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Deficits in Processing Characters in Chinese Developmental Dyslexia: Preliminary Results From Event-related Potentials and Time Frequency Analyses

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Abstract

Individuals with dyslexia have deficiencies in lexical organization and processing that are behaviorally manifested as difficulties in learning grapheme-phoneme correspondences. The present study investigates the lexical representations of Chinese reading-impaired children using event-related potentials (ERP) and time-frequency analysis. Two Cantonese-speaking male children, one with reading impairment (PR) and one with normal reading performance (CA), performing a character recognition task were conducted. ERP results indicated that CA showed lexicality effect at N400 and N170 that was not evident in PR. The time-frequency analyses found greater event-related synchronization and phase coherence at theta band suggesting greater cognitive demand in processing pseudowords than real words for CA. Greater synchronization between cortical regions was also observed at the gamma band for pseudowords. These differences were not found for PR, suggesting that PR may have weaker lexical representations, resulting in inefficient orthographic processing and perhaps difficulties in accessing phonological and/or semantic information of known characters.

Keywords: Chinese developmental dyslexia, Event-related potentials, Time frequency analysis, Chinese character recognition

1. Introduction

A sizeable body of evidence has shown that individuals with developmental dyslexia have longer response latencies than controls in auditory/phonological processing tasks (Booth et al., 2000; Breznitz & Misra, 2003 for review). In addition, delayed responses in rapid visual processing tasks have also been observed of reading impaired individuals (e.g. Booth et al. 2000; Breznitz & Meyler, 2003; Scheuerpflug et al., 2004; Wilmer et al., 2004). An extensive review of the related literature by Farmer and Klein (1995) has led to the hypothesis that developmental dyslexia is strongly linked to a general deficit in speed of processing (SOP) in both visual and auditory modalities. Chinese children with reading disorders have also been found to show poorer performance than chronological age matched (CA) children with normal reading abilities on visual and auditory temporal processing tasks, and a correlation between reading performance and orthographic processing (Cheung et al., 2009; Chung et al., 2008; Ho & Bryant, 1997; Ho, Chan, Lee, Tsang, & Luan, 2004; Liu, Shu, & Yang, 2009; Siok & Fletcher, 2001). Furthermore, it has been argued that morphological awareness is critical to reading development since Chinese characters represent morphemes, and poor morphological awareness is a core deficit underlying developmental dyslexia in Chinese (Wu, Packard, & Shu, 2009 for review). These findings suggest that reading disorders may result from inaccurate representation, inefficient access and/or processing of phonological (Goswami, 2003), and possibly orthographic and/or semantic information of the character, and that developmental dyslexia is biological in origin. Indeed, ample evidence for reading disorders in young children as neurological in nature has come from functional magnetic resonance imaging (*f*MRI) (e.g. Booth & Burman, 2001; Siok, Perfetti, Jin, & Tan, 2004).

However, given the poor temporal resolution of functional imaging and the SOP hypothesis, event-related potentials (ERPs) would be uniquely suitable for investigating the disorder (Booth et al., 2000), because of its superb temporal resolution and its ability to reflect effects at different temporal stages and at several levels of cognitive processing between a stimulus and its response. ERP studies in the last decade have found deviant patterns in terms of reduced amplitude and/or longer latency of early (P2, N2) and late ERP (P300) components in dyslexic individuals participating in tasks of visual recognition of non-linguistic and linguistic stimuli of alphabetic scripts (Breznitz et al., 2003, for a review). The mismatch negativity (MMN) has been used extensively to examine the sensitivity of individuals with dyslexia to various speech sound contrasts, including place of articulation, voicing, vowel and tone. Key findings of the relevant literature can be characterized by abnormal appearance of the MMN in terms of reduced amplitude or topographic distribution (Csepe, 2003, for a review). Compatible observations have recently been reported of Chinese children with dyslexia (Meng et al., 2005).

