaker in the dyslexic students of the study.

Therefore, the first steps to literacy in a Chinese classroom is to begin with learning of strokes in direction and order, pictographic characters such as "山" (mountain) and "火" (fire), radicals of complex characters, and simultaneously with introduction of 'hanyu pinyin' through rhymes, syllables and tone diacritics (Ingulsrud & Allen, 2003). Chen and Lin (2009) argued that literacy intervention for Chinese children should cover three main areas that may be most beneficial. Firstly, phonological awareness intervention focuses on syllable awareness and progresses gradually to onset-rime awareness and tone awareness. Chinese tone detection – a new and more complex form of phonological process in the Chinese language, was found a predictive factor for acquiring English reading and future research was suggested in helping dyslexic children to improve their reading ability by training in Chinese tone detection (Wang et al., 2005). Secondly, building awareness of Chinese character orthographic structure as the majority of Chinese characters consist of radicals that are semantic-phonetic in nature. Visual-orthographic skills are skills needed to recognise shapes and structure of a Chinese character and understand radical positional rules (e.g. where is 讠 ?). This allows for the strategic attempt of "splitting into parts" when reading Chinese as accurately as possible (e.g. 也、他、地).

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Thus, training of phonological strategies can be done simultaneously while children learn to identify and analyse meaning and pronunciation of semantic-phonetic radicals within the characters.

Last but not least, morphological awareness intervention is helpful, because another salient feature of Chinese language is the large number of homophones, such as /jǐu/ can be "九", "酒" or "久" which means "nine", "liquor" or "long (time)" respectively. This also helps to clarify rules and expand knowledge. For example, when a character is read (e.g. "大" /dà/ [big]), two characters can be formed with another character (e.g. "大象" /dà xiàng/ [big elephant] and "伟大" /wěi dà/ [great or mighty]). Having such awareness allows for visual chunking skills to process Chinese characters efficiently and accurately, especially in reading fluency and writing (i.e. copying, spelling and even learning and retrieval). Poor visual chunking skills also indicate lack of sufficient morphological awareness in orthographic and radical positional and functional knowledge to process Chinese characters efficiently and accurately (McBride-Chang, 2011; Cao, 2011). Thus, children can be taught to identify and differentiate by forming new words with a character and analysing the relationship of the words, simultaneously with character orthographic structure training. A well-structured pedagogy of morphological instruction was found to be useful for children with dyslexia in Beijing and Hong Kong (Cheng-Lai, 2010). Studies in mainland China (Shu, McBride-Chang, Wu & Liu, 2006) and Hong Kong (Chung et al., 2008) have pointed out morphological awareness as a point of distinction of children with and without dyslexia. As morphological awareness is a key contributor to reading development in Chinese, it is then essential that intervention targets this area of difficulty.

Lin et al. (2009) had identified four strategies from their study on Hong Kong mothers and children that vary in learning autonomy with age. The least effective strategies were copying and visualisation (rote memory learning through practice and test drills). The more effective strategies were segmentation of radical forms and functions, and morphological instruction due to the pictographic and semantic-phonetic componential nature of Chinese characters. On the other hand, Aram and Levin (2004) found that the quality of the latter strategies partially influence the literacy development of the children in their longitudinal study. Segmentation and morphological strategies need to be mediated well with adults clarifying rules, expanding knowledge and facilitating these children with tools to cope in literacy tasks, rather than mere modelling of procedures of character deconstruction.

Overall, Chinese literacy instruction should encompass all the above propositions with the acknowledgement that Chinese language and/or characters processes engage in the activation of visual, phonological and semantic nodes in working memory, according to the EPAM theory (Feigenbaum & Simon, 1984; Best, 2006), lexical constituency model (Perfetti & Tan, 1998), interactive activation model (Taft & Zhu, 1997) and polysyllabic-character visual recognition framework (Tan & Perfetti, 1999). Ng, Varley and

