

Neural Mechanisms of English Phonological processing in Chinese Children with English Reading Impairment

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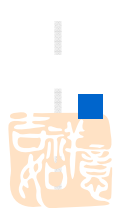
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Introduction




- A large body of research has proved that phonological skills are important to reading acquisition and development (e.g., Wagner et al., 1994).
- Deficits in phonological skills have also been found to be the most prominent symptom and source of developmental dyslexia (Beaton, 2004; Paul et al., 2006; Ramus et al., 2003).






- Little is known about the development of phonological or orthographic skills in children with English as their second language (ESL) .
- It is therefore important to understand whether children's different linguistic backgrounds influence the process of learning to read in English and whether the underlying neural mechanisms for reading sub skills, such as phonological or orthographic processing, are similar in children with English as their first language compared to ESL children.





- Previous research has suggested that educational variables such as program type, method of instruction, socioeconomic status or characteristics of the native language of the child may impact literacy proficiency in ESL children (August and Hakuta, 1997; Fitzgerald, 1995; Hakuta, 1999; Tabors and Snow, 2001).

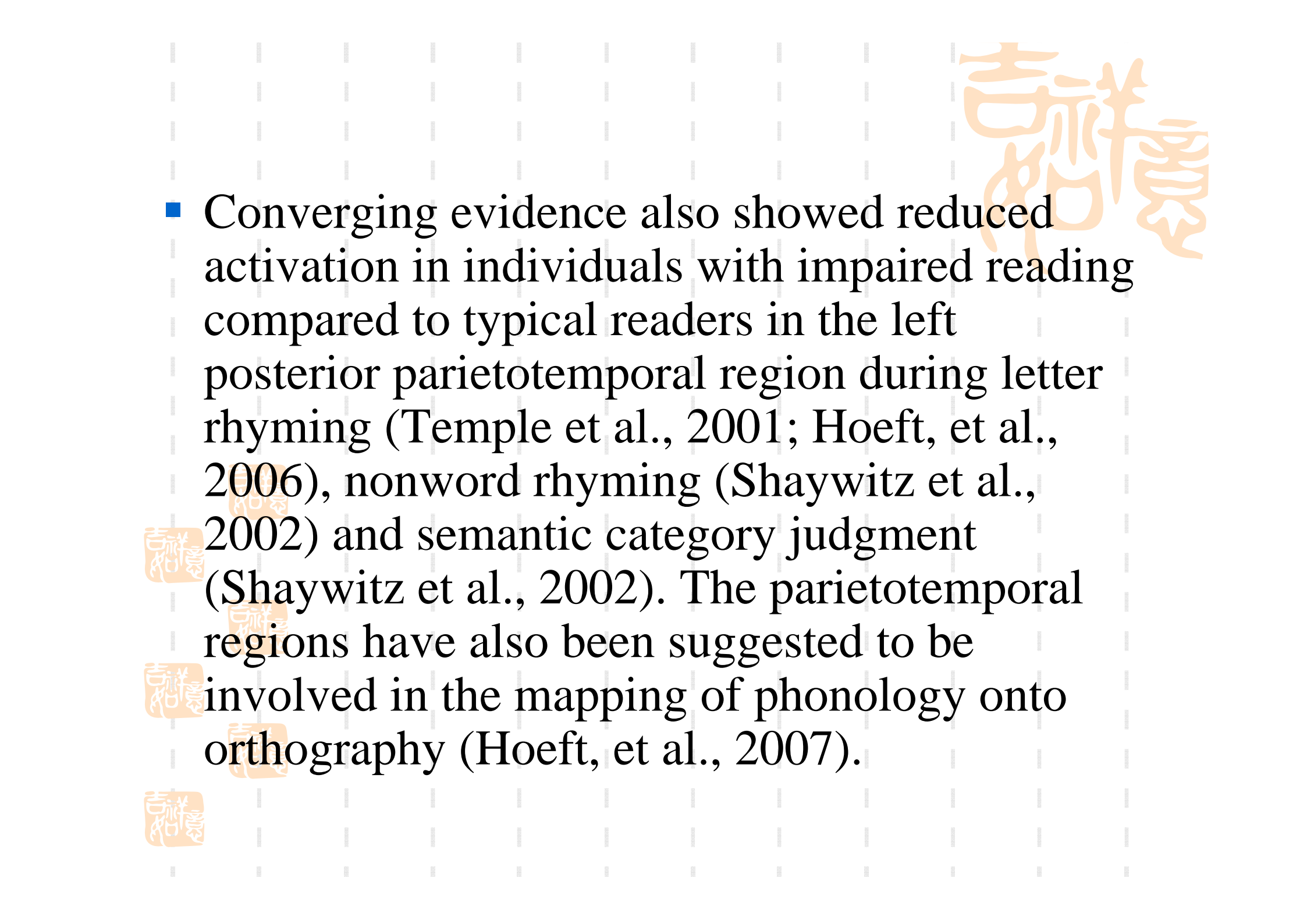


- However, no study to date has compared the underlying neural mechanisms of phonological and orthographic processing in ESL children with and without reading impairment in English.



- The neural correlates of phonological processing have been identified in typically developing English (as the first language) speaking readers (L1) .
- which is a dorsal pathway in the left-hemisphere including the inferior parietal lobule and the posterior aspect of the superior temporal gyrus (see review, Pugh et al., 2000; Temple, 2002).