In this paper, we report preliminary behavioral and electroencephalogram (EEG) data from two Chinese young readers, a nine-year-old with developmental dyslexia and his age-matched control. A lexical decision task was used as lexicality judgments require access to orthographic, phonological, and perhaps semantic representations as well. Processes at these levels can be reflected in ERP components in different time windows post-stimulus (e.g. Liu & Perfetti, 2003; Perfetti & Liu, 2005). To gain insights into brain activities during character recognition of reading impaired children, the method of data analyses differed from most previous work in two aspects. First, in additional to traditional ERPs, a more innovative method of time frequency analysis (TFA) was employed. As amplitude changes in an ERP can arise from a change in power and/or phase-synchronization, time frequency analyses (TFA) with measures of event-related spectral perturbation (ERSP) and inter-trial coherence (ITC) will provide richer information on brain activities with respect to power modulation, oscillation and phase resetting across frequency bands and time windows, compared to averaged ERPs (Makeig, Debner, Onton, & Delorme, 2004). Increasing evidence has suggested that these measures could reflect differences between normal and poor readers (Klimesch et al., 2001a, 2001b; Spironelli, Penolazzi, & Angrilli, 2008; Penolazzi, Spironelli, & Angrilli, 2008). We focused in particular on activities in the theta (4-7 Hz) and gamma (> 30 Hz) bands. The former is sensitive to psycholinguistic effects at different processing levels including lexicality (Krause et al., 2006), whereas the latter signals synchronization of activity at the cortical networks level (Bastiaansen & Hagoort, 2003). Second, the present study employed single-trial and single subject analyses (Bishop & Hardiman, 2010). This approach is arguably more appropriate for studying individuals with language disorders of possibly heterogeneous underlying causes. Importantly, developmental dyslexia may be one such disorder as subtypes of dyslexia have been proposed (Bosse, Tainturier, & Valdois, 2007; Ho et al., 2004; Valdois, Bosse, & Tainturier, 2004; Wu et al., 2009).

2. Method

2.1 Participants

The participants were two age-matched right-handed Cantonese-speaking male students with normal non-verbal intelligence, one with reading impairment, PR and the other with normal reading performance, CA. PR (M / 9;06) just finished Grade 4 when he came to the dyslexia clinic in the Division of Speech and Hearing Sciences at the University of Hong Kong for treatment of his poor Chinese reading performance. The reading abilities and non-verbal intelligence of PR and CA are shown in Table 1.

Table 1. Non-verbal intelligence and reading performance of participants

	PR	CA
Age	9;06	9;03
Non-verbal intelligence		
RSPM[1] (standard score)	113	100
Chinese reading abilities		
HKGCNT[2] (z-score)	-1.43	2.06
Word reading subtest of HKT-SpLD[3] (z-score)	-1.00	2.00

[1]RSPM - Raven's Standard Progressive Matrices (Raven, 1989).

[2]HKGCNT - The Hong Kong Graded Character Naming Test (Leung, Lai, & Kwan, 2008).

[3]HKT-SpLD - Hong Kong Test of Specific Learning Difficulties (Ho, Chan, Tsang, & Lee, 2000).

2.2 Stimuli

Real word stimuli consisted of 160 monosyllabic characters selected from a children's Cantonese database (Leung & Lee, 2002). All characters were learned by Primary 2. The same number of pseudo characters were created by randomly combining the phonetic and semantic radicals of the real character stimuli in accordance to orthographic rules. Visual complexity between real and pseudo characters was controlled $t(304.83) = 1.02$, $p = .31$), see Table 2.

Table 2. Characteristics of character stimuli

	Real characters			*Pseudo characters*		
	M	SD	Range	M	SD	Range
Stroke number	12.44	2.67	[6-22]	12.01	3.29	[5-20]
Cumulative frequency (Grade 4)	105.14	114.91	[6-554]			

2.3 Procedure

Participants performed a lexical decision task. Yellow characters (100 x 90 pixels) on the computer screen were presented on a black background located approximately 60cm away. Each trial began with a fixation cross followed by a blank screen, the target stimulus and another blank screen as illustrated in Figure 1. The child was instructed to press the response button with the left thumb to characters they had learned, and with the right thumb to characters they had not learned before. Each child was presented with a different random sequence of stimuli given in 6 blocks delivered by E-Prime (Psychology Software Tools Inc., USA).