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Andrade (2000) found an effective way of mediating information for recognition to be finger tracing as it stimulates both spatial and sequential awareness of the strokes in a character through kinaesthetic feedback. They reiterated its effectiveness for a subgroup of dyslexics with visual deficits by stating that 'this proprioceptive channel may be an augmentation to their deficient visual processing route and finger tracing may be a useful intervention method to alleviate reading difficulties' (Ng et al. 2000, p.569). In other words, it was suggested the beneficial effect of finger-tracing to improve writing or remembering Chinese characters as the sequence and spatial information embedded in the kinaesthetic-tactile movements can be a part of mediating visuo-spatial information, implying the importance of visual skills in Chinese language acquisition. Moreover, simultaneous multisensory approaches to learning have been proven effective for dyslexic learners (Gillingham & Stillman, 1997). Visual-integration skills are basically copying and writing skills, such as producing a Chinese character with strokes that are in the correct direction, sequence and proportion and learning and retrieval of Chinese characters. McBride-Chang (2011) illustrated a study conducted in Hong Kong which investigated paired-association and visual -motor integration skills of dyslexics and non-dyslexics through use of nonsense names with pictures and unfamiliar languages. It was found that dyslexics' poor performance was not because of inexperience with print but the orthography and paired-association learning of language in general.

Another question related to Chinese language acquisition in Singapore is the implication of Chinese being a second language on experience with print. Poor performance in language could be due to learning difficulties such as dyslexia or experience with print. Given that dyslexia is a lifelong condition and its rate of occurrence in the population, it is important and vital that intervention is done early and is effective. Early intervention improves the rate of success by close to four times (Hall & Linch, 2007) and other benefits includes earlier development of compensatory strategies, and lowered risk of development of emotional and behaviour problems. As such, intervention programmes need to be measured for effectiveness to ensure that these students benefit from intervention. The use of the response-to-intervention model has been on the rise in the recent years, especially on individuals with learning difficulties.

Ho (2010) developed a three-tiered response-to-intervention model to identify and teach children with learning disabilities in Hong Kong. A total of 573 participants who were in Grade 1 contributed to the study. The results of the study showed that oral language, morphological awareness and orthographic skills made significant contributions to Chinese word reading and dictation. In addition, it was also found that syntactic awareness made significant contribution to reading comprehension, reading fluency and simple writing. As such, it was concluded that oral language, morphological awareness, orthographic skills and syntactic awareness are significant reading-related cognitive-linguistic skills in

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mastering Chinese. Similar to Ho's study, the aim of this study is to measure students with dyslexia's response to intervention and if it is effective in developing skills critical to the mastery of Chinese language.

STUDY 2

DAS Chinese Remediation Programme

Following the findings from the preliminary survey and previous study, the team started developing a remediation programme in 2012 focusing on oracy and word recognition components, as well as building interest in the Chinese language. The Chinese remediation programme started in January 2013 and emphasises three main aspects:

1. Common vocabulary and sentence structure to enhance the student's expressiveness using Chinese language.
2. Character structures, radicals and stroke patterns to enhance the student's word recognition skills.
3. Morphological awareness to help expand the student's vocabulary network.

The aim of the programme is to help students become independent and inquisitive learners in Chinese language. Students are taught the orthographic structures of Chinese characters, based on 谢 (2002) who named 14 basic structures that help with visual chunking in order to identify types of radicals. At the same time, students are taught the different types of radicals and their legal positions in order to decipher the semantic and phonetic components within the Chinese characters. According to Ho, Yau and Au (2003, cited by McBride-Chang, 2004), orthographic knowledge development for reading and spelling skills involve a progressive set of processes: (1) character configuration knowledge – rudimentary orthographic skill that differentiates writing from drawing of Chinese characters, (2) structural knowledge – understanding of Chinese characters being compounded with two or more separate components called radicals, (3) radical information and positional knowledge – understanding of the meanings of semantic radicals and their legal positions within the Chinese characters, (4) functional knowledge – ability to associate phonetic radicals with particular sounds and semantic radicals with particular meanings, (5) amalgamation stage – combining knowledge of forms, functions and positions of phonetic and semantic radicals, and (6) complete orthographic knowledge – ability to read and write correct Chinese characters consistently and logical understanding of semantic and phonetic radicals in pseudo-characters. Thus, students are also taught to produce strokes and stroke patterns (e.g. 亅, 丷 and𠂉) in proper direction, sequence and proportion.

