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Orthographic awareness and its relationship to Chinese word reading and spelling in young bilingual learners with Chinese reading difficulties in Singapore

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Abstract

Impairment in orthographic awareness (OA) is one of the primary cognitive deficits of Chinese reading difficulties (RDs). This study aimed to investigate the development of Chinese OA in elementary school learners in the bilingual context of Singapore by examining structural and functional OA. This study also aimed to evaluate the relationship between the two facets of OA and word reading and spelling in typically developing (TD) learners and learners with Chinese RDs. 218 bilingual TD learners from Grade 3 to 5 and 513 bilingual learners with Chinese RDs from Grade 1 to 6 were assessed on their OA, word reading, and spelling. The results showed that structural and functional OA development has reached a high level in Grade 5 TD learners. As for learners with Chinese RDs, there appears to be stagnated development of OA from the middle to upper elementary grades. The significantly lower OA scores in learners with Chinese RDs compared to TD learners suggested OA impairments. In addition, the difference in functional OA score between TD learners and learners with Chinese RDs was found to be more significant than that of their structural OA score. The regression analysis showed that both structural and functional OA significantly contribute to word reading and spelling for both groups of learners. Functional OA played an increasingly important role in word reading and spelling as learners progressed from lower to upper elementary. Our findings emphasised the importance of targeted intervention in building structural and functional OA in learners with Chinese RDs.

Keywords: Chinese reading difficulties, orthographic awareness, bilingual, word reading, spelling, dyslexia

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INTRODUCTION

Learners with reading difficulties (RDs) typically show reading performance significantly below expected levels and low literacy achievement, given their normal intelligence levels (Swanson et al., 2013). Crosslinguistic studies on monolingual children showed that the underpinning cognitive deficits of RDs vary from language to language. In the literature on children with Chinese RDs and that on developing readers of Chinese in general, orthographic awareness (OA) – a learner's insights into the orthographic rules of Chinese characters (Wei et al., 2014) – has been particularly underscored (Lam & Tsui, 2013; Tong et al., 2019; Wong, 2020). Nevertheless, the issue has been investigated predominantly with native Chinese-speaking children in societies such as Mainland China, Taiwan, and Hong Kong. Many issues related to OA, reading, and spelling remain to be understood in bilingual learners of Chinese, for whom Chinese may not be their home language and primary literacy. How may OA characterise RDs in those bilingual learners? How may different aspects of OA contribute to Chinese literacy in bilingual learners with or without RDs?

The present study aimed to fill this gap by comparing the English-Chinese bilingual learners of Chinese with RDs and those typically developing Chinese learners (hereafter, TD learners) in Singapore. Singapore is a multilingual society with a bilingual education policy that mandates all children to be schooled in English and study a mother tongue as a second language. Singapore thus presents a unique socio-educational context of Chinese literacy learning compared to other Chinese societies (Cheung & Ng, 2003). This study measured two facets of Chinese OA (structural and functional OA) and compared them in bilingual TD learners and learners with Chinese RDs at different grades in elementary schools in Singapore. It also compared the relative importance of those two OA facets in predicting Chinese word reading and spelling among those learners.

Orthographic awareness and its importance in Chinese literacy acquisition

Chinese is a morphosyllabic language where a syllable is mapped onto a character (logograph), and each character comprises different strokes, stroke patterns, and orthographic units. More than 80% of Chinese characters are compound units comprising two or more orthographic units (DeFrancis, 1989; Kang, 1993). The different orthographic units can be organized differently with a fixed set of typographic configurations such as top-down and left-right, half-circle, full-circle, up-left, up-right, etc. (Dai et al., 2007; Lin et al., 2019). The Chinese writing system and orthography properties suggest that OA is important when learning Chinese.

Orthographic skills and knowledge are particularly important in learning Chinese, more so than alphabetic language. Unlike English, Chinese is a language in which the character's pronunciation cannot be readily retrieved from the character's writing. Scholars commonly recognise OA as an essential skill that supports learners of Chinese to form connections between orthography, semantics, and phonology of Chinese characters and subsequently leads to the acquisition of reading and writing skills (Chan et al., 2006; Tan et al., 2005; Zhang, 2017a, 2017b).

According to Wei et al. (2014), OA is the understanding of the orthographic rules of Chinese characters, including the legality of its parts, namely, stroke, radical, and component, and the knowledge of their positional and functional regularities. Based on this definition, OA entails different types and levels of insights into the orthographical features of Chinese characters, and it may be broken down into two broad facets: structural and functional OA. Structural OA refers to basic understanding related to the strokes within the character, the stroke order, and the orientation and placement of the components of a character (Leong & Ho, 2012). On the other hand, functional OA refers to the understanding and knowledge related to the functional components of Chinese characters (e.g., semantic radicals and phonetic radicals) that contribute to character learning.