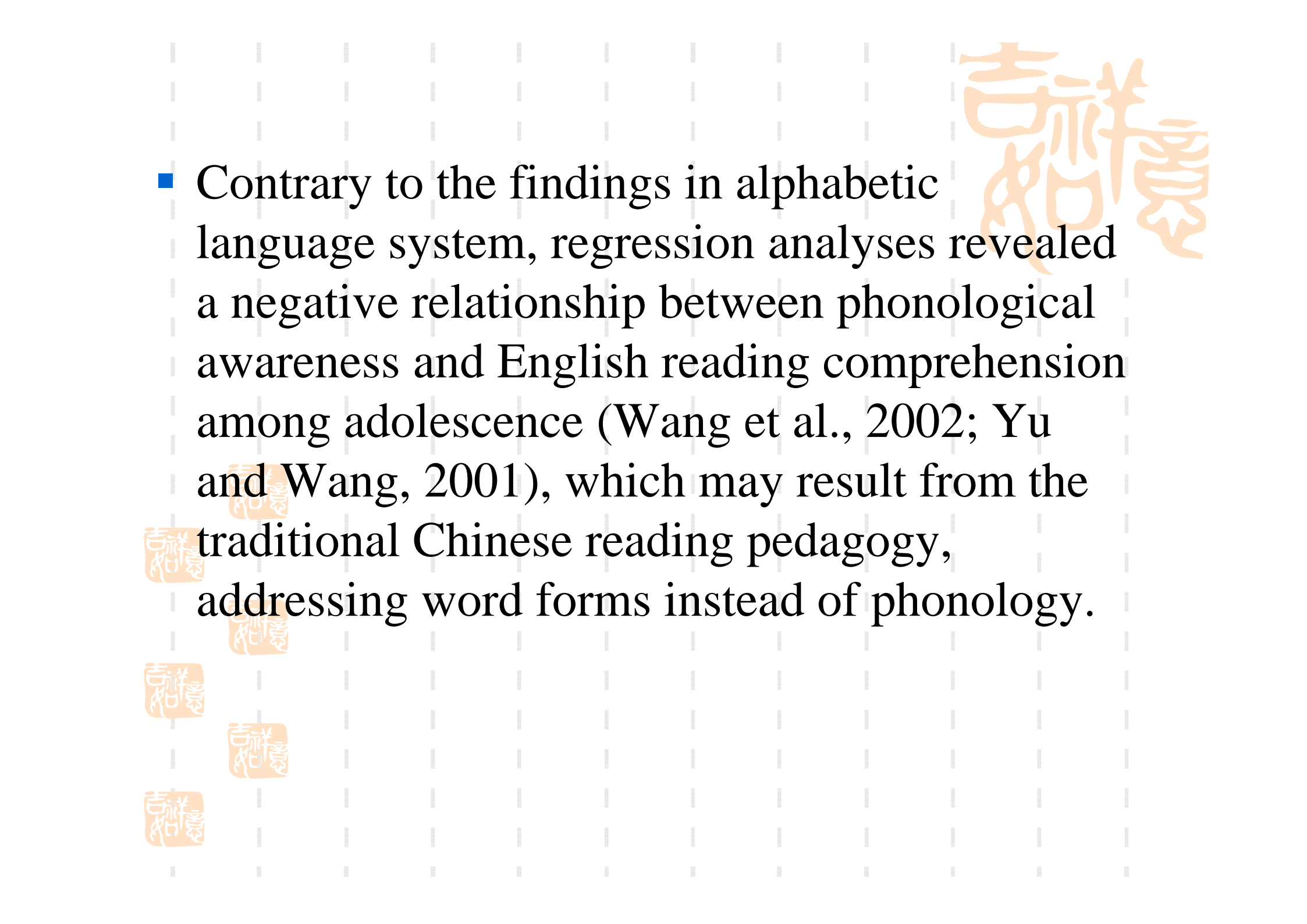


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- Converging evidence also showed reduced activation in individuals with impaired reading compared to typical readers in the left posterior parietotemporal region during letter rhyming (Temple et al., 2001; Hoeft, et al., 2006), nonword rhyming (Shaywitz et al., 2002) and semantic category judgment (Shaywitz et al., 2002). The parietotemporal regions have also been suggested to be involved in the mapping of phonology onto orthography (Hoeft, et al., 2007).



- Most research studies exploring difficulties with English reading in Chinese children have utilized behavioral measures of phonological processing but the results are somewhat controversial (Wang, et al., 2002; Yu and Wang, 2001; Ho and Fong, 2005).

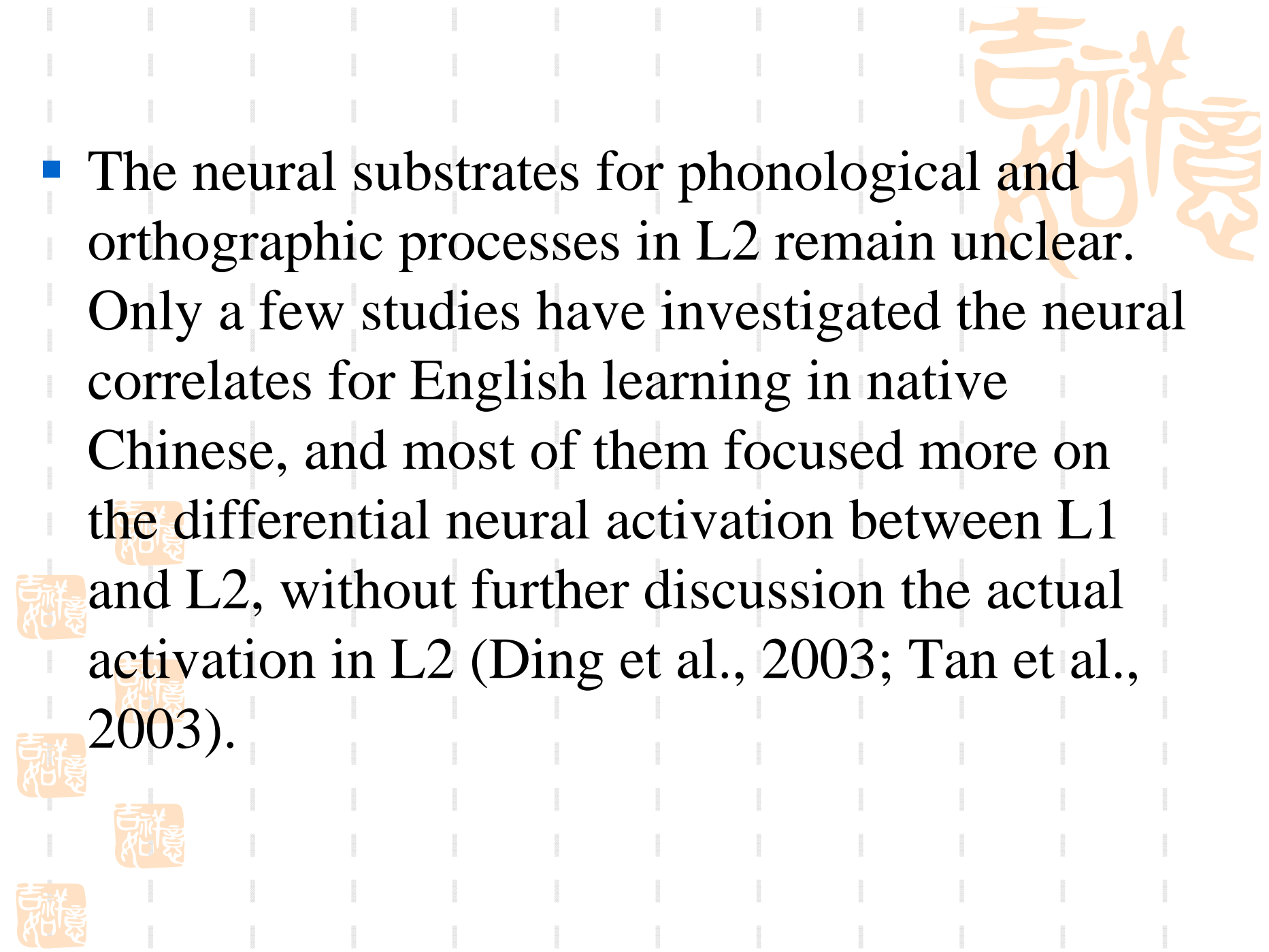


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- Contrary to the findings in alphabetic language system, regression analyses revealed a negative relationship between phonological awareness and English reading comprehension among adolescence (Wang et al., 2002; Yu and Wang, 2001), which may result from the traditional Chinese reading pedagogy, addressing word forms instead of phonology.



- However, Ho and Fong (2005) revealed that Chinese children with developmental dyslexia demonstrated a weakness in English reading and phonological processing when compared to typical readers.
- Additionally, the Chinese children's phonological performance in English exhibited a significantly positive correlation with their English word reading, suggesting that phonological skills are also fundamental in learning English as a second language.



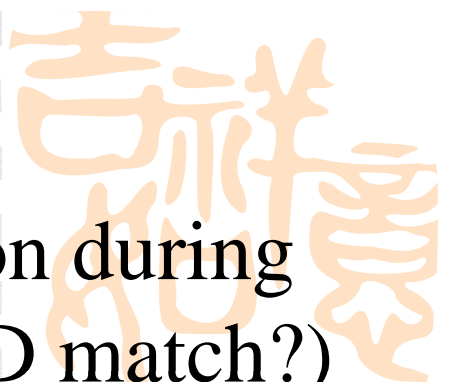

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- The neural substrates for phonological and orthographic processes in L2 remain unclear. Only a few studies have investigated the neural correlates for English learning in native Chinese, and most of them focused more on the differential neural activation between L1 and L2, without further discussion the actual activation in L2 (Ding et al., 2003; Tan et al., 2003).