With the Orton-Gillingham teaching principles (Gillingham and Stillman, 1997) adapted in the remediation programme, students are taught through hands-on activities, educational games, storytelling, as well as tracing and tracking of characters/words. These aspects are delivered through themes that surround the student and his/her everyday life (e.g.

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myself, home, school, neighbourhood, etc). The focus of these teaching methods is for the students to find the language more meaningful as they relate what they are taught in class to themselves and their surroundings, and hence gain interest in using the language. The teachers are effectively bilingual to facilitate teaching. This allows for the teachers to be able to tap into their English vocabulary and help the students to express themselves in Chinese.

While the programme does not follow the school's curriculum, the coverage of the vocabulary used is based on the Ministry of Education (MOE) Primary school syllabus for Chinese (2007). This programme is also designed to suit the varied profile of our students. To date, there are 53 students enrolled in the Chinese remediation programme. Most of the students often speak English (62%), sometimes speak Mandarin (63%) and never speak a dialect (83%) at home. These were reported by parents when they enroll their children for the programme.

As Study 1 was only conducted with Primary Four students, whose mean age was about 9 years, further research is needed to gain greater understanding about the difficulties of dyslexic students in the Chinese language as well as to study the effectiveness of the programme. In addition, the Chinese remediation programme is the first intervention programme developed for students with special needs in Singapore by the DAS. Thus, pre- and post-tests are conducted for students who are on the Chinese remediation programme in order to monitor their progress. The assessments for pre-testing are also used to profile the students according to their strengths and weaknesses so that intervention can be better targeted. Parents who enrol their children in the programme are aware that their children will be contributing to the evaluation study on its effectiveness.

Methodology

Participants

A total of 16 participants (4 females, 12 males) with a diagnosis of dyslexia were involved in the study. Participants were between the ages of 6 to 12, the majority were in Primary 3 and 4, and are enrolled in a local primary school. Gender was not controlled as it is not considered as a factor in the study. Nevertheless, the sample used is representative of a dyslexic population, with more males than females.

Procedure

The purpose of the pre- and post-test carried out on the participants was to measure the effectiveness of intervention in helping primary school students with dyslexia. The pre-test was conducted prior to the start of intervention. After which, participants received remediation once a week for an hour. The post-test was then carried out after at least six months of intervention. If the participant was unable to undergo the post-test within nine months of intervention, their results were omitted. On average, participants underwent remediation for 8.19 months prior to post-testing. At the stage of post-testing, participants were at a mean age of 9.71 years old.

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Assessment tools and administration

The testing tool used was The Revised Battery of Chinese Literacy Tests based on Study 1 conducted from 2010 to 2011.The test takes about 60 to 90 minutes long to administer. All instructions given for the test were provided in the assessor's guide to ensure that the same instructions were given to all participants and at both pre and post testing, so as to minimise any tester bias. In addition, practice questions were used to ensure that participants understood the instruction given. The test was carried out in Chinese language as much as possible and in instances that the participant has great difficulty in understanding Chinese language, instructions were translated into English.

The assessment can be broken down into four main tests measuring Chinese character orthographic awareness, character reading and vocabulary, basic Chinese character reading and writing and picture sequencing and verbal expression. Table 2 below illustrates the components assessed in each main test.

Results

In order to assess the effectiveness of the programme and whether students are benefiting from the intervention, mean scores of their pre- and post- tests were compared using within-samples t-tests. There was a significant difference in overall Chinese Literacy scores, between pre-test (mean = 313.75, s.d. = 91.46) and

Table 2. Main tests and components

Revised Battery of Chinese Literacy Tests	Components Assessed
1. Chinese Character Orthographic Awareness	a. Shape and Structure Matching b. Orthographic Structure Recognition c. Strokes and Radicals Copying d. Character Learning and Retrieval
2. Chinese Character Reading Test	a. Reading of Characters b. Vocabulary Knowledge Test
3. Basic Chinese Character Reading and Writing	a. Multiple-choice Spelling b. Free Recall Spelling c. Short Passage Copying
4. Picture Sequencing and Verbal Expression	a. Picture Sequence and Description b. Freedom of Expression

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post-test (mean = 354.44, s.d. = 93.47), $t(15) = -5.13$, $p < .001$. This suggests that the students' Chinese literacy skills have improved significantly after receiving intervention.