The orthographic developmental theory proposed by Ho et al. (2003) suggests the development of orthographic knowledge follows this sequence: character configuration knowledge, structural knowledge, radical information knowledge, positional knowledge, functional knowledge, amalgamation, and complete orthographic knowledge. Many subsequent research findings support the development sequence of orthographic awareness. Qian et al. (2015) suggested that children as young as three demonstrated some ability to determine the legality of Chinese characters. By age five, they were able to identify missing or rotated parts within a character. However, their functional OA remained limited. Tong et al. (2017) examined the development of positional, phonetic, and semantic cues of radicals in learners from kindergarten to elementary two and elementary five. The researchers concluded that there was a shift from a structural-based focus to a functional-based focus in learning Chinese at later ages. In the current study, it is hypothesised that the development of structural OA is ahead of the development of functional OA.

Previous studies investigated the relationship between OA and Chinese literacy competency and found the awareness of radical function essential for Chinese literacy development. Ho et al.'s study (2003) revealed that processing radical information, position, and function strongly correlated with Chinese word-reading, sentence-reading comprehension, and word spelling. Other studies found that students who successfully accessed semantic and phonetic radical knowledge showed improvements in reading skills, including word reading and reading comprehension (Cheung et al., 2007; Yeung et al., 2011). In another study, children were taught explicitly how to break down the components of characters and explained that radicals within a character provided information either as the meaning or the pronunciation of the character. As a result, an improvement in the children's ability to write characters and spelling was observed

(Packard et al., 2006). However, these findings largely came from studies on monolingual Chinese-speaking children.

Despite the importance of OA in Chinese literacy development, studies that examine OA on a deeper level, such as differentiating structural and functional OA remained limited. Studies on OA in bilingual learners acquiring biliteracy are even fewer. It is vital that OA is examined in greater depth by examining its structural and functional aspects and how they differentially contribute to Chinese word reading and spelling across elementary grades in the English-Chinese bilingual context of Singapore.

The impairment of orthographic awareness and Chinese reading difficulties

Chinese children with RDs have deficits in a wide range of cognitive and linguistic skills. These children have deficits in morphological awareness, orthographic knowledge, phonological awareness, rapid naming, working memory, and visual skills and moderate deficits in short-term memory and motor skills compared to age-matched typically developing children (Peng et al., 2017).

Growing evidence supports that OA deficit is a significant cause of reading difficulties in Chinese. OA is a primary deficit factor alongside the other multiple cognitive deficits in learners with Chinese RDs. Lin et al.'s study (2020) revealed that learners with dyslexia performed significantly poorer in OA tasks, such as non-character recognition and component recognition, than peers without dyslexia. Similarly, in Ho et al.'s study (2002), learners with dyslexia performed poorer in orthographic tasks such as identifying characters with incorrect orientation, identifying non-characters, and indicating the legal position of radicals.

These studies were nevertheless limited in that while they focused on OA and literacy in children with Chinese RDs, given that OA progresses developmentally and in complexity, they rarely explored how different facets of OA may impact Chinese literacy acquisition differentially across different stages of elementary schooling. Moreover, they did not investigate how the pattern of influence may differ between children with Chinese RDs and their TD peers. In addition, most of these studies were based on monolingual Chinese learners with Chinese RDs.

Research Questions

This study examined the development of two facets of OA (structural and functional) in bilingual TD learners of Chinese and bilingual learners with Chinese RDs in Singapore. It also investigated the relationship between the two facets of OA with two Chinese literacy competencies, namely, word reading and spelling. The following two research questions guided the study.

1. Are there developmental differences in the two facets of OA (structural and functional) in bilingual TD learners and learners with Chinese RDs?

2. Do structural and functional facets of OA differentially predict Chinese word reading and spelling across elementary grade levels in bilingual TD learners and learners with Chinese RDs?

MATERIALS AND METHOD

Participants

Participants included two groups of elementary school English-Chinese bilingual learners of Chinese in Singapore: learners with RDs and TD learners. Following the bilingual education policy in Singapore, both groups received formal literacy instruction in both Chinese and English in mainstream schools; yet they showed contrasting reading development profiles.

The group with Chinese RDs consisted of 513 children who were identified by their mainstream schools as struggling with reading in Chinese and were thus referred to DAS for extra-curricular Chinese literacy support provided by specialists there. Chinese language teachers in mainstream schools reported that those children's Chinese language achievement was below grade level despite receiving remedial instruction at school. Parents also reported learning difficulties in Chinese, such as difficulties preparing for the spelling test and needing extra support from private Chinese tuition services. Concomitantly, those children were diagnosed as having dyslexia (in English) by educational psychologists using standardized English literacy assessments in Singapore. Formal diagnosis of Chinese reading difficulties, however, was not conducted by educational psychologists due to the lack of similar standardized Chinese literacy assessments in the country. For all children, IQ was within the normal range. About 5% (N = 35) had other accompanying learning-related difficulties, such as attention deficit and hyperactivity disorder. None had any sensory or neurological disorders.