The Purposes of the Present Study



- Here, using functional magnetic resonance imaging (fMRI), we investigated English phonological processing in Chinese school children with English reading impairment and typically developing children.



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- In the first experiment, brain activation during a letter matching task (e.g. do D and D match?) and rhyme judgment task (e.g. do D and T rhyme?; Temple, 2001, 2003) was compared between children with impaired English reading and age- and IQ-matched typical developing peers to investigate the neural correlates of phonological processing during written language processing.
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- In the second experiment, brain activation during an auditory rhyme decision task (e.g., Do Ten and Pen, or Big and Sun rhyme?) was compared between Chinese children learning ESL with and without impaired English reading.





- The aim of this study was to identify the neural substrates and deficits of English phonological processing in Chinese school children with reading impairments in English, in modalities of visual and auditory.
- If the neurocognitive deficits for impaired English reading are universal regardless of which first language is learned first, we expect the atypical activation pattern for impaired English readers among Chinese-speaking children to be similar to the activation pattern of children with English as their first language.





- These findings will provide theoretical and practical implications for English as a second language (ESL) teaching pedagogy.

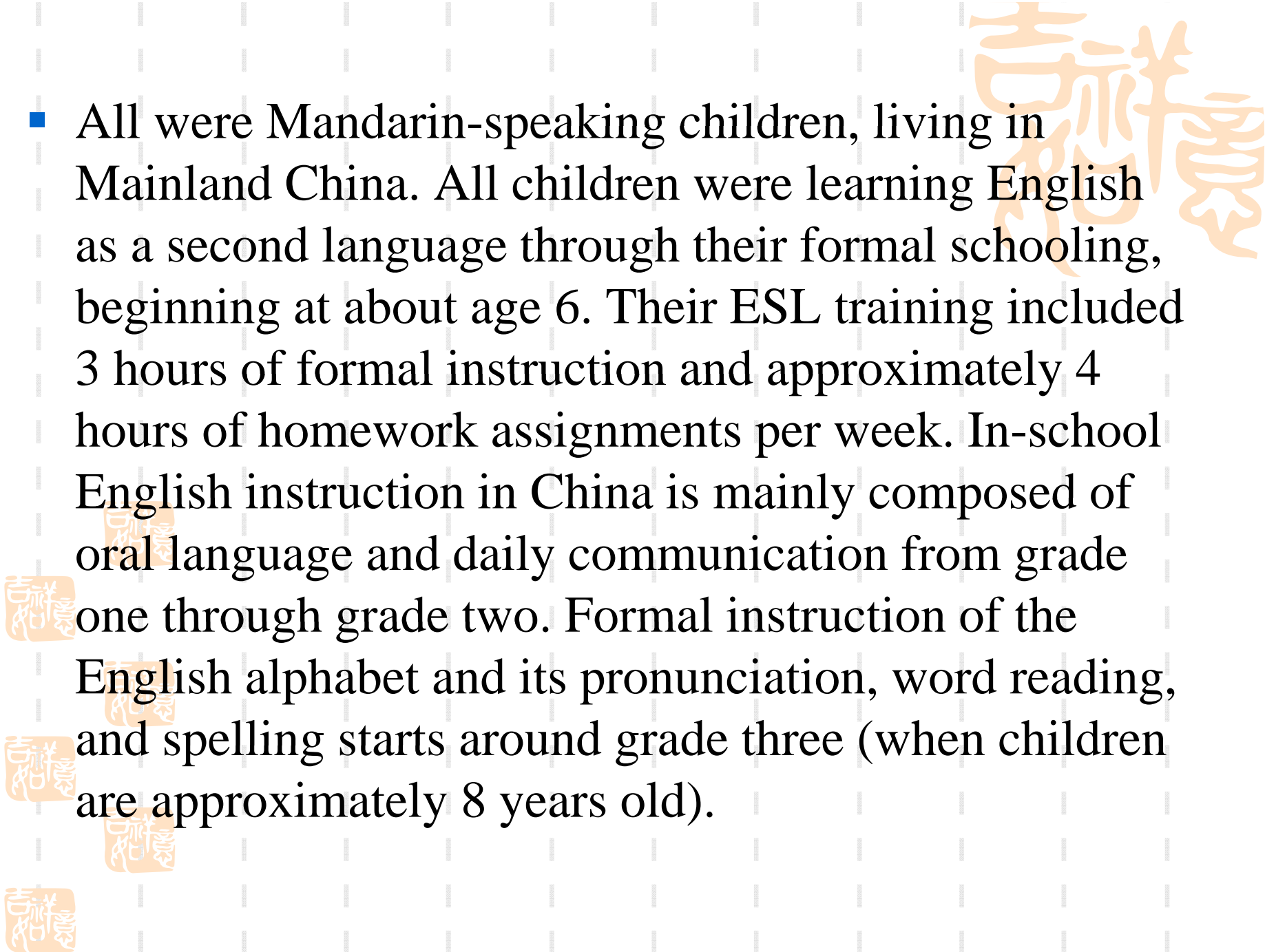


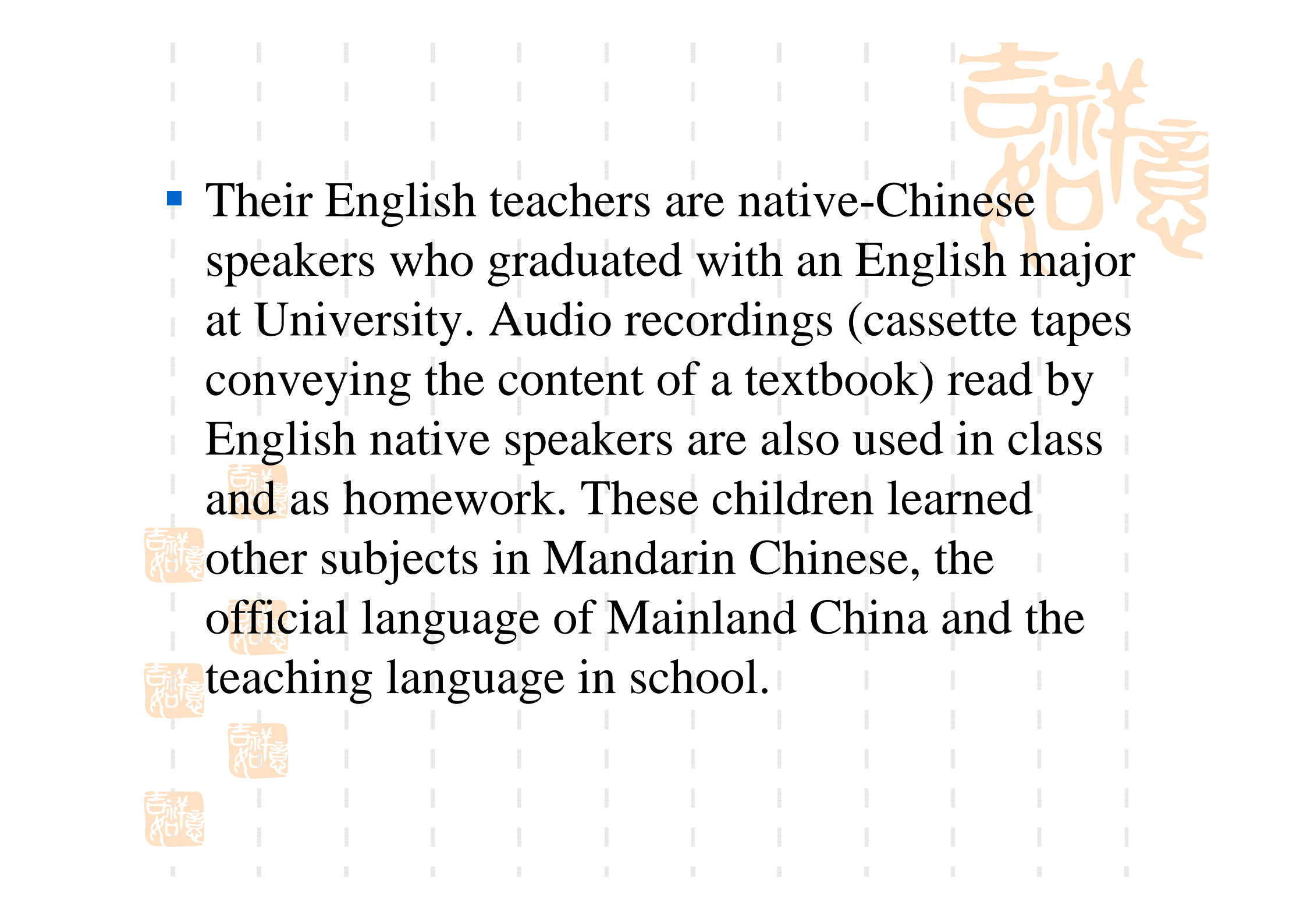
Participants



- Twenty-five children were selected from a pool of 857 children in grades 4, 5, and 6 (mean age: 10.85 years of age; range: 9.3-12.1 years old), and divided into two groups: with or without English reading impairment

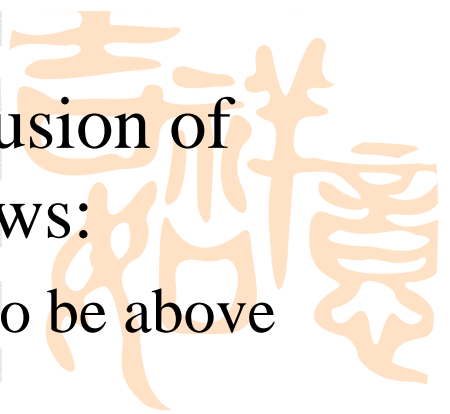



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- All were Mandarin-speaking children, living in Mainland China. All children were learning English as a second language through their formal schooling, beginning at about age 6. Their ESL training included 3 hours of formal instruction and approximately 4 hours of homework assignments per week. In-school English instruction in China is mainly composed of oral language and daily communication from grade one through grade two. Formal instruction of the English alphabet and its pronunciation, word reading, and spelling starts around grade three (when children are approximately 8 years old).