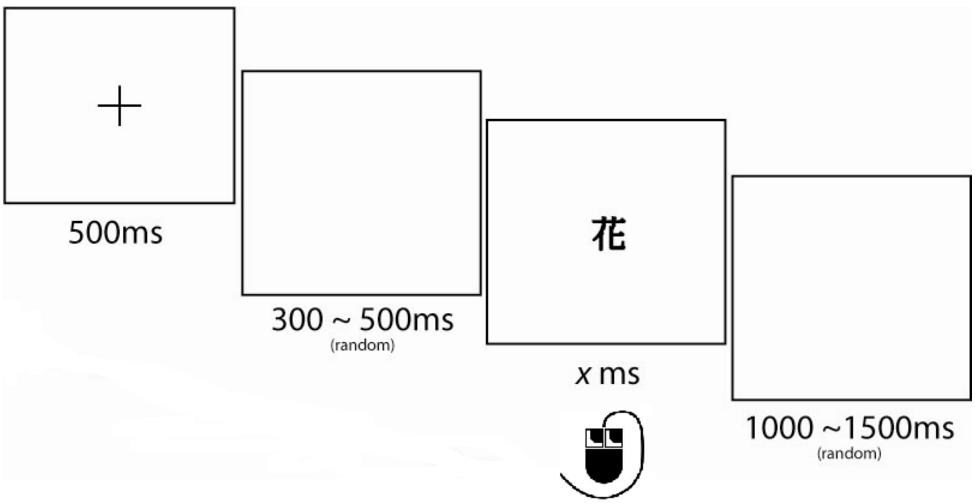

Figure 1. Schematic illustration of each trial sequence.

2.4 Data Recording

EEG was recorded using SynAmps2 NeuroScan Inc. system in a sound attenuated and electrically shielded room. Online EEG was sampled at 1000Hz with a bandpass of 0.05 to 200 Hz. An electrode cap (Quik-cap, Compumedics Ltd., USA) was fitted to record from 128 silver-silver chloride (Ag/AgCl) sintered electrodes (Compumedics NSL system). The vertex was used as the reference, and the ground (GND) was located between channels 59 and 60. Eyeblink and vertical eye movement was monitored using bi-polar electrodes placed above and below the left eye (vertical electrooculogram, VEOG), and the horizontal eye movement using two bi-polar electrodes placed at the outer canthi of each eye (horizontal electrooculogram, HEOG). Impedance was kept below 10 kΩ whenever possible.

2.5 Pre-processing of ERP data and analysis

ERP data was later filtered offline using Neuroscan 4.5 software (Compumedics Ltd., USA) with a zero-phase shift bandpass 0.05 to 30 Hz (12d/B slopes). Epochs of -200ms to 1000ms stimulus onset were obtained. Trials with errors, responses exceeding 3000ms and artifacts greater than ± 100 μv in any channel were excluded. Each channel was then baseline corrected using the -200ms to 0ms pre-stimuli onset, and re-referenced to an average reference. The data were further down sampled to 250Hz using EEGLAB (Delorme & Makeig, 2004; Makeig et al., 2004) for statistical analysis. Significant differences between real and pseudo characters were tested using bootstrap analysis (5000 permutations) at each time point, with correction based on false discovery rate (FDR) as consecutive time points are dependent of each other.

2.6 Single trial TFA

A zero-phase shift bandpass 0.05 to 100 Hz (12d/B slopes) was first applied and correct trials were then epoched at -500ms to 1000ms. Using EEGLAB (Delorme & Makeig, 2004), the data was downsampled to 250Hz. Noisy channels, muscle activity, and channels affected by eyeblinks and horizontal eye movements were removed manually using principle component analysis (PCA) with 20 components. After removal of artifact components, the signal was reconstructed. Trials with artifacts that exceeded ± 100 μv, trends greater than 75 μv, abnormal distributions or improbable data exceeding 5 SDs in any channel were automatically rejected. Each channel was then baseline corrected (-500ms to 0ms), and re-referenced (average reference). The remaining data was used to run the TFA. Measures of ERSP and ITC were obtained using the ‘timef’ function in EEGLAB. For these analyses, spectral power was measured at different time points during each epoch using fast-Fourier transform (FFT) and Hanning windows. The frequency range was specified at 1-50Hz, with a pad ratio of 8 and a baseline of -300 to -100ms. To assess significant differences of these two indices, bootstrap analysis (10 000 permutations) and FDR correction was used at each time point with an in-house script.

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3. Results

3.1 Behavioral data

CA was more accurate and faster in making lexicality judgments, at 90% correct with a mean response latency (RT) of 599ms for real words and 91% and 625ms for pseudowords, than PR who scored 78% for real words (852ms) and only 58% for pseudowords (952ms).