Those children comprised 62.4% male (N = 320) and 37.6% female (N = 193). They were predominantly (96.1%) Chinese ethnicity, while the rest were of Eurasian, Indian, Malay, Filipino, or other ethnicities. In the Singapore public education system, elementary schools are referred to as primary schools, which include six years of education from Primary 1 to 6 (or Grade 1 to 6). Of the 513 children, 99, 102, 128, 89, 62, and 33 were in Grades 1 to 6, respectively. Their age at the date of the assessments described below was between 6.13 years and 12.94 years (M = 9.00, SD = 1.50).

For comparison purposes, data was also drawn from a group of TD learners (N = 128) who participated in a previous study in Singapore. Those elementary school students were not reported to experience reading difficulties in Chinese; neither were they diagnosed to have dyslexia in English or reported to have any learning difficulty in school. They comprised 62 females and 66 males. Participants were from three grades: Grade 3 (*N* = 42), Grade 4 (*N* = 42), and Grade 5 (*N* = 44); and their ages ranged from 8.83 to 12 years old (*M* = 10.38, *SD* = 0.84). Data was not collected for children in Grades 1, 2, and 6 in that study. All participants were of Chinese ethnicity.

Assessments and procedure

All tests described below, including orthographic awareness, word reading, and word spelling, were adopted from Tan et al.'s (2018) Chinese Literacy Assessment tool, previously validated for Singapore school learners. Learners with Chinese RDs were assessed between October 2017 and November 2021, whereas TD learners were assessed between August 2016 and October 2016. During the different data collection periods for the two groups, two Chinese language curriculums (or the national curriculum for Chinese) were implemented: the Chinese Language Syllabus for Primary Schools 2007 and 2015. The two curriculums, however, were broadly similar in learning goals for the skills assessed in the participants for the present study (MOE, 2015).

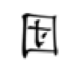
The tests were administered individually to each participant by trained research assistants who underwent test administration and scoring training. For learners with Chinese RDs, about half (*N* = 265) were tested in a quiet room between October 2017 and February 2020; the other half (*N* = 248) were tested online between March 2020 and November 2021 due to the COVID-19 pandemic restrictions. In both data collection modes, the assessments were conducted in a one-to-one setting, with the assessor being able to interact and look at the child's response directly or through a live camera. None of the measures showed any significant difference between the two assessment conditions for any grade (i.e., 1-6), except functional OA for Grades 4 and 5 and word reading for Grade 5 ($p < .05$). This suggested that the influence, if any, of different assessment conditions, was very limited.

Orthographic awareness task

Orthographic awareness was evaluated using a character decision task (Tan et al., (2018). The task had 30 items, 19 non-characters as test items, and 11 real characters as filler items. The real characters were very low in frequency, so participants would unlikely have had prior exposure. Ten Chinese character structures, such as left-right (e.g., 扞), left-middle-right (e.g., 御), up-down (e.g., 宂), up-middle-down (e.g., 荛), left-down (e.g., 廷), up-left (e.g., 屏), enclosure (e.g., 囵), up-left-down (e.g., 匡), left-up-right (e.g., 夙), and left-down-right (e.g., 函) were covered (see Table 1).

The items assessing structural OA (n = 10) are non-characters with visual-spatial violations, such as a whole-character mirrored (e.g., ) or a radical mirrored

Table 1. Violations of the non-characters in the orthographic awareness test

	Character Structure	Violation	Example
1	Left-right	Radical position	
		Radical mirror	
2	Left-middle-right	Character mirror	
		Radical position	
3	Up-down	Radical position	
		Radical mirror	
4	Up-middle-down	Radical position	
		Radical mirror	
5	Enclosure	Character mirror	
6	Up-left-down	Radical combinations	
		Radical mirror	
7	Left-down	Character mirror	
		Radical position	
8	Up-left	Radical combinations	
		Character mirror	
9	Left-down-right	Radical combinations	
		Character mirror	
10	Left-up-right	Radical mirror	

(e.g. ). The items assessing functional OA (*n* = 9) are non-characters with either a violation of the positional or combination rules of functional components such as semantic radicals (e.g.,  and ). Participants were shown one item at a time and decided whether the item was a character or a non-character. The order of the test items was randomized for each participant. One point was awarded when the participant correctly identified a non-character. The raw scores were then converted to the percentage of correct responses for each facet. Tan et al. (2018) reported that the reliability of the overall OA test had a Cronbach's alpha of .643. In the current study, based on the data collected from the 513 learners with Chinese RDs, the structural and functional test items showed moderate or satisfactory internal consistency, with Cronbach's alpha being .740 and .623, respectively.