The pre- and post- test mean scores for each main test and their components in the Revised Battery of Chinese Literacy Tests were also compared to better understand the areas in which students had benefited from intervention. The results showed that there is a significant improvement in "Chinese Character Orthographic Awareness Test", $t(15) = -5.24$, $p < .001$. For its components, there is significant improvement in the mean scores of "shape and structure recognition" and "strokes and radical copying", $t(15) = -3.47$ and $t(15) = -2.94$, $p < .01$ respectively. There is also improvement in the mean scores of "Character learning and retrieval", $t(15) = -2.72$, $p < .05$. A graphic representation of the means comparisons is shown in Figure 2.

In the "Chinese Character Reading Test", mean scores showed significant improvement, $t(15) = -4.04$, $p < .001$. Students were also better able to form meaning to characters that they read, as the scores of "Vocabulary Knowledge Reading Test" have significantly improved, $t(15) = -3.09$, $p < .01$. A graphic representation of the means comparisons is shown in Figure 3.

However, there were no other significant results for writing and oral tests, and although the results showed an increase in scores at post-test, these are not statistically significant.

Comparison of mean scores was also conducted for Reading errors, and there was a significant difference between pre-test (mean = 155.94, s.d. = 25.80) and post-test (mean = 148.56, s.d. = 25.98), $t(15) = 4.066$, $p < .001$. Although the mean number of errors made in the post-test was comparatively less than those made in pre-test, only the Phonetic-Semantic Error showed a significant difference, $t(15) = 4.16$, $p < .001$.

In order to yield greater analysis of the programme effectiveness, Pearson correlations between the main tests were conducted so as to have a better understanding of how the participants have benefited from the programme. Statistical results have shown interesting findings.

In the pre-test, there were significant correlations between "Chinese Character Orthographic Awareness Test" and the components of "Chinese Character Reading Test" – with "Reading of Characters", r = .67, n = 16, $p < .01$, and with "Vocabulary Knowledge Reading", r = .71, n = 16, $p < .01$. The components of "Chinese Character Reading Test" also correlate significantly with "Basic Character Reading and Writing Test", r = .57, n = 16, $p < .05$ and r = .67, n = 16, $p < .01$ respectively. In addition, the "Picture Sequencing and Verbal Expressions Test" correlates significantly with "Chinese Character Orthographic Awareness Test", r = .66, n = 16, $p < .05$, with "Reading of Characters", r = .56, n = 16, $p < .05$, as well as with "Vocabulary Knowledge Reading", r = .62, n = 16, $p < .05$.

