

**Chinese dyslexic children's learning of an orthographically transparent language:
Evidence for a facilitation effect**

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Abstract

The aim of the present research is to compare phonological abilities and visuo-spatial abilities in Chinese dyslexic children (CDC) vs. Italian dyslexic children (IDC). Specifically, 10 CDC, 10 IDC, 10 Chinese and 10 Italian children with typical development (TD) were administered instruments to assess reading, writing, visual-perceptual, and visual-spatial memory abilities. CDC showed lower performance in the reading task, in the text and sentence dictation tasks, in the visual-perceptual, visual-motor integration, and visual-spatial memory tasks, as compared to Chinese TD. IDC made more errors in the reading task and more phonological errors in the text and in the sentence dictation tasks, as compared to the Italian TD, but no significant differences emerged in visual-perceptual, visual-motor integration and visual-spatial memory abilities. The most important result is that CDC made significantly less errors in the reading task and in the phonological dictation task, despite they performed worse in the visual-perceptual, visual-motor integration and visual-spatial memory tasks, as compared to IDC.

Indeed, CDC's perceptual deficits do not appear to impair learning of reading and writing in a language with transparent orthography, despite those perceptual deficits represent a fundamental component of Chinese dyslexic children's profile. Educational and practical implications are discussed.

Keywords: Chinese dyslexic children; cross-cultural differences; transparent vs. opaque languages; reading and writing ability; visual-spatial processes.

Introduction

Developmental dyslexia is a neurobiological disorder with a genetic origin characterized by a failure to acquire reading skills. It is typically associated with adequate intelligence, education and sociocultural opportunity (Wydell, 2012). The DSM-5 (2013) diagnostic criteria for Specific Learning Disabilities (SLD) introduced the major change of including one overarching category of SLD with 'specifiers' to characterize the specific manifestations of learning difficulties at the time of assessment in three major academic domains, namely, reading, writing and mathematics. Three subcomponents of the reading disorder are expressly differentiated: word reading accuracy, reading rate, and fluency and reading comprehension. Impaired sub-skills of the specific learning disorder with impairment in written expression are spelling accuracy, grammar and punctuation accuracy, and clarity and organization of written expression.

Cross-cultural differences in dyslexia

Typically, dyslexic children show deficits in phonological awareness, verbal memory, and processing speed. However, due to linguistic differences, different types of cognitive deficits might be expected. For instance, phonological deficits reported for English speaking dyslexic children might be hardly detected in children who speak such languages as German or Italian. (Kalindi, McBride, Tong, Wong, Chung, & Lee, 2015). Indeed, it has been reported that up to 10 – 12% of children in the English speaking world suffer from developmental dyslexia (Wydell, 2012), while the percentage is lower in the Italian speaking population (although extant data on the rate of dyslexic children in Italy are somewhat mixed, see e.g., Barbiero, Lonciari, Montico, Monasta, Penge, Vio et al., 2012).

In the last years, most cross-cultural studies focussed on the question of whether dyslexic children belonging to different cultures show similar cognitive profiles or they differ on the basis of their own native language. Several researchers (e.g., de Luca, Burani, Paizi, Spinelli, & Zoccolotti, 2010; Landerl, Wimmer, & Frith, 1997; Wydell & Butterworth, 1999; Zoccolotti, de Luca, de Pace, Gasperini, Judica, & Spinelli, 2005) have argued that the main differences in developmental dyslexia among different languages may depend on relevant differences in the orthography/phonology matching, that is the way in which phonology is computed from orthography (Wydell, 2012).

As regards the alphabetic languages, learning to read is thus a process of matching distinctive visual symbols to units of sound (phonology). In those languages, in which the grapheme-to-phoneme correspondence is consistent and “transparent”, such as, for example, Dutch, German, or Italian, dyslexia mainly consists of a “phonological disorder”, i.e., a difficulty in the conversion from the grapheme to the correspondent phoneme. As a consequence, the developmental dyslexia is less frequent (Wydell, 2012). In contrast, for other orthographies, such as English or Danish, the grapheme-to-phoneme mapping is often one-to-many and less consistent/transparent. In those languages, developmental dyslexia is more frequent (Wydell, 2012).