Word reading task

Word reading was measured with the word recognition task in Tan et al. (2018). The task had 100 test items selected from the Dictionary of Frequently Used Chinese Characters Encountered by Students in Singapore (Lin et al., 2014). Participants were asked to read aloud a Chinese character. For each correct character reading, a point was awarded. An example item and a trial item were administrated first to help students familiarise themselves with the test requirement. The task was stopped if the participants could not read seven consecutive characters. Participants only had 20 seconds to attempt each character. Tan et al. (2018) reported a Cronbach's alpha of .97 for this task. Independent samples t-tests showed that for all three grades (i.e., 3-5), the word reading scores of the learners with RDs were significantly lower than those of the TD learners (all ps < .001).

Word spelling task

The word spelling tasks had 50 two-character words arranged in order of increasing difficulty (Tan et al., 2018). The words were selected from the Dictionary of Frequently Used Chinese Vocabulary Words Encountered by Students in Singapore (Wu et al., 2013). Participants listened to the word being read out, followed by a sentence to provide context, and then the word again for clarity. They had 30 seconds to attempt each word. One point was awarded for each character spelled correctly, with a maximum of two points for each item. The test would stop if a participant consecutively scored 0 for seven items. In an earlier study by Tan et al. (2018), Cronbach's alpha for this task was .967. Independent samples t-tests showed that for all three grades, the spelling scores of the learners with RDs were significantly lower than those of the TD learners (all ps < .001).

Data analysis

To answer the first research question, three sets of ANOVAs were conducted. Two sets of 2 (OA facet) x 3 (grade) mixed ANOVAs were first performed for TD learners and learners with RDs, respectively. For TD learners, there were three grades (i.e., 4-6).

Learners with RDs from all grades were included but were regrouped into three stages of elementary schooling, namely lower elementary grades (Grade 1 and 2; $N = 201$), middle elementary grades (Grade 3 and 4; $N = 217$), and upper elementary grades (Grade 5 and 6; $N = 95$). A further 2 (OA facet) x 3 (grade) x 2 (learner type) three-way mixed ANOVA was subsequently carried out that aimed to additionally compare RDs and TD learners. For this ANOVA, only grades 3-5 were included for learners with RDs to match the grades available in the TD group.

To answer the second research question, a Pearson correlation analysis was first performed to assess the relationship between age, structural OA, functional OA, word reading, and word spelling in TD learners and learners with Chinese RDs. The correlation analysis was followed by a set of hierarchical multiple regression analyses to assess how structural and functional OA may distinctly predict word reading and spelling in TD learners and learners with Chinese RDs in different grades. In all hierarchical regression analyses, age was entered in the first step as the control variable, and structural OA and functional OA were subsequently entered as the second and the last step, respectively.

RESULTS

Comparing orthographic awareness

OA facets and TD learners in grade three to five

The means and standard deviations of different OA facets (as well as word reading and spelling scores) for the three grades of TD learners are shown in Table 2. Two-way ANOVA showed no statistically significant interaction between grade and facet of OA, $F(2, 125) = 0.121$, $p = .886$, partial $\eta^2 = .002$. The main effect of OA facets was not significant, $F(1, 125) = 3.37$, $p = .069$, partial $\eta^2 = .026$. The main effect of grades showed a statistically significant difference between the three grades, $F(2, 125) = 6.05$, $p = .003$, partial $\eta^2 = .088$. The Tukey post-hoc analysis showed that the OA of grade 5 learners was significantly higher than that of grade 3 ($p = .005$) and grade 4 ($p = .020$). However, the OA difference between grade 3 and 4 learners was not significant ($p = .870$).

OA facets and learners with RDs in lower, middle, and upper elementary grades

The means and standard deviations of different OA facets (as well as word reading and spelling scores) in the six grades and three grade levels (lower, middle, and upper elementary) are shown in Table 2. The two-way mixed ANOVA result showed no statistically significant interaction between elementary grade levels and OA facets, $F(2, 510) = 0.091$, $p = .913$, partial $\eta^2 = .000$. The main effect of OA facet was significant, $F(1, 510) = 150.28$, $p < .001$, partial $\eta^2 = .228$. It suggested that averaged across the three elementary grade levels, learners' functional OA scores were significantly lower than their structural OA scores. The main effect of elementary grade levels also showed

Table 2. The descriptive data of the two groups of learners: Typically developing learners and learners with Chinese reading difficulties