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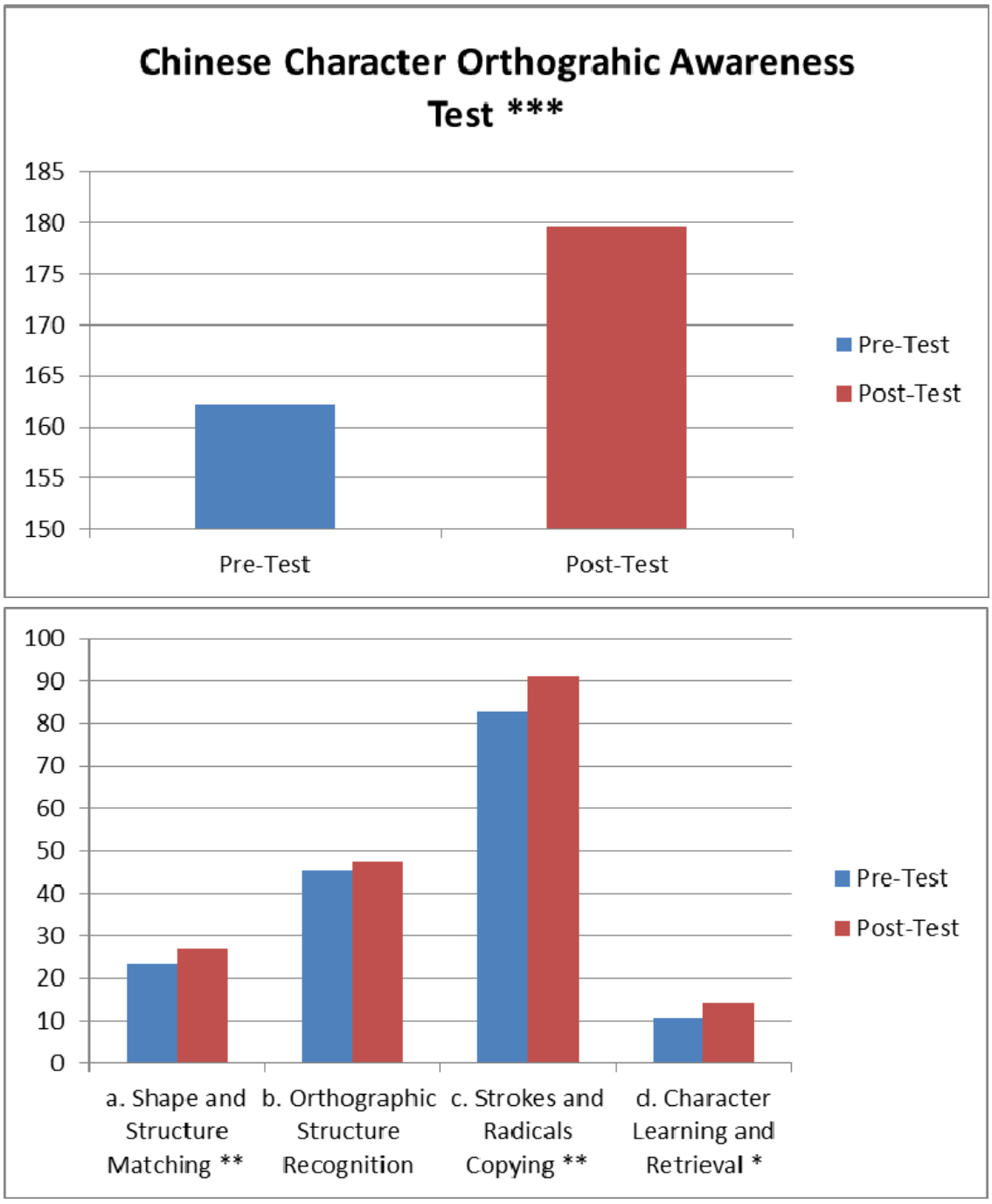

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

Figure 2. *Comparison of Pre-test and Post-test scores (Test 1 - Chinese Character Orthographic Awareness Test)*

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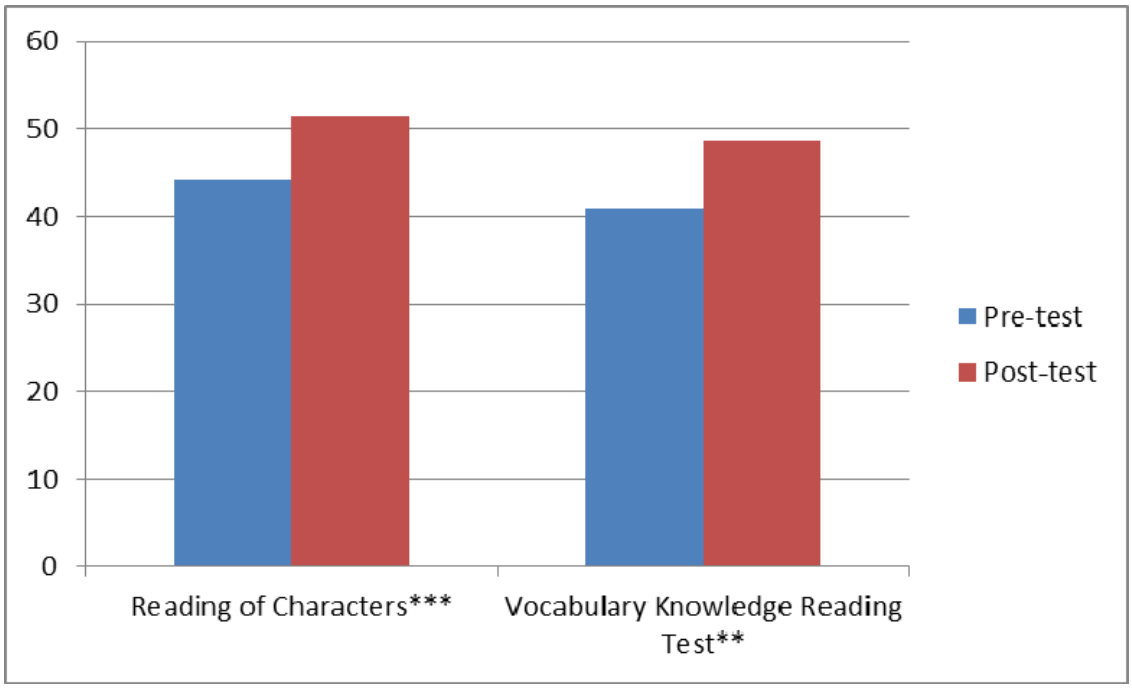