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- Their English teachers are native-Chinese speakers who graduated with an English major at University. Audio recordings (cassette tapes conveying the content of a textbook) read by English native speakers are also used in class and as homework. These children learned other subjects in Mandarin Chinese, the official language of Mainland China and the teaching language in school.

Participants' characteristics and mean scores for reading measures, with minimum and maximum (in parenthesis)

Variable	Impaired readers	Typical readers	<i>p</i>
Raven's	74% (50%-95%)	77% (50%-95%)	ns
Spelling	79.71(68.04-87.65)	122.37(110.77-137.83)	<0.001
WRAT-spelling	0.8(0-3.0)	5.1(1.0-15.0)	<0.001
Word reading	7.5(1.0-17.0)	39.1(33.0-44.0)	<0.001
Woodcock-Johnson Reading Mastery			
Word identification (word reading)	15.3(5.0-19.0)	27.0(21.0-33.0)	<0.001
Word-attack (non-word decoding)	2.8(0-7.0)	14.4(7.0-22.0)	<0.001
Phonological awareness Test			
Rhyme detection	5.1(2.0-9.0)	8.5(5.0-10.0)	<0.001
Oral cloze	0.6(0-4.0)	8.4(6.0-10.0)	<0.001
Syllable identification	6.2(6.0-8.0)	6.8(6.0-8.0)	<0.05
Initial phoneme deletion	3.9(0-8.0)	7.4(4.0-8.0)	<0.005
Chinese Reading Test			
Reading Fluency Test	96.74(78.18-109.64)	108.37(82.60-132.73)	<0.05
Chinese Vocabulary Test	90.37(59.17-114.19)	114.05(103.21-126.04)	<0.001

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- Three criteria needed to be met for the inclusion of English reading impaired children, as follows:
 - first, the percentile in the Raven's test needed to be above the 50th percentile to ensure average IQ;
 - second, the standard score for the Spelling test needed to be at most 88 (below standard score 90);
 - third, the raw scores for the Word Reading test needed to be below the grade average.
 - The age- and grade-matched typically developing readers were selected among the reading impaired children's peers.
 - For children defined as typical English readers, besides having normal IQ as measured by Raven's test, they needed to have a standard score above the 70th percentile on the Spelling test and their Word Reading performance needed to be above the grade average.
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- None of the participants had a history of neurological diseases, head injury, or psychiatric disorders. The DSM-IV Attention-Deficit/Hyperactivity Disorder (ADHD) Scale (American Psychiatric Association, 1994) was also used to exclude children with ADHD.