3.2 Conventional ERPs

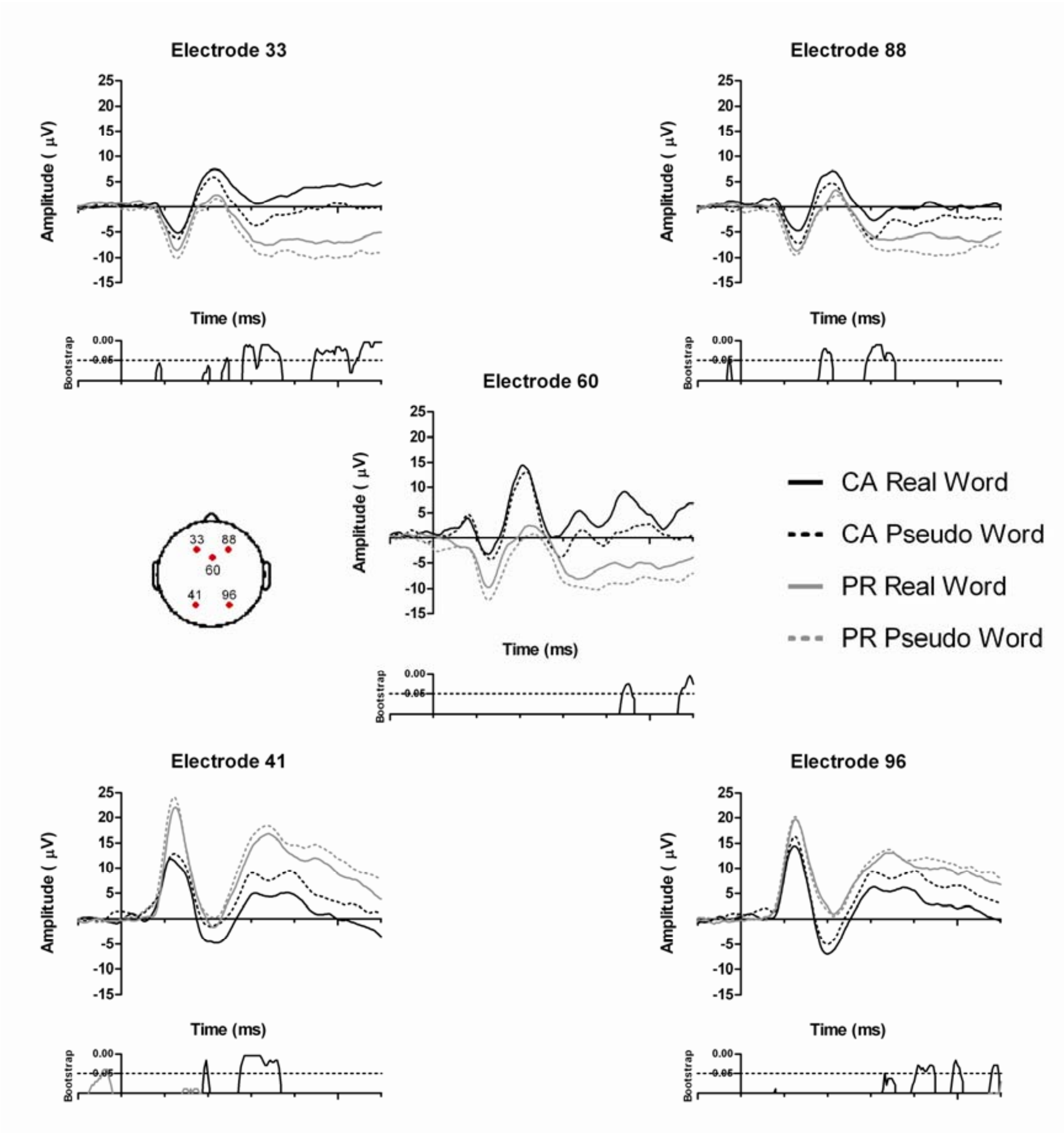

Figure 2. Mean lexicality ERP waveforms and significance bootstrap differences across time for CA and PR at electrodes 33, 41, 88, 60 and 96.

Figure 2 reveals that the effect of lexicality was significant for CA at electrode 60 (central) during 400-500ms post-stimulus, a time window traditionally associated with N400, where pseudowords elicited greater negativity, as well as a period after 550ms. Significant differences were also observed around 200ms post-stimulus at electrode 41 (left occipital), associated with N170, where real words evoked greater negativity, and additionally during 270-370ms at the same electrode and at various time points after 300ms post-stimulus at electrode 96 (right occipital). While no significant lexicality effects were found before 250ms in electrode 33 (left frontal) associated with P200, a significant difference was revealed around 200ms with greater positivity for real words in electrode 88 (right frontal). Other significant differences were found at various time periods after 270ms in the left frontal site and during 290-360ms in right frontal. Importantly, the lexicality contrast never reached significance in any of these electrodes for PR.