The dyslexia in Chinese children

A peculiar picture emerges with Chinese language. As it is well known, Chinese language is a tonal language, i.e., it uses tone to distinguish words, whose basic unit is the character. Each Chinese character is monosyllabic and represents the basic unit (morpheme) of meaning. An obvious advantage of this morphosyllabic nature of the Chinese language is that the same script can be used despite the presence of different dialects within such a large population. The Chinese characters are a kind of logographic scripts that do not follow the rules of grapheme - phoneme correspondence (Ho, Chan, Lee, Tsang, & Luan, 2004).

In order to account for the differences in reading abilities among more or less transparent languages, Wydell and Butterworth (1999) put forward the Hypothesis of Granularity and Transparency. These authors proposed that the different orthographies can be described according to two dimensions: Granular size (fine vs. coarse), which refers to the orthographic unit (phoneme, syllable/character and word) and degree of transparency

(transparent *vs.* opaque), according to whether the level of translation is one-to-one or not. Therefore, in accordance with the Hypothesis of Granularity and Transparency, it can be hypothesized that if the grapheme-to-phoneme mapping is consistent/transparent, even children with phonological deficits might be able to acquire the grapheme-phoneme correspondence rules. In contrast, if the grapheme-phoneme relationship is opaque, such as, for example, in English, Japanese and Chinese, children might encounter more difficulties in reading acquisition (Wydell, 2012).

Some researchers argued that reading Chinese characters might require, firstly, greater cognitive demand for visual processing than reading in alphabetic languages such as English, and, secondly, a greater interaction between orthography and phonology (Wydell, 2012). Because Chinese characters are visually distinctive and complex (indeed, there are more than 40.000 ideograms in the Chinese language), some studies suggested that Chinese dyslexic children have also difficulty in visual processing (Woo & Hoosain, 1984) and visual memory (Ho et al., 2004).

Besides visual processing, phonological abilities may be at the root of learning to read logographic Chinese (Ho et al., 2004). Indeed, in order to read Chinese characters it is necessary retrieving phonology as a whole rather than “*reconstructing phonology in a piece-meal fashion*” (Wydell, 2012, pag. 11). Chinese dyslexic children show severe difficulties in all the rapid naming tests (digits, colours, pictures and Chinese characters) (Ho et al., 2004). Therefore, in Chinese dyslexic children, the phonological deficit might be associated with anomalous visuo-spatial elaboration (Ho et al., 2004), unlike Italian or English dyslexic children who clearly show no impairment in visuo-spatial processes (Brosnan, Demetre, Hamill, Robson, Shepherd, & Cody, 2002; Jeffries & Everatt, 2004; Kibby, Marks, Morgan, & Long, 2004) and in visuo-spatial short-term memory (Bacon, Parmentier, & Barr, 2013).

Despite the existence of a very large literature on cross-cultural differences, most research investigated the relationship between dyslexia in the Chinese language and dyslexia in the languages with an opaque orthography (i.e., English and Dutch). However, research on the similarities and differences in the level of impairment between dyslexia in Chinese *vs.* transparent orthography languages (as Italian) has been rather scant. Therefore, further research may help understand whether Chinese children with a diagnosis of dyslexia from their own country have (or not) similar difficulties when they have to learn reading a transparent language. From an educational

perspective, such a kind of investigation may be extremely relevant to the construction of more appropriate teaching strategies and interventions.

Accordingly, the main aim of the present research is to compare phonological abilities in Chinese dyslexic children *vs.* Italian dyslexic children. In addition, given that the most part of extant cross-cultural studies focussed on the analysis of phonological abilities (Branum-Martin et al. 2012), hence neglecting the visuo-spatial component of the ability to read and writing, a corollary aim of the present study is to explore similarities and differences in both Chinese and Italian dyslexic children in their visuo-spatial abilities.