	Typical developing learners					Learners with Chinese reading difficulties				
Grade	*N*	Structural OA *M(SD)*	functional OA *M(SD)*	Reading *M(SD)*	Spelling *M(SD)*	*N*	Structural OA *M(SD)*	Functional OA M(SD)	Reading *M(SD)*	Spelling *M(SD)*
1	-	-	-	-	-	99	.639 (.248)	.526 (.231)	9.09 (9.42)	3.84 (5.66）
2	-	-	-	-	-	102	.717 (.230)	.568 (.214)	14.79 (12.27)	6.93 (7.70)
3	42	.874 (.108)	.902 (.121)	63.10 (28.55)	46.36 (28.52)	128	.791 (.207)	.670 (.203)	20.95 (15.62)	11.63 (9.59)
4	42	.860 (.098)	.904 (.164)	65.02 (36.54)	44.02 (32.18)	89	.873 (.162)	.726 (.199)	27.84 (17.13)	15.09 (13.38)
5	44	.939 (.075)	.959 (.064)	79.73 (28.34)	61.76 (30.85)	62	873 (.162)	.710 (.225)	32.16 (22.17)	22.87 (18.21)
6	-	-	-	-	-	33	.888 (.136)	.784 (.184)	36.82 (27.56)	31.00 (27.36)
Lower (G1&2)	-	-	-	-	-	201	.679 (.242)	.548 (.223)	11.99 (11.30)	5.41 (6.93)
Middle (G3&4)	-	-	-	-	-	217	.824 (.194)	.693 (.203)	23.78 (16.57)	14.20 (11.69)
Upper (G5&6)	-	-	-	-	-	95	.878 (.153)	.736 (.214)	33.78 (24.14)	25.69 (22.03)

a statistically significant difference, $F(1, 510) = 53.43$, $p < .001$, partial $\eta^2 = .173$. The Tukey post-hoc analysis revealed that the lower elementary grades' OA was significantly lower than the middle elementary grades' ($p < .001$) and upper elementary grades' ($p < .001$). There was no significant difference in OA between the middle and upper elementary grades ($p = .066$).

Learner types, grades, and OA facets

The 2 (OA facet) x 3 (grade) x 2 (learner type) mixed ANOVA did not show a statistically significant three-way interaction, $F(2,401) = 0.221$, $p = .802$, partial $\eta^2 = .001$. There was a statistically significant two-way interaction between OA facet and learner type, $F(1, 401) = 57.57$, $p < .001$, partial $\eta^2 = .126$. All other two-way interactions were not statistically significant ($p > .05$). The mean functional OA scores were higher in TD learners than in learners with Chinese RDs, with a mean difference of 0.220, 95% CI [0.181, 0.259], $p < .001$. The mean structural OA scores were higher in TD learners than those with Chinese RDs, with a mean difference of 0.056, 95% CI [0.021, 0.090], $p = .002$. Averaged across three grades, the gap between the two groups of learners (TD learners > learners with RDs) on OA was more salient for the functional aspect than the structural aspect.

Effects of different OA facets on word reading and spelling in TD learners and learners with Chinese RDs

Bivariate correlations

Table 3 presents the Pearson correlations between age at assessment, overall OA, structural OA, functional OA, word reading, and word spelling for the 128 TD learners (above the diagonal) and 513 learners with Chinese RDs (below the diagonal). For both groups of learners, all correlations were statistically significant (all *p*s < .001). Notably, OA was significantly correlated with both word reading and spelling for TD learners (*r*s = .450 and .410, respectively) as well as the learners with RDs (*r*s = .646 and .617, respectively).

OA facets predict word reading in TD learners and learners with RDs

A set of hierarchical multiple regression was run to test whether structural OA and functional OA independently predicted word reading, controlling for age, in TD learners. As shown in the bottom panel of Table 4, adding structural OA to the prediction of word reading led to a statistically significant increase (about 21%) in R^2. The addition of functional OA led to a further statistically significant increase (about 15%) in R^2. In the full regression model, the unique effect of both OA facets was significant ($\beta = .340$ and $\beta = .420$, respectively), with that of functional OA being stronger. These results indicate that structural and functional OA independently and significantly contributed to word reading in TD learners, with the contribution of functional OA being stronger.

Table 3, Pearson correlation for main study variables in typically developing learners and learners with Chinese reading difficulties

RDs^TD	Age	OA	Structural OA	Functional OA	Word Reading	Word Spelling
Age	-	.277***	.265***	.193***	.250***	.362***
OA	.449***	-	.791***	.844***	.646***	.617***
Structural OA	.411***	.870***	-	.340***	.505***	.507***
Functional OA	.356***	.843***	.468***	-	.551***	.504***
Word Reading	.475***	.450***	.383***	.388***	-	.854***
Word Spelling	.526***	.410***	.336***	.368***	.930***	-

*Note. TD: Typical developing learners (above the diagonal), N = 128; RDs: Learners with Chinese reading difficulties (below the diagonal), N = 513. *** p < .001*

The same regression analysis was conducted on word reading for learners with Chinese RDs from the lower, middle, and upper elementary grades (Table 4). In the lower and middle elementary grades, the addition of structural OA and then functional OA to the prediction of word reading scores led to a statistically significant increase (6.5% and 2.3% in lower elementary and 7.7% and 3.1% in middle elementary, respectively) in R^2. In the upper elementary grades, the unique effect of structural OA (β = .087), as opposed to that of functional OA (β = .289), was not significant. Taken together, these findings suggested that for learners with Chinese RDs, functional OA remained as a significant and robust predictor of word reading across all elementary grades.