*p < 0.05, **p < 0.01, ***p < 0.001

Figure 3. Comparison of Pre-test and Post-test scores (Test 2 - Chinese Character Reading Test)

In the post-test, correlations between "Chinese Character Orthographic Awareness Test" and components of "Chinese Character Reading Test" remain significant – with "reading of Characters", r = .69, n = 16, p < .01, and with "Vocabulary Knowledge Reading", r = .62, n = 16, p < .05. Similarly, the correlations between the components of "Chinese Character Reading Test" remain significant with "Basic Character Reading and Writing Test", r = .65, n = 16, p < .01 and r = .67, n = 16, p < .01 respectively, indicating a stronger relationship as compared to pre-test. Interestingly, new significant correlations were found between "Chinese Character Reading Test" and one of the components of "Basic Character Reading and Writing Test" which is the "Short Passage Copying" (number of correct words copied and copying speed), r = .53, n = 16, p < .05 and r = .54, n = 16, p < .05 respectively. The correlations of "Picture Sequencing and Verbal Expressions Test" with "Chinese Character Orthographic Awareness Test", "Reading of Characters" and "Vocabulary Knowledge Reading" also remain significant, r = .52, n = 16, p < .05, r_s = .53, n = 16, p < .05 and r = .55, n = 16, p < .05 respectively.

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Discussion

Participants showed improvements in their overall literacy skills after intervention, suggesting that the remediation programme had been effective for them. The significant improvement in mean scores of components in the "Chinese Character Orthographic Awareness Test" suggests that participants have gained better awareness of how characters are formed through strokes and stroke patterns, which may also have helped them to learn and remember an unfamiliar character.

Participants' reading of Chinese characters and ability to build vocabulary knowledge showed significant improvement. That is, they are able to recognise more Chinese characters and form meaning (e.g. 他 /tā/ ➔ 他们, instead of 地 /dì/). Although the improvement "Basic Character Reading and Writing Test" which assesses writing aspects of Chinese language was not significant, studies have also shown the relationship between orthographical awareness and reading/writing of Chinese characters (Li, Shu, McBride-Chang, Liu & Peng, 2012; Tong & McBride-Chang, 2014; Packard, Chen, Li, Wu, Gaffney, Li & Anderson, 2006)

Moreover, the significant decrease in mean number of Reading errors suggests that students tend to make less wild guesses on or 'skip' unfamiliar Chinese characters when reading. In other words, participants seem to be able to recognise more Chinese characters and are better able to apply orthographical and morphological skills in reading. In addition, the significantly lower number of Phonetic-Semantic Errors in the post-test suggests that students are less confused by homophones as well as semantically-related characters caused by mispronunciation. According to Tzeng (1994), learning the logographs (i.e. orthographical symbols) of Chinese characters also involves phonological understanding of the language. Hence, together with morphological skills training, confusion and mispronunciation of homophones have significantly reduced.

Though there are improvements in orthographical awareness, morphological skills and reading, these do not seem to be translated into areas of spelling and writing as well as verbal expressiveness. A further analysis on the relationship between scores on the Chinese character orthographic awareness test with reading and spelling scores yields some understanding. The relationship found between "Character Reading Test" and "Basic Character Reading and Writing Test" scores reflecting the strong relationship between understanding orthographic structure and morphologic awareness of Chinese characters in order to be able to read and write. Li et al. (2012) found that morphological construction and orthographic skills are important in literacy development for Chinese language, though the latter was found more prominent particularly in primary school.