Based on extant literature (Ho et al., 2004; Wydell, 2012), according to which the profile of the Chinese dyslexic children is mixed (i.e., they show both phonological and perceptual difficulties), while the profile of Italian dyslexic children is mainly characterized by phonological deficits, it is hypothesized that the Chinese dyslexic children, as compared to Italian dyslexic children, should show greater difficulties in visuo-spatial processes (visual-perceptual abilities and ability of visual-motor integration) and visual-spatial memory abilities, and that both groups should present greater visuo-spatial and phonological difficulties compared with Chinese and Italian children without dyslexia. On the other hand, in accordance with previous literature (Bacon et al., 2013; Brosnan et al., 2002; Jeffries & Everatt, 2004; Kibby et al., 2004), we expect no differences in visuo-spatial abilities between dyslexic and TD Italian children. In addition, as phonological coding in transparent languages is more accessible than the morphological coding of typical Chinese ideograms (Wydell & Butterworth, 1999), it is expected that Chinese dyslexic children are facilitated in learning Italian language reading and writing. To our knowledge, this is the first study that attempts to detect any facilitation Chinese children may experience when learning to read and writing alphabetic characters.

In order to obtain composite scores of phonological abilities, we also measured phonological processes in writing tasks. To date, a number of studies (Berninger, Abbott, Abbott, Graham, & Richards, 2002; Fitzgerald & Shanahan, 2000; Jenkins, Johnson, & Hileman, 2004) suggested that reading and writing involve similar cognitive processes; in addition, a recent study (Ahmed, Wagner, & Lopez, 2014) has documented co-development of reading and writing at the level of words and sentences.

Method

Participants

The sample was composed of 40 fourth and fifth-grade children aged between 9 and 10 years ($M=9.6$; $SD=.496$), matched by gender and attending Italian Primary Schools located in three different cities (Prato, Rome and Palermo). Ten Italian and 10 Chinese dyslexic children were matched by age and gender with their correspondent group with typical development (TD).

All children had normal intelligence on Raven's Standard Progressive Matrices (i.e. with IQ 85 or above). This is a standardized test of nonverbal intelligence. There were five sets of 12 items each in the test. Each item consisted of a target matrix with one missing part. The children were asked to select, from six to eight alternatives, the part that best completed the matrix.

Dyslexic chinese subgroup

The Chinese children were recruited from some specialized centres in three different Italian cities: Palermo, Rome and Prato. The Chinese group had received a diagnosis of developmental dyslexia in China through the administration of the Hong Kong Test of Specific Learning Difficulties in Reading and Writing (HKT-SpLD; Ho, Chan, Tsang & Lee, 2000). The test is typically used to measure dyslexia in children who speak Chinese Mandarin and Cantonese in the primary and secondary schools. The test is composed by 12 sub-tests clustered in four domains: Rapid naming (with the Digit Naming subtest), phonological awareness (with the Rhyme Detection and the Onset Detection subtests), phonological memory (with the two Word Repetition subtests and the Nonword Repetition subtest) and orthographic processing (with the Left/Right Reversal, the Lexical Decision and the Radical position subtests).

In accordance with the diagnostic criteria of developmental dyslexia as used in the HKT-SpLD, children's literacy composite score (on Chinese word reading, spelling, and speeded word reading) and at least one cognitive composite score (on rapid naming, phonological processing, orthographic processing, or visual processing) were at least one standard deviation below their respective age means. Importantly, Chinese children had been attending the Italian school since at least one year before the test.

Dyslexic Italian subgroup

Dyslexic Italian children were recruited from five different rehabilitation centres operating in the area of the city of Palermo, Rome and Prato, which provided diagnoses for all participants following standard DSM-V criteria for Learning Disability (American Psychiatric Association, 2013). The diagnosis was carried out through the MT-Reading Test (Cornoldi & Colpo, 2012) and the Battery for the evaluation of writing and orthographic skills in the primary school (Tressoldi & Cornoldi, 2000).

These instruments showed good psychometric characteristics (Cornoldi & Colpo, 2012; Tressoldi & Cornoldi, 2000) and has been used in several studies in the Italian context (Cecilia, Vittorini, & Di Orio, 2015; Filippello, Marino, Spadaro, & Sorrenti, 2013; Filippello & Spadaro, 2014; Filippello, Spadaro, Sorrenti, Mafodda, & Drammis, 2016; Filippello, Tassone, Spadaro, & Sorrenti, *in press*; Mammarella et al., 2016; Padovani, 2006; Tressoldi & Vio, 2008).

Dyslexic subgroups were composed of children who obtained a score lower than 2 SDs in the reading-writing test.