OA facets predict word spelling in TD learners and learners with RDs

The same set of hierarchical regression analyses reported on word reading was conducted on word spelling for the two groups of learners. For TD learners, the overall pattern for the independent contribution of functional and structural OA facets was very similar to that for word reading. The addition of structural OA and functional OA to the prediction of word spelling led to a statistically significant increase (18.2% and 10.7%, respectively) in R^2 (see the bottom panel of Table 5). Both structural (β = .330) and functional OA (β = .350) independently contributed to word spelling in TD learners (both *p*s < .001), with the contribution of the functional aspect being slightly stronger.

Table 4. Hierarchical multiple regression predicting word reading from age, structural OA and functional OA in learners with Chinese reading difficulties and typically developing learners

	R^2	ΔR^2	β (p)
Learners with Chinese RDs			
	Lower Grades (Grade 1 & 2) (N = 201)		
Age	0.084	0.084	0.212 (.002)**
Structural OA	0.149	0.065	0.194 (.010)*
Functional OA	0.172	0.023	0.169 (.020)*
	Middle Grades (Grade 3 & 4) (N = 217)		
Age	0.053	0.053	0.141 (.032)*
Structural OA	0.129	0.077	0.222 (.001)**
Functional OA	0.160	0.031	0.190 (.005)**
	Upper Grades (Grade 5 & 6) (N = 95)		
Age	0.011	0.011	0.063 (.527)
Structural OA	0.049	0.039	0.087 (.416)
Functional OA	0.119	0.070	0.289 (.009)**
Typically Developing Learners			
	Grade 3-5 (N = 128)		
Age	0.060	0.060	0.080(.270)
Structural OA	0.270	0.210	0.340 (<.001)***
Functional OA	0.420	0.150	0.420 (<.001)***

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

Table 5. Hierarchical multiple regression predicting word spelling from age, structural OA, and functional OA in 513 learners with Chinese reading difficulties and 128 typically developing learners

	R^2	ΔR^2	β (p)
Learners with Chinese Reading Difficulties			
	Lower Grades (Grade 1 & 2) (N = 201)		
Age	0.062	0.062	0.182 (.009)**
Structural OA	0.110	0.048	0.145 (.057)
Functional OA	0.141	0.032	0.197 (.009)**
	Middle Grades (Grade 3 & 4) (N = 217)		
Age	0.073	0.073	0.206 (.002)**
Structural OA	0.111	0.038	0.147 (.036)*
Functional OA	0.133	0.022	0.160 (.021)*
	Upper Grades (Grade 5 & 6) (N = 95)		
Age	0.043	0.043	0.168 (.088)
Structural OA	0.081	0.038	0.089 (.396)
Functional OA	0.146	0.065	0.278 (.010)*
Typical Developing Learners			
	Grade 3-5 (N = 128)		
Age	0.131	0.131	0.210 (.005)**
Structural OA	0.313	0.182	0.330 (< .001)***
Functional OA	0.420	0.107	0.350 (< .001)***

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

For learners with RDs, as shown in Table 5, the addition of structural OA to the prediction of word spelling led to a statistically significant increase in R^2 in middle elementary grades but not in lower and upper elementary grades. Over and above age and structural OA, functional OA, however, was a significant, unique predictor of word spelling for all three elementary grade levels. The results suggested that functional OA plays a vital role in word spelling, as in the case of word reading, for learners with Chinese RDs throughout elementary school.

DISCUSSION

The present study investigated the development of OA and the relationship of different OA facets with Chinese word reading and word spelling in bilingual learners aged twelve and under, including TD learners and learners with Chinese RDs.

Orthographic awareness development in bilingual learners of Chinese

The first goal of the present study was to understand if there were developmental differences in two facets of OA (structural and functional OA) in bilingual learners of Chinese, including both TD learners and learners with Chinese RDs. The results showed significant developmental OA differences in TD learners. The OA score increased as learners progressed from grade 3 to grade 5. However, Tukey's post-hoc analysis revealed no significant difference in OA between grade 3 and grade 4 learners. There was also no significant difference between structural and functional OA in all three grades. It seems that structural and functional OA development has already reached a high level (ceiling) in grade 5 TD learners.

The results showed significant developmental OA differences in learners with Chinese RDs across the three elementary levels (lower, middle, and upper elementary). The OA score increased as learners progressed from the lower, middle, to upper elementary. The Tukey post-hoc analysis revealed that OA scores in the lower elementary grades were significantly lower than in the middle and upper elementary grades. The OA scores for learners with Chinese RDs were also significantly lower than those of TD learners in all three grades (Grade 3, 4, and 5).