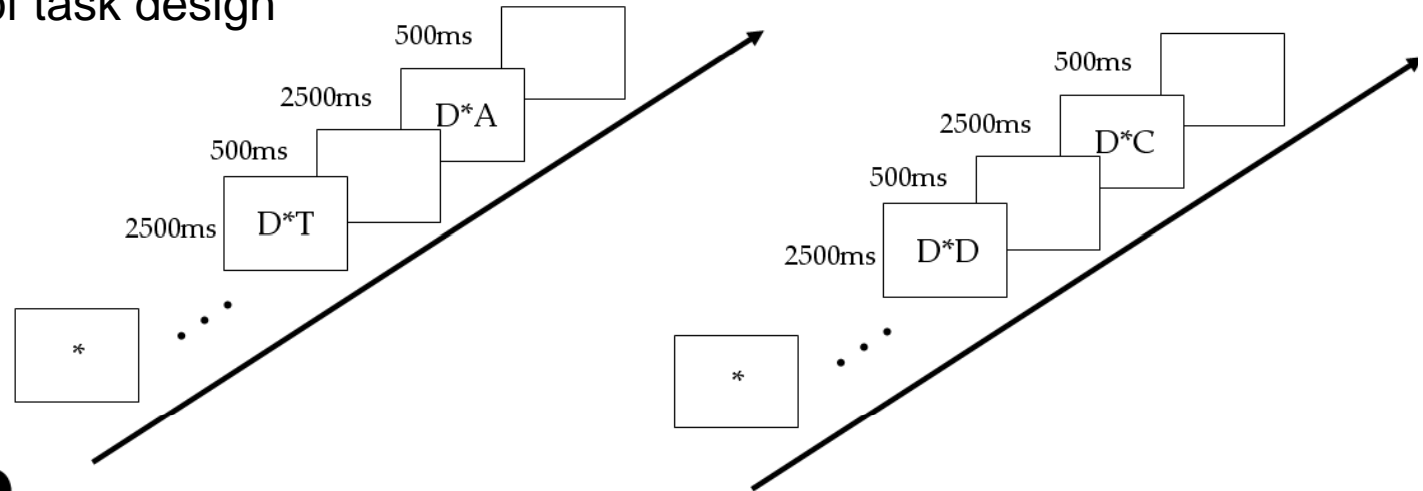


Results: Visual word processing

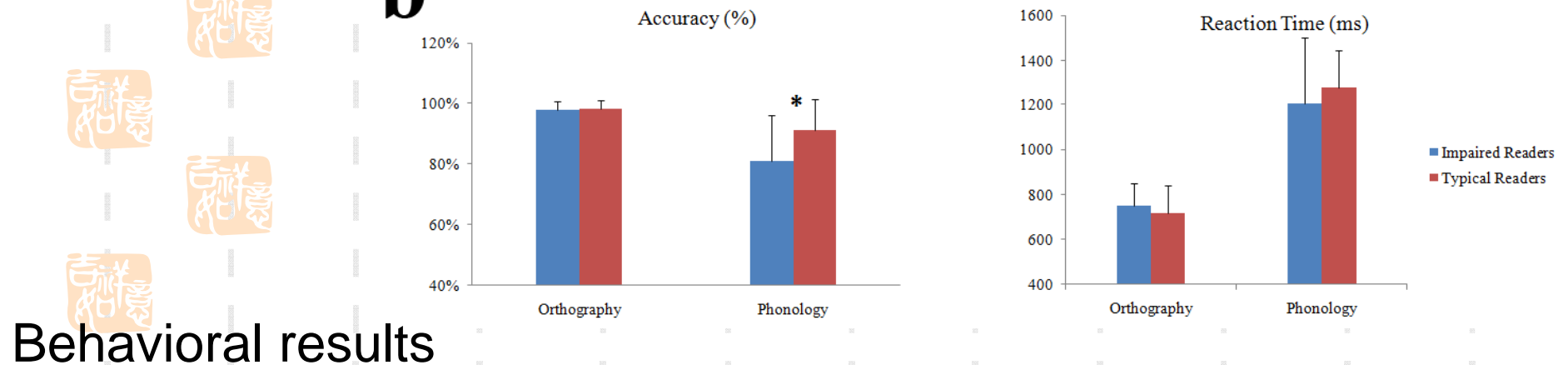


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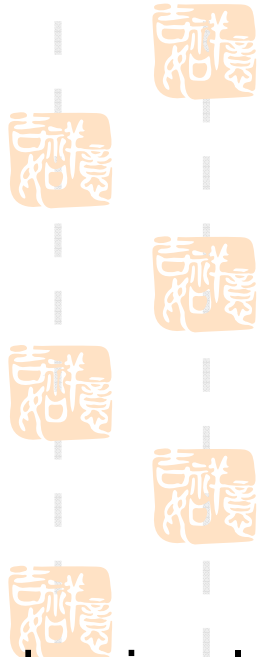
Graphical description of task design



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Behavioral results



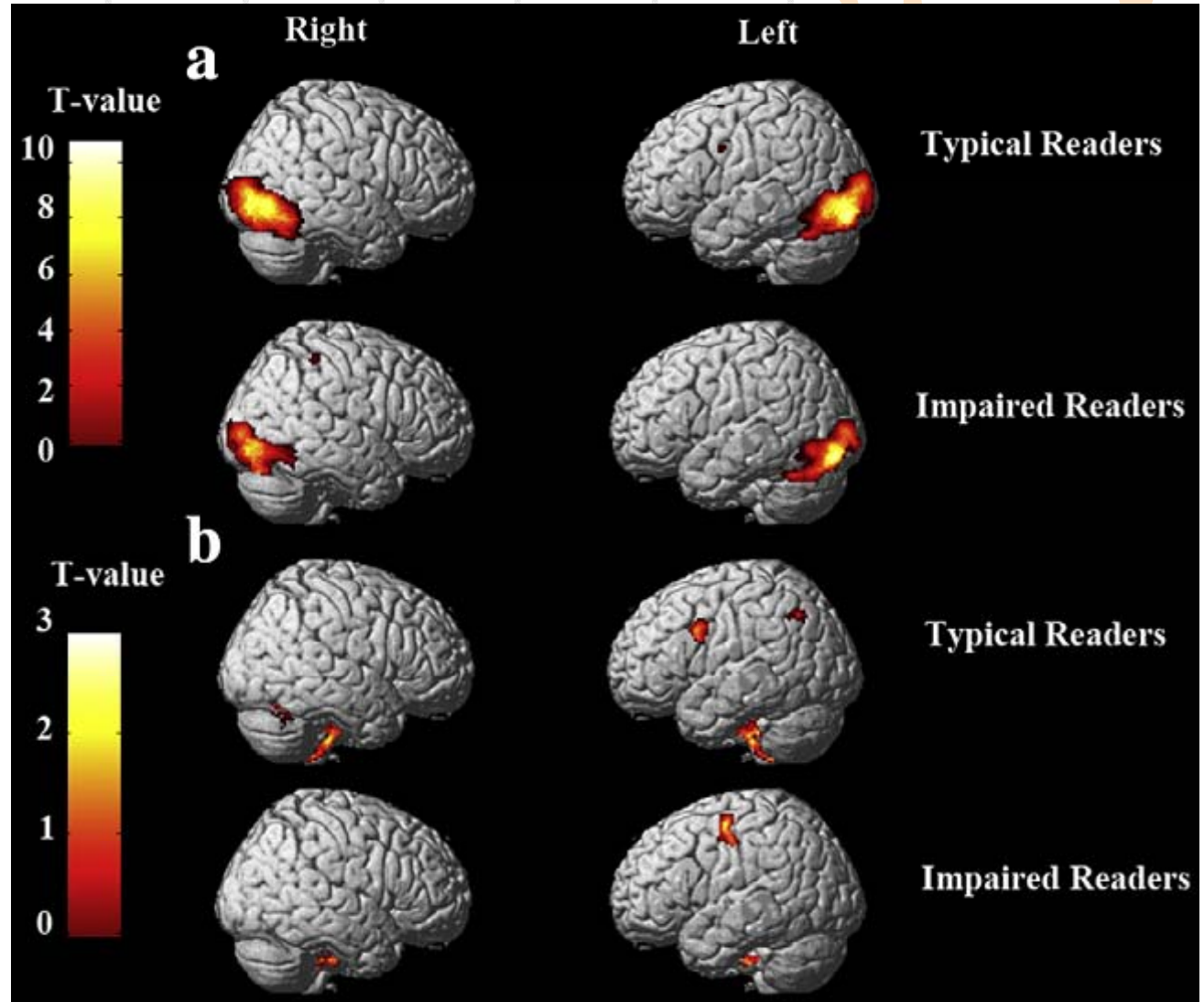
FMRI Results: Whole brain analysis



Orthographic Processing



Phonological Processing





- Orthographic processing was defined as letter-match vs. fixation. The typical readers showed activation in bilateral lingual, bilateral inferior occipital, left calcarine, several regions in the frontal lobe and left thalamus. Impaired English readers exhibited activation in bilateral lingual, bilateral inferior occipital, right inferior parietal and left SMA regions
- The left lingual /calcarine gyrus was the only cluster that survived the multiple comparison correction.