3.3 TFA with ERSP and ITC measures

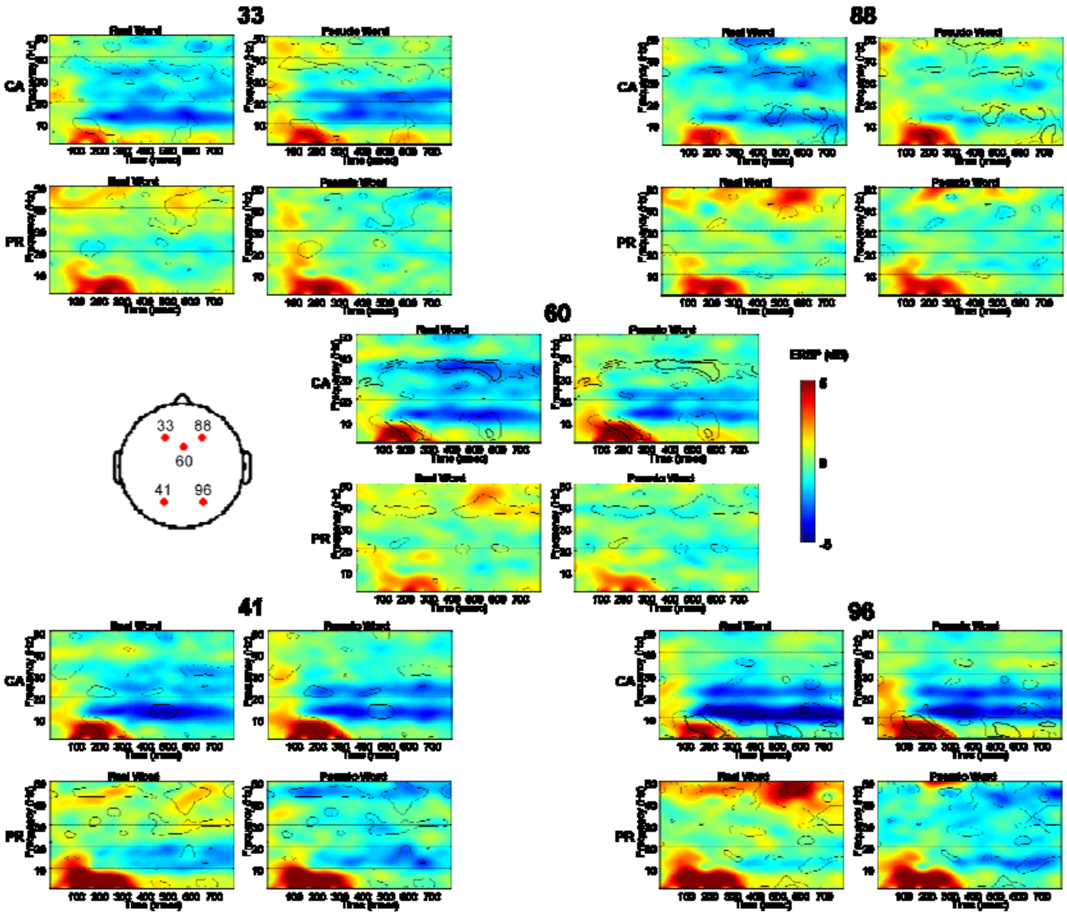

Figure 3. Event-Related Spectral Perturbation (ERSP) graphs showing power modulation for real and pseudo words across frequency bands for CA and PR. (*Significant bootstrap differences encircled by thin lines, and with FDR correction by thick lines*)

Similar to ERPs, TFA results found significant lexicality effects at different electrodes under observation only for CA. There were no differences between conditions for PR that could survive correction for multiple comparisons (see Figures 3 and 4). CA showed greater synchronization in the theta band for pseudowords than real words during 120-300ms and 500-600ms post-stimulus in the central and right occipital electrodes, and during 700-760ms in the right frontal electrode. Greater synchronization in gamma band was found for pseudowords during 100-200ms, 350-640ms, and after 750ms in the central electrode, and 300-550ms in the right frontal electrode. Greater phase-resetting for pseudowords was also seen in the theta band during 200-300ms post-stimulus for all the electrodes, and additionally during short intervals between 500 and 600ms in the central, left frontal and right occipital electrodes, and between 100-200ms in the central, left and right frontal electrodes.