Furthermore, there appears to be stagnated OA development from the middle to upper elementary grades in learners with Chinese RDs as there was no significant difference in OA between the middle and upper elementary grades, and the performance in upper elementary grades did not reach the ceiling (Table 2). In addition, the results showed that the difference in functional OA between the two reader types was more significant than that of structural OA. Based on the findings, we postulate that continued and sustained instruction in OA would be necessary for bilingual learners with Chinese RDs to help them overcome their impairments in OA and support literacy acquisition, with a greater focus on the functional aspect of OA.

These findings on OA in bilingual learners of Chinese seem to largely corroborate those on monolingual learners. For example, there was evidence to support the developmental progression of OA in typically developing pre-schoolers to school-age children (Qian et al., 2015; Tong, Tong, et al., 2017). There was also evidence to support that at the elementary school ages, there was a developmental difference where typical children first acquire structural knowledge in Grade 1 and 2 and then proceed to gain an understanding of the functional position and meaning of radicals as they grow older (Ho, Ng, & Ng, 2003; Lam & Tsui, 2013; Shu & Anderson, 1999). It is evident from the current study that there is a developmental progression of OA, and developmental differences exist in the two facets of Chinese OA, indicating that learners first acquire structural OA and then gradually acquire functional OA.

The result of the present study on bilingual learners of Chinese is consistent with previous monolingual studies that found that Chinese learners with dyslexia have deficits in Chinese OA. For example, Lee and Tong (2020) found that children with dyslexia are less sensitive to sub-lexical radicals' positional and functional regularity than typically developing children.

Contribution of different orthographic awareness facets to word reading and spelling

The finding that OA significantly predicted Chinese reading and spelling for TD learners and learners with Chinese RDs is consistent with the hypothesis, suggesting the importance of OA for learning to read Chinese as a mother tongue and second school language in Singapore. This general importance of OA found in bilingual learners of Chinese in Singapore corroborates the findings of previous studies that examined the role of OA in Chinese reading and spelling acquisition when learning Chinese as the first language (Cheung et al., 2007; Ho, Ng, et al., 2003; Li et al., 2012; Lin et al., 2019; McBride-Chang & Suk-Han Ho, 2005; Tong et al., 2009; Yeung et al., 2016; Yeung et al., 2011). The finding is also consistent with Wong (2020), whose study suggests that OA is key for students learning Chinese as a second language.

In the current study, the variance explained by the structural or functional OA in word reading ranged from 2.3% to 7.7% (Table 4), and the variance explained by structural or functional OA in word spelling ranged from 2.2% to 6.5% (Table 5). With the progression of developmental stage, an increased influence of OA, especially functional OA, on word reading and spelling was observed. There is a resonance between current study and previous studies on the increasing influence of OA on word reading and spelling as young learners develop.

In other studies, the variance in word reading accounted for by OA ranged from 2% (Li et al., 2012; Kindergarten), 5.7% (Tong et al., 2009; 3rd-year Kindergarten), 9.7% (Yeung et al., 2011; Grade 1), 24.01% (Wong, 2020; Grade 4 Chinese as Second Language Learners) to 36% (Yeung et al., 2016; Grade 2-4), and the variance in word spelling accounted for by OA ranged from 2.7% (Yeung et al., 2011, Grade 1), 4.0% (Tong et al., 2009; 3rd-year Kindergarten), to 15% (Yeung et al., 2016; Grade 2-4).

In the following section, the similarities and differences of the regression results are discussed between the aspects below: structural OA and functional OA; TD learners and learners with Chinese RDs; learners in different stages of elementary school; and word reading and spelling.

Between structural OA and functional OA

Structural and functional OA was found to statistically significantly contribute to word reading and spelling in all three grades for TD learners. For learners with Chinese RDs, the structural OA statistically significantly contributed to word reading in the lower and middle elementary grades but not in the upper elementary grades, while functional OA statistically significantly contributed to reading throughout elementary school. On the other hand, the functional OA statistically significantly contributed to word spelling throughout elementary grades. The functional OA, as compared to the structural OA, seems to play a more salient, important, and sustained role in Chinese literacy acquisition among learners with Chinese RDs.

Between TD Chinese learners and learners with Chinese RDs

The present study revealed that the total amount of variance explained in literacy outcome by OA was smaller in learners with Chinese RDs than in TD learners in both word reading and spelling. While OA was also predictive of literacy abilities in the learners with Chinese RDs, the effect was smaller, showing that individual differences in literacy in bilingual learners with Chinese RDs were affected by their OA impairments alongside other factors.