The inclusion criteria of the dyslexic subgroups were: (a) a diagnosis of developmental dyslexia; (b) an average age of 9,6; (c) a full scale IQ higher than 85 in the Raven's Standard Progressive Matrices. The exclusion criteria were: (a) presence of comorbidity of behavioral disorders, experience of any kind of sensory problems or impairments and mental retardation; (b) presence of identifiable chromosomal or neurological conditions (e.g., history of fragile X, encephalitis, or other known medical conditions associated).

Measures

Reading abilities. To evaluate children's reading abilities the individual accuracy sub-scale of the MT reading test by Cornoldi and Colpo (2012) was used. The sub-test involves reading a text chosen to be consistent with each child's level of education. Scores are assigned on the basis of specific errors the child makes while reading aloud. The score of 1 is assigned to each error in reading a syllable, syllable omissions, word or row omission, syllable or word intrusion, repetition of the same row, and more than 5 sec. pause; a score of 0,5 is assigned to emphasis shift or hesitation.

Writing abilities. To evaluate the phonological processes involved in the writing abilities, 2 different dictation tasks (sentences and a text with homophones) from the Battery for the evaluation of writing and orthographic skills in the primary school (Tressoldi & Cornoldi, 2000) were administered. The tests were consistent with each child's level of education. The task measures the number of phonological errors, out of the number of written words due to inefficient or incomplete development of the alphabetic phase.

Visual-perceptual abilities. Visual-perceptual abilities were tested by means of the Developmental Test of Visual Perception, Second Edition (DTVP-2) by Hammil, Pearson, and Voress (1993). The test is composed by 8 sub-tests: 4 sub-tests measure visual-perceptual abilities (position in the space; figure / background, picture completion, shape constance), which implies the recognition of shape; 4 sub-tests measure the ability of visual-motor integration (eye-hand coordination; copying and reproduction, spatial relationships, visual-motor speed), which require graphic abilities. Correct responses could vary from 0 to 2 on the basis of the criteria set within each test. This instrument showed good psychometric characteristics (Hammil et al., 1993) and has been used in several studies in the Italian context (Germanò et al., 2005; Veggiotti, Bova, Granocchio, Papalia, Termine, & Lanzi, 2001; Gagliardi et al., 2015).

Visual-spatial memory abilities. Finally, visual-spatial memory abilities were assessed through the Corsi Test (Mammarella, Toso, Pazzaglia, & Cornoldi, 2008). The materials for this very well-known test consists of a wooden board on which nine fixed blocks are arranged in random positions. Three sequences were designed for each length. In each trial, children had to reproduce, by using their preferred hand, the sequence of positions previously shown by the experimenter. The score was calculated based on the longest series correctly reproduced with at least 2 out of 3 sequences. This instrument showed good psychometric characteristics (Mammarella et al., 2008) and has been used in several studies in the Italian context (Mammarella, Lucangeli, & Cornoldi, 2010; Mammarella & Pazzaglia, 2010; Mammarella, Pazzaglia, & Cornoldi, 2008).

Procedure

The present study was performed in accordance with the ethical standards of the Helsinki Declaration as revised in 2013. Only participants whose parents provided informed consent took part in the study.

Each child was tested individually; dyslexic children were tested in a clinical context, while typically-developing children were tested in a quiet classroom of the school. Three days after each reading and dictation sessions, visual processing and visual-spatial memory tasks were administered. To avoid sequence effects, all the tasks were fully randomized.

Data analyses

MANOVA with Bonferroni correction, effect size, and *t* tests were calculated on the data using SPSS package. We chose a significance value of $p < .05$.

Results

Group differences

To investigate group differences a MANOVA was conducted with the word reading accuracy, phonological processes involved in the writing abilities, visual-perceptual abilities, visual-motor integration abilities, and visual-spatial memory abilities as the dependent variables and the four participant groups (Chinese dyslexic children, Italian dyslexic children, Chinese TD children, and Italian TD children) as the independent variables. There was a significant multivariate main effect of group [$F(6; 18)=69.571$, $p<.001$, $\eta^2=.923$].