Furthermore, the comparison between the pre- and post-tests and stronger relationship between the "Chinese Character Reading Test" and "Basic Character Reading and Writing Test" in the post-test analysis indicate that the

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intervention was effective for the participants in building Chinese literacy skills. Packard et al. (2006) found in their experimental study that increased knowledge of orthographic and morphological structure of Chinese characters improved children's ability to copy and write from memory. They also provided some educational implications of such explicit instruction in getting children to learn to write. Hence, this research study can deepen our understanding of the sub-skills that are important in development of competence in spelling and writing in Chinese. Implications of this research study are discussed in the following section.

CONCLUSION AND FUTURE IMPLICATIONS

Despite the small sample sizes, findings of both Study 1 and Study 2 have provided valuable insights on the difficulties of Chinese language acquisition that are unique in the presence of dyslexia and the effectiveness of intervention developed for the DAS Chinese remediation programme.

A study done by Goswami, Wang, Cruz, Fosker, Mead and Huss (2011) supported the language-universal theory of identifying phonological awareness as the most significant predictor of language acquisition despite the phonological and orthographical differences between different languages. A study on dyslexic Hong Kong Chinese children by Chung and Ho (2010) also found evidence for different units of phonological awareness that are related to the characteristics of the different languages being learned, supporting the theories of psycholinguistic grain size and linguistic coding differences. In a similar study, Wang, Georgiou, Das and Li (2012) found phonological processing significantly poorer in dyslexic children than their normal peers, including other processes such as orthographic processing and successive and simultaneous processing. Ho and Yan (2014) also found similar results to Study 1 that children with learning difficulties may not prefer to use orthographic processing in learning Chinese characters, in comparison to their other peers without learning difficulties. These studies supported the findings of Study 1 that our students do struggle with learning of Chinese due to dyslexia and their difficulties can be unique from those without dyslexia.

Goswami et al. (2011) added that remediation strategies that involve rhythmic perception and syllable segmentation according to the nature of language should benefit learners in their linguistic development. Tong and McBride -Chang (2010) suggested best-fitting models that benefit Hong Kong students (from Kindergarten to fifth graders) generally involve metalinguistic constructs that involve orthographical and morphological processing. A cross-sectional study conducted by Liao (2007) on Taiwanese children found that phonological awareness and rapid naming are important skills for Chinese literacy development and that systematic understanding of radical function and internal orthographic structure of characters develops greater reading proficiency. These studies have also supported the direction in which the DAS

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Chinese Remediation Programme is developed and the positive results yielded in Study 2.

To supplement the overall findings, feedback on students' academic achievements in school as well as testimonials from parents and educational therapists were gathered during DAS' biennial Parent-Therapist Conference. All written records of the discussions were collated and summarised. According to feedback from parents, the students have shown improvement in their Chinese grades in school, especially in their oral scores. One student (Primary 3) was awarded the Most Improvement Award in Chinese for his level. And another student (Primary 3) scored the second highest in his Chinese class. Moreover, parents have reported an increased interest in their children in learning Chinese after starting classes at the DAS. They are generally happy with the improvement in their children in terms of verbal expressiveness and confidence in speaking Mandarin in social settings. Further feedback has suggested that the effectiveness of the remediation support and intervention could be further developed to higher level of learning. Parents have asked for longer classes so that their children could have greater exposure to Chinese language and more in-depth learning. Some parents are requesting more support beyond oracy with literacy components such as comprehension skills and composition writing, as well as strategies to prepare students to cope with Chinese language papers at the Primary School Leaving Examinations (PSLE).

Therefore, the Chinese remediation programme should continue to be researched and reviewed, by looking into enhancing other literacy skills such as writing, as writing is required to gain mastery of the language. More emphasis on writing and comprehension components should also be considered in remediating and assessing the students, in response to the feedback received from parents. As students' views on the Chinese language have not been reflected or captured in this research study, it would be vital that we gather such information to evaluate if we have been successful in meeting the objective of building their interest in the language. It would also serve to inform the educational therapists of the attitude of students towards the language and provide useful insights on what matters in developing literacy skills in Chinese in learners with dyslexia.

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