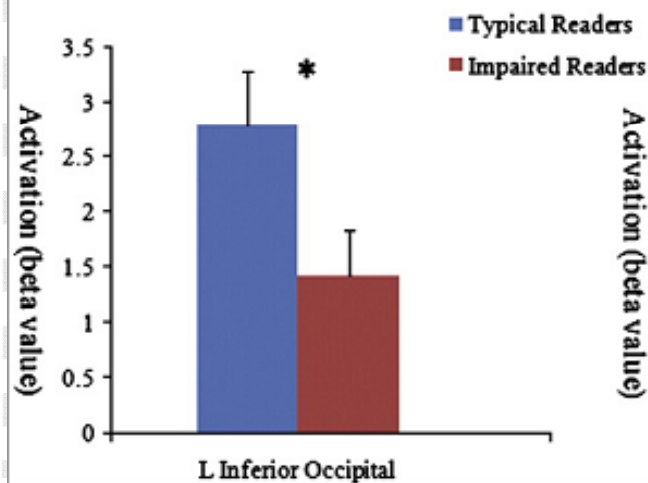
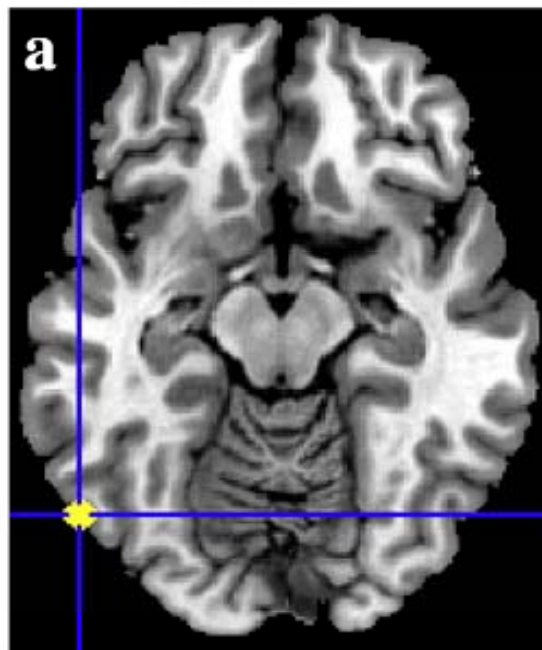


- For the phonological task contrasted with letter matching, typical readers exhibited neural activation in several regions within the frontal lobe, left inferior parietal and the cerebellum. Impaired English readers exhibited activity in left precentral areas, left postcentral areas and the cerebellum
- Direct comparison between these two groups indicated increased activation in typical compared to the impaired readers in left angular regions. However, this area did not survive the multiple comparison correction.

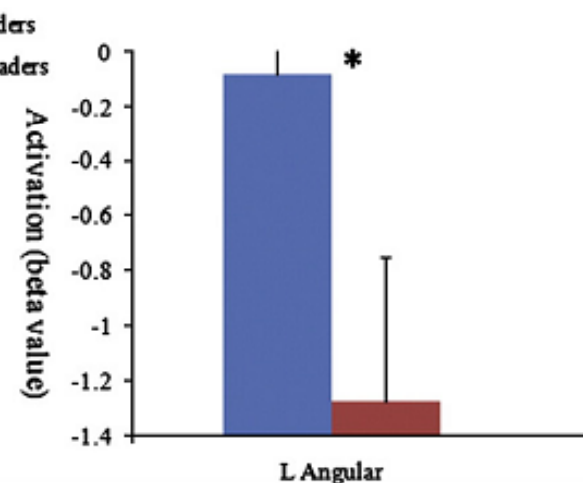
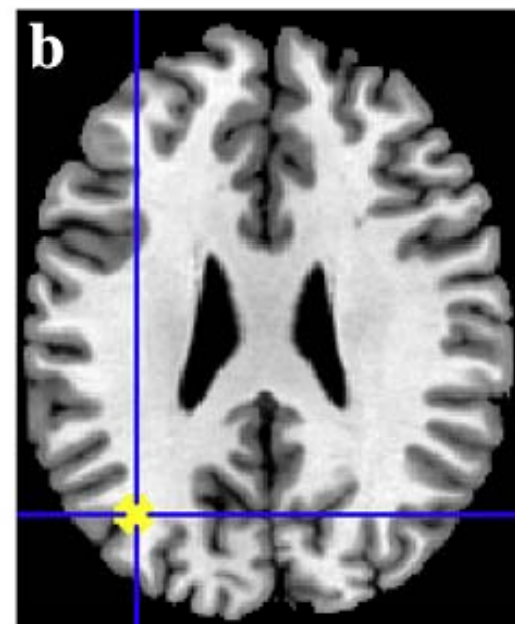
FMRI Results: independent regions of interests (ROIs) analysis

- ROIs revealed the group activation differences within the left inferior occipital region (occipitotemporal region, BA 37) during orthographic processing;
- And the group activation differences within the left angular gyrus (parietotemporal region, BA 7) during phonological processing.

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Correlations between brain activations in two conditions and reading measurements

	WRAT-spelling	Spelling	Word reading	Rhyme detection	Oral cloze	Syllable identification	Initial phoneme deletion	Word identification	Word attack
Left angular	0.286	0.389*	0.374*	0.237	0.337	0.233	0.338	0.373	0.356 (P=0.063)
Left inferior occipital	0.436*	0.388*	0.427*	0.29	0.421*	0.120	0.353	0.509*	0.594***

Notes: β for left angular came from Typical Reader vs. Impaired Reader for rhyming vs. letter match; β for left inferior occipital came from Typical Reader vs. Impaired Reader for letter match vs. rest (fixation). * <0.05 ; ** <0.01 ; *** <0.005

Interim Summary



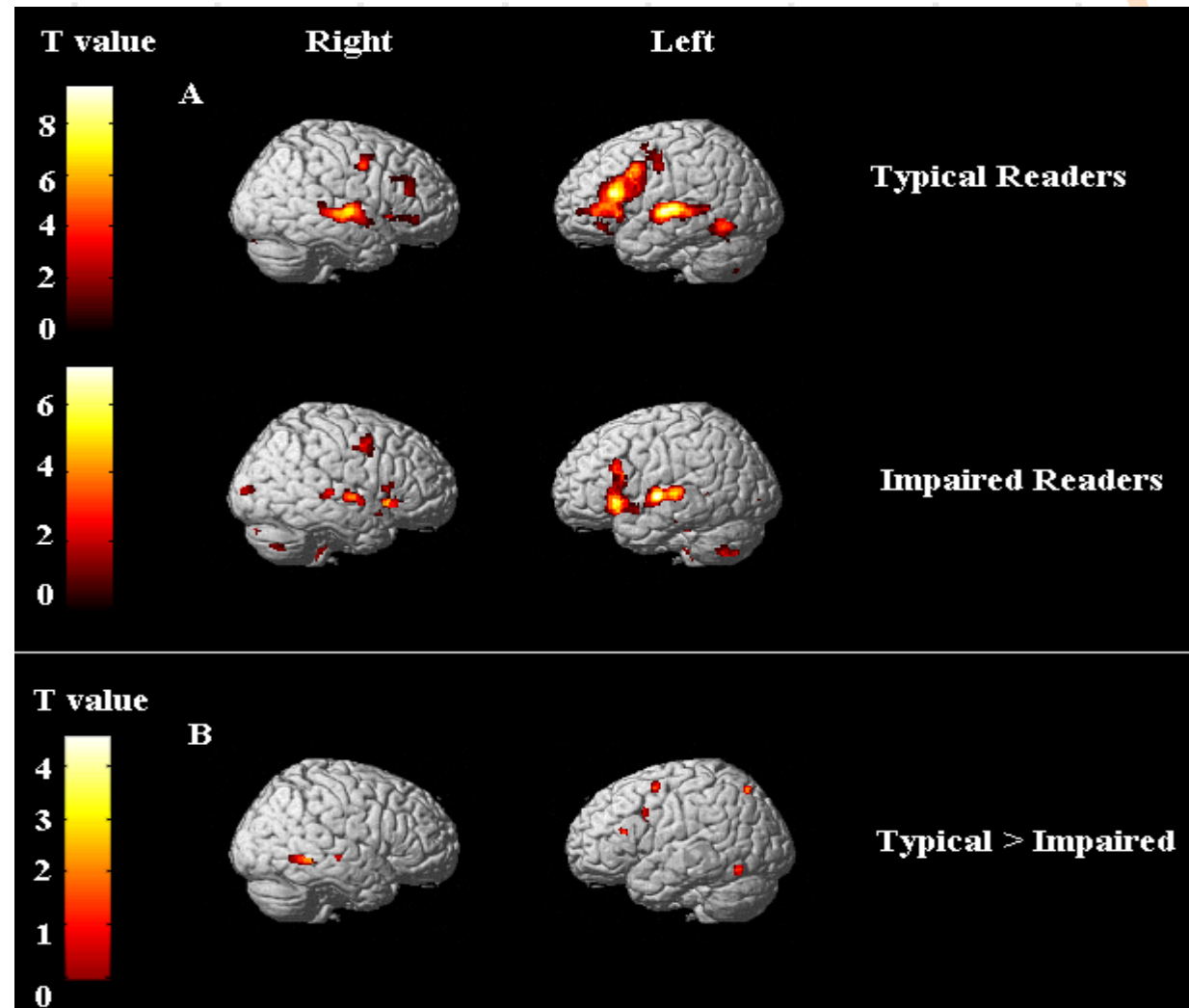
- These findings in Chinese-speaking children are very similar to those of native English speakers, which suggested a common neural mechanism in English learning as both of L1 and L2.