Multiple *t* test comparisons between Chinese dyslexic and Chinese TD subgroups (tab. 1) revealed significant differences in all the observed measures. In particular, Chinese dyslexic children made more errors in word reading [$t(18) = 2.846$, $p < .05$], phonological text task [$t(18) = 2.215$, $p < .05$], and phonological sentence task [$t(18) = 2.997$, $p < .05$], as compared to Chinese TD children. In addition, Chinese dyslexic children showed a worse performance in visual-perceptual abilities [$t(18) = -19.156$, $p < .001$], visual-motor integration abilities [$t(18) = -61.933$, $p < .001$], and visual-spatial memory abilities [$t(18) = -20.804$, $p < .001$].

Tab. 1. Means and SD for each task (Chinese dyslexic children and Chinese TD children)

	Subgroup	N	M	SD
Reading abilities	Chinese dyslexic	10	7,80	4,590
	Chinese TD	10	3,60	,843
TOT errors phonological text- task	Chinese dyslexic	10	5,00	2,539
	Chinese TD	10	2,90	1,595
TOT errors phonological sentence-task	Chinese dyslexic	10	20,30	10,863
	Chinese TD	10	9,50	3,440
Visual-perceptual abilities	Chinese dyslexic	10	36,80	7,036
	Chinese TD	10	81,30	2,111
Visual-motor integration abilities	Chinese dyslexic	10	27,20	5,770
	Chinese TD	10	151,70	2,669
Visual-spatial memory abilities	Chinese dyslexic	10	4,00	,471
	Chinese TD	10	8,60	,516

Multiple *t* test comparisons between Italian dyslexic and Italian TD subgroups (tab. 2) showed that dyslexic children made more errors in the word reading task [$t(18) = 5.39, p < .001$], phonological text-task [$t(18) = 4.789, p < .01$], and phonological sentence-task [$t(18) = 6.9, p < .001$], as compared to TD children. No significant differences emerged in the visual-perceptual [$t(18) = -.782, p > .05$], visual-motor integration [$t(18) = -.073, p > .05$], and visual-spatial memory tasks [$t(18) = -1, p > .05$].

Tab. 2. Means and SD for each task (Italian dyslexic children and Italian TD children)

	Subgroup	N	M	SD
Reading abilities	Italian dyslexic	10	9,10	4,067
	Italian TD	10	2,10	,568
TOT errors phonological text- task	Italian dyslexic	10	11,10	6,280
	Italian TD	10	1,40	1,265
TOT errors phonological sentence-task	Italian dyslexic	10	25,00	9,345
	Italian TD	10	3,80	2,658
Visual-perceptual abilities	Italian dyslexic	10	78,60	3,777
	Italian TD	10	79,80	3,048
Visual-motor integration abilities	Italian dyslexic	10	150,20	3,259
	Italian TD	10	150,30	2,830
Visual-spatial memory abilities	Italian dyslexic	10	7,80	2,098
	Italian TD	10	8,50	,707

Finally, comparisons between Chinese dyslexic and Italian dyslexic subgroups (tab. 3) showed that Chinese dyslexic children made less errors in the word reading task [$t(18) = -3.647, p < .01$], and in the phonological text-task [$t(18) = -2.848, p < .05$], with respect to Italian dyslexic children. However, they performed worse in visual-perceptual [$t(18) = -16.552, p < .001$], visual-motor integration [$t(18) = -58.697, p < .001$], and visual-spatial memory tasks [$t(18) = -5.589, p < .001$]. No significant differences emerged in the phonological sentence-task [$t(18) = -1.037, p > .05$].

Tab. 3. Means and SD for each task (Chinese dyslexic children and Italian dyslexic children)

	Subgroup	N	M	SD
Reading abilities	Chinese dyslexic	10	5,70	2,058
	Italian dyslexic	10	10,10	3,213
TOT errors phonological text- task	Chinese dyslexic	10	5,00	2,539
	Italian dyslexic	10	11,10	6,280
TOT errors phonological sentence-task	Chinese dyslexic	10	20,30	10,863
	Italian dyslexic	10	25,00	9,345
Visual-perceptual abilities	Chinese dyslexic	10	36,80	7,036
	Italian dyslexic	10	78,60	3,777
Visual-motor integration abilities	Chinese dyslexic	10	27,20	5,770
	Italian dyslexic	10	150,20	3,259
Visual-spatial memory abilities	Chinese dyslexic	10	4,00	,471
	Italian dyslexic	10	7,80	2,098

Discussion

The main aim of the present research was to compare phonological abilities (encoding and naming speed) in Chinese dyslexic children vs. Italian dyslexic children. An additional aim of the present study was to explore similarities and differences in both Chinese and Italian dyslexic children in their visuo-spatial abilities. To our knowledge, this is the first study that attempts to identify any difficulty Chinese children may encounter when learning to read and writing alphabetic characters.