Between different stages of elementary school

The size of the influence of OA on word reading and spelling seemed to be affected by the developmental stage of the learners. The functional OA contributes more significantly to word reading and spelling than structural OA in upper elementary learners (Grade 5 & 6) than in middle elementary (Grade 3 &4) and lower elementary (Grade 1 & 2) learners. This result is likely related to the development sequence of orthographic awareness in kindergarten and elementary school. In kindergarten to lower elementary, learners first develop structural OA. Hence, the impact of structural OA is likely to be stronger at the early stage of reading acquisition. As children progress from lower primary to middle and upper primary, their orthographic analysis shifts to the positional and specific knowledge of the radicals. Hence, functional OA becomes more critical for word reading and spelling.

Between word reading and spelling

The result also indicated that in both learner groups (more obviously in learners with Chinese RDs), the influence of structural and functional OA in word reading was more consistent and significant than in word spelling. One potential explanation for this difference might be related to the different cognitive processes related to the two literacy tasks. Spelling is regarded as more complex than reading (Bosman & Orden, 1997; Tong, McBride, et al., 2017). Different cognitive functions, such as orthographic awareness, morphological awareness, phonological awareness, and rapid naming, may have different levels of significance relating to the two types of literacy tasks (Chung & Lam, 2020).

In summary, the present study extended the understanding of OA in Chinese and literacy development in previous studies by distinguishing the facets of OA and examining its impact and contribution to reading and spelling abilities. The present study highlighted the particular importance of functional OA because this OA facet was consistently predictive of word reading and spelling in all groups, regardless of the reading competency and grade levels across elementary school. The differentiation in OA facets and its analysis related to literacy acquisition may have an instructional value in intervention for TD learners and learners with Chinese RDs. The salient role of functional OA in predicting word reading and spelling among learners with Chinese RDs in the upper elementary grades suggests that OA-focused intervention for Chinese language learning for learners with Chinese RDs should be sustained in elementary school, with a strong focus on functional OA to support word recognition and spelling.

LIMITATIONS & FUTURE STUDIES

Despite filling a notable gap in the literature with its focus on OA and bilingual learners of Chinese with RDs, the present study has a few limitations. To begin with, the OA task, which was drawn from Tan et al.'s study (2018), did not include the assessment of learners' specific radical knowledge, such as the meaning of semantic radicals and the pronunciation of phonetic radicals. Consequently, the findings on the developmental pattern with a close-to-ceiling performance from Grade 3 TD learners may be limited. It also suggests that the role of functional OA, despite the salient roles revealed in word reading and spelling, could have been underestimated in the study of bilingual learners of Chinese. Furthermore, the number of items in each subset of orthographic awareness may not be sufficient. The small number of items in each category may also explain the moderate reliability of the test.

The present study did not concurrently investigate other skills underpinning word reading and spelling in Chinese, including oral literacy, morphological awareness, rapid naming, and phonological awareness, which are noted in the literature to underpin dyslexia in Chinese monolinguals. This limitation should be addressed in the future studies to generate a more comprehensive understanding of how multiple cognitive linguistic factors may interplay in explaining Chinese reading and spelling difficulties in bilingual learners.

Due to pandemic restrictions, the present study used two different data collection modes in learners with Chinese RDs, face-to-face and online. Although a mean comparison of the main variables revealed only three small but significant differences among the 24 pairs of comparisons, the learners' experiences during the assessments may be very different, and overall results should still be interpreted with caution.

CONCLUSION

This study generated important findings on the development of OA and the importance of different facets of OA in word reading and spelling in bilingual Chinese learners, especially those with Chinese RDs. Bilingual TD learners seem to achieve excellent structural and functional OA by middle grades in elementary school through regular school-based instruction and literacy experiences. On the other hand, bilingual learners with Chinese RDs, despite receiving regular school-based instruction in Chinese, could have significant OA impairment throughout elementary school, especially in the functional aspect of OA. Among learners with Chinese RDs, functional OA played an increasingly important role than structural OA for both word reading and spelling when learners progressed through lower elementary to middle and upper elementary. These findings collectively seem to lead to a conclusion that for bilingual learners with Chinese RDs, continued efforts to improve their OA and bridge deficits, especially in the functional OA aspect, through interventions across elementary school years would help them develop literacy skills.

ETHIC APPROVAL AND INFORMED CONSENT

This research involved human subjects and obtained approval from an independent ethics committee, the Dyslexia Association Singapore Research Committee. The approval number was RC-22-03.

This research was based on existing data, hence informed consents from the subjects were waived by the ethics committee.

STATEMENTS AND DECLARATIONS

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Catherine Chunhong Ni and Yun Rui Kong. The first draft of the manuscript was written by Yun Rui Kong, Catherine Chunhong Ni and Chien Ling Loo, and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Competing interests

The authors report there are no competing interests to declare.

Data availability statement

The data that support the findings of this study are available from the corresponding author, [Ni, C.], upon reasonable request.

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