Results: Spoken words processing

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Whole brain analysis

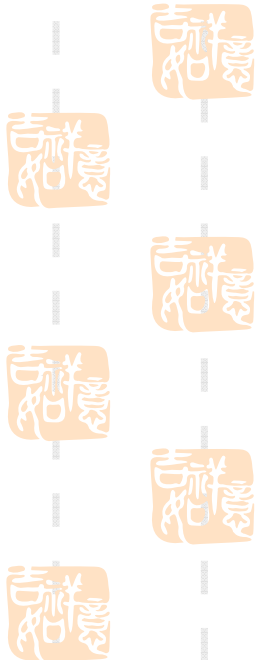
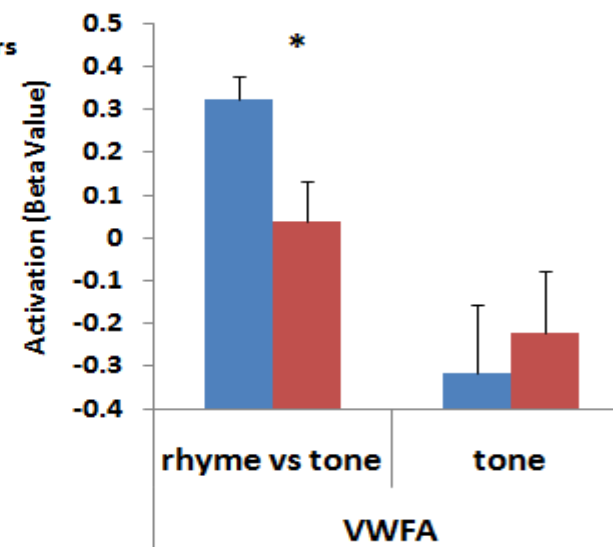
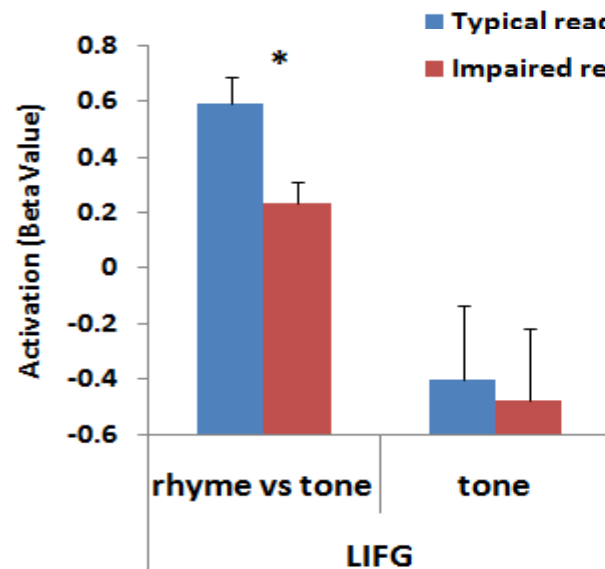
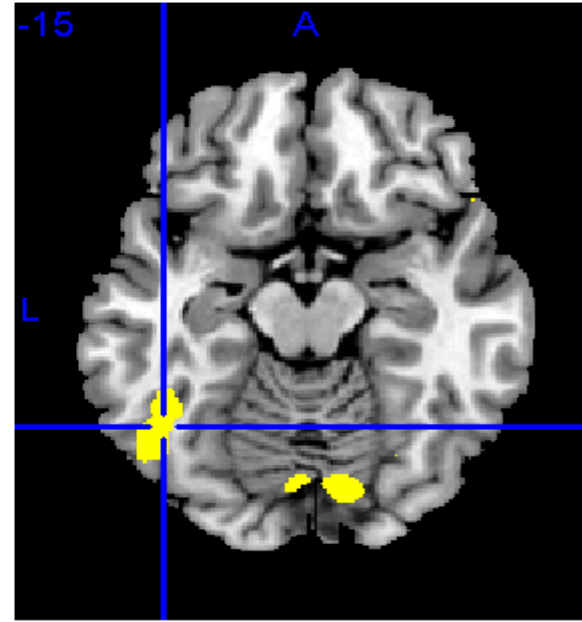
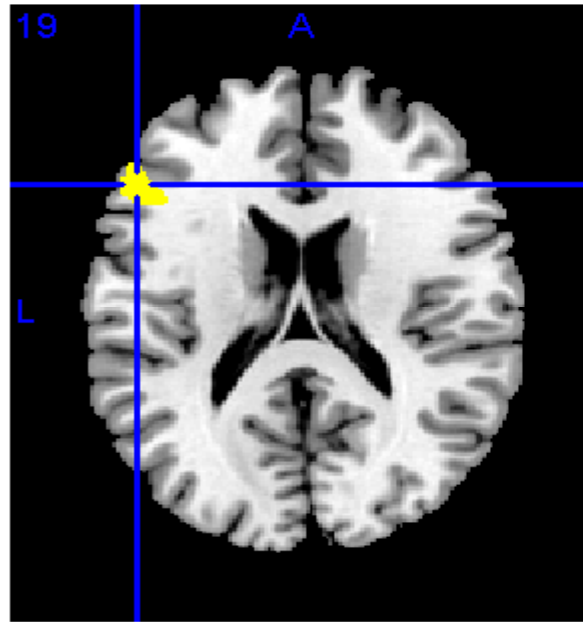


- **Activation for Typical Group:** Bilateral temporal lobe, bilateral inferior frontal, bilateral precentral, left occipital lobe, left supplement motor area, right insula, and several subcortical areas (Fig. A).
- **Activation for Impaired Group:** Bilateral temporal lobe, left inferior frontal, right superior occipital, right fusiform, left lingual, right precentral, bilateral insula, left supplemental motor area and in some subcortical regions (Fig. A)
- **Group Activation Differences:** Compared with the impaired English readers, the typically developing group exhibited significant greater activation in left inferior occipital/fusiform, left precentral, left superior parietal, left inferior triangularis frontal, right middle/inferior temporal and right cerebellum (Fig. B).