Chinese dyslexic children showed lower performance in the reading task and in the text and sentence dictation tasks as compared to Chinese TD

children. They also obtained lower scores in the visual-perceptual, visual-motor integration, and visual-spatial memory tasks. These data are in accordance with previous results in the literature on Chinese dyslexic children's phonological deficits (Wang, Bi, Gao, & Wydell, 2010; Wydell, 2012) and emphasize the presence of visual-processing deficits (Ho et al., 2004), confirming the hypothesis that Chinese dyslexic children are characterized by a mixed impairment in both phonological and visuo-spatial domains (Ho et al., 2004).

Dyslexic Italian children made more errors in the reading task and more phonological errors in the text and in the sentence dictation tasks, as compared to the TD children. In line with literature (Bacon et al., 2013; Brosnan et al., 2002; Jeffries & Everatt, 2004; Kibby et al., 2004), no significant differences emerged in visual-perceptual, visual-motor integration and visual-spatial memory abilities. This result seems to confirm that the profile of Italian dyslexic children is mainly characterized by phonological deficits (de Luca, et al., 2010; Zoccolotti et al., 2005).

Most important for the aims of the present research, as compared with Italian dyslexic children, Chinese dyslexic children made significantly less errors in the reading task and in the phonological dictation task, despite they performed worse in the visual-perceptual, visual-motor integration and visual-spatial memory tasks. In line with the Hypothesis of Granularity and Transparency (Wydell, 2012), these results suggest that when Chinese dyslexic children, who learned a native language characterized by ideograms, approach a transparent language, the correspondence between letter and sound facilitates reading and writing processes. Therefore, if the grapheme-to-phoneme mapping is consistent/transparent, even children with phonological deficits may be able to acquire the grapheme-phoneme correspondence rules.

The present results fill an important gap in the extant literature which mainly focused on either visual or phonological deficits of Chinese dyslexic children, thus failing to provide a full picture of the cognitive profile of Chinese dyslexia (Ho et al., 2004). Indeed, our results clearly showed that Chinese dyslexic children's perceptual deficits do not appear to impair learning of reading and writing in a language with transparent orthography, despite those perceptual deficits represent a fundamental component of Chinese dyslexic children's profile.

The main limitation of the present study refers to the relatively low number of participants, which does not allow deeper statistical analyses (e.g., multiple regression) to investigate, for instance, variables directionality. Such a limitation, however, is due to the great difficulty of recruiting a clinical sample of Chinese dyslexic children who had obtained a diagnosis in their native country and who were in the age range between 9 and 10 years. For sake of methodological validity, we chose not to include in the study Chinese children who had received their diagnosis of dyslexia in Italy, as that choice could have implied the risk of including in the sample false positives. Despite this limitation, the present study represents a first attempt to investigate on how Chinese dyslexic children afford to learn literacy processes of an orthographically transparent language as the Italian language.

The present study may also have important implications for educational contexts. Indeed, despite the existence of a very large literature on cross-cultural differences, most research investigated the relationship between dyslexia in the Chinese language and dyslexia in the languages with an opaque orthography (i.e., English and Dutch). However, research on the similarities and differences in the level of impairment between dyslexia in Chinese *vs.* transparent orthography languages (as Italian) has been rather scant. Therefore, further research may help understand whether Chinese children with a diagnosis of dyslexia from their own country have (or not) similar difficulties when they have to learn reading a transparent language. Due to the growing number of Chinese children attending Italian schools, expanding our knowledge on the above issues may allow to improve teaching procedures in the class. The present results clearly indicate that Chinese dyslexic children outperform Italian dyslexic children in phonological tasks. Therefore, they may take advantage from the same rehabilitation procedures as used for Italian children, thereby favouring important inclusion processes.

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