Independent ROIs Analysis

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Independent ROIs Analysis

- Both Left Inferior Frontal and VWFA revealed a significant group difference.
- Both regions exhibited significantly positive correlations with Word Identification, Spelling and Phonological Awareness.



Interim Summary



- Consistent with studies in native English speakers, impaired English readers exhibited reduced activations in VWFA compared to typical English learners in China, suggesting that they might have difficulty in automatically accessing orthographic representations during auditory phonological processing.
- when English is learnt as the second language, decreased activation in left IFG in Chinese children with impaired English reading could indicate a phonological disruption similar to that of dyslexic children in English-speaking countries during spoken language processing.





General Discussions



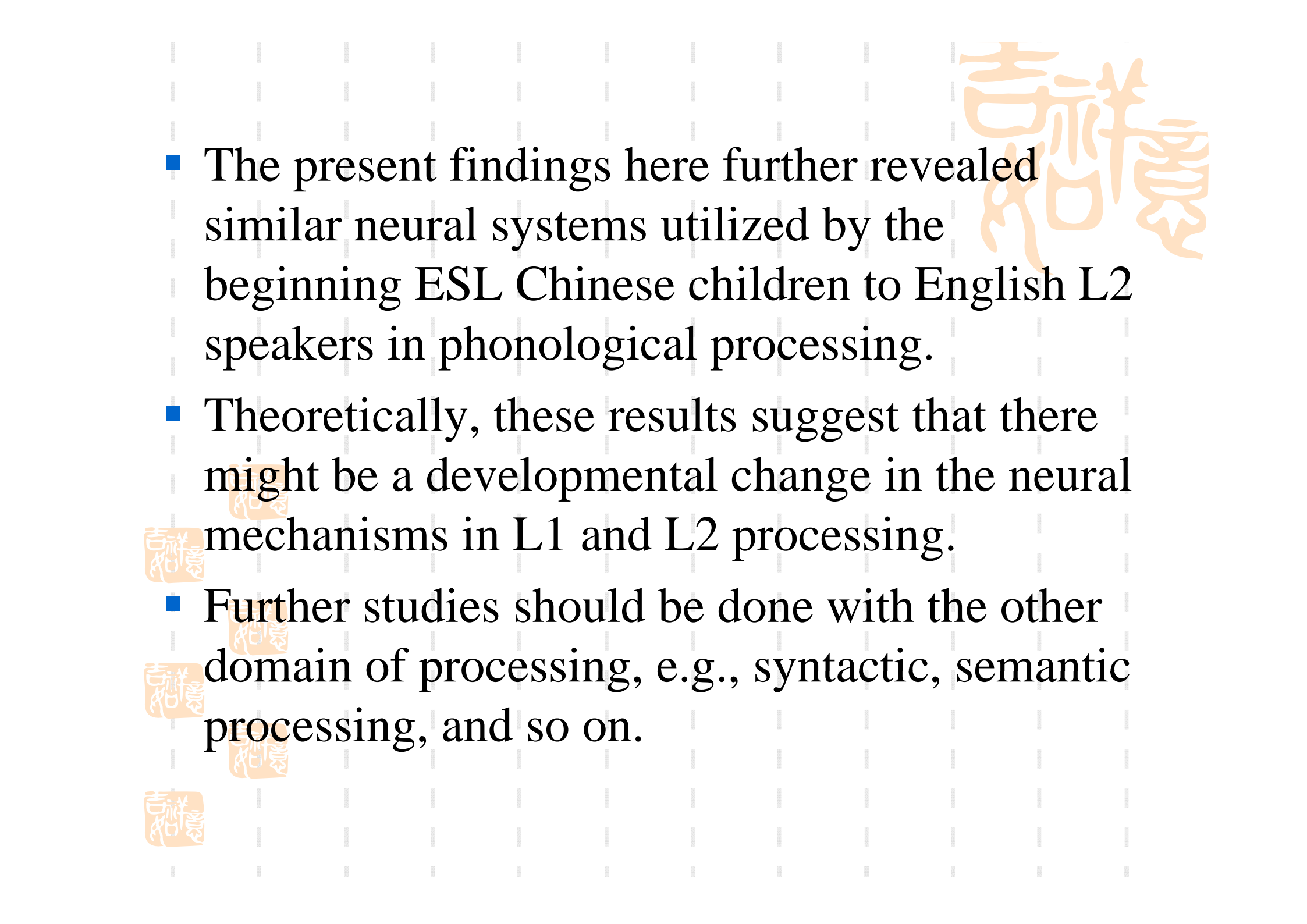
- To date, most neuroimaging studies investigating L2 in Chinese-English(C/E) or English-Chinese (E/C) bilinguals have examined whether there is a sharing or separate neural system in processing L1 and L2.

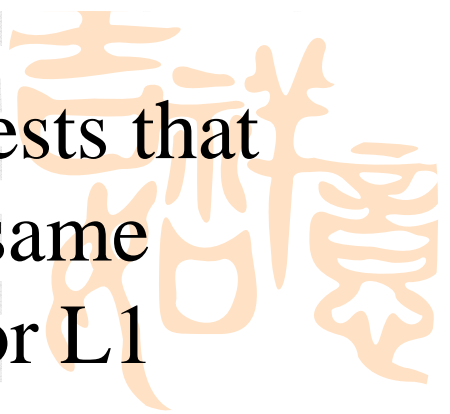



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- The results of these studies suggest that although a similar neural system is utilized to process L1 and L2 (Chee, Tan, et al., 1999; Chee, Caplan, et al., 1999; Xue, et al., 2004; Tan, et al., 2003; Gandour, et al., 2007);
 - Neural activation seems to be related to language proficiency (Xue, et al., 2004; Chee, et al., 2004) and may even be language-specific (Tan, et al., 2003; Chee, et al., 2003).
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- Very few studies have investigated the neural deficits in Chinese children with English reading difficulties and the neural correlates of language processing in Chinese children who are beginning English learners.

- e.g., Dong et al. (2004) found that for Chinese children who had very limited exposure to English (as their L2), the left inferior frontal region was activated for both L1 and the newly obtained L2 during a visually presented rhyme judgment task, but activation in the L2 tasks was less intensively.

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- The present findings here further revealed similar neural systems utilized by the beginning ESL Chinese children to English L2 speakers in phonological processing.
 - Theoretically, these results suggest that there might be a developmental change in the neural mechanisms in L1 and L2 processing.
 - Further studies should be done with the other domain of processing, e.g., syntactic, semantic processing, and so on.

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- Empirically, the present finding suggests that an ESL curriculum should target the same neural network than the curriculum for L1 children and that reading remediation programs for ESL children can be developed based on existing intervention programs in L1 children.
 - However, future research projects investigating larger sample sizes and targeting other reading skills as well as reading fluency and comprehension in ESL children are needed.
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Conclusion



- These results suggest that similar neural deficits are involved for impaired phonological processing in English as both the first and the second language acquired. These findings pose implications for reading remediation, educational curriculum design, and educational policy for second language learners.



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Thanks

Q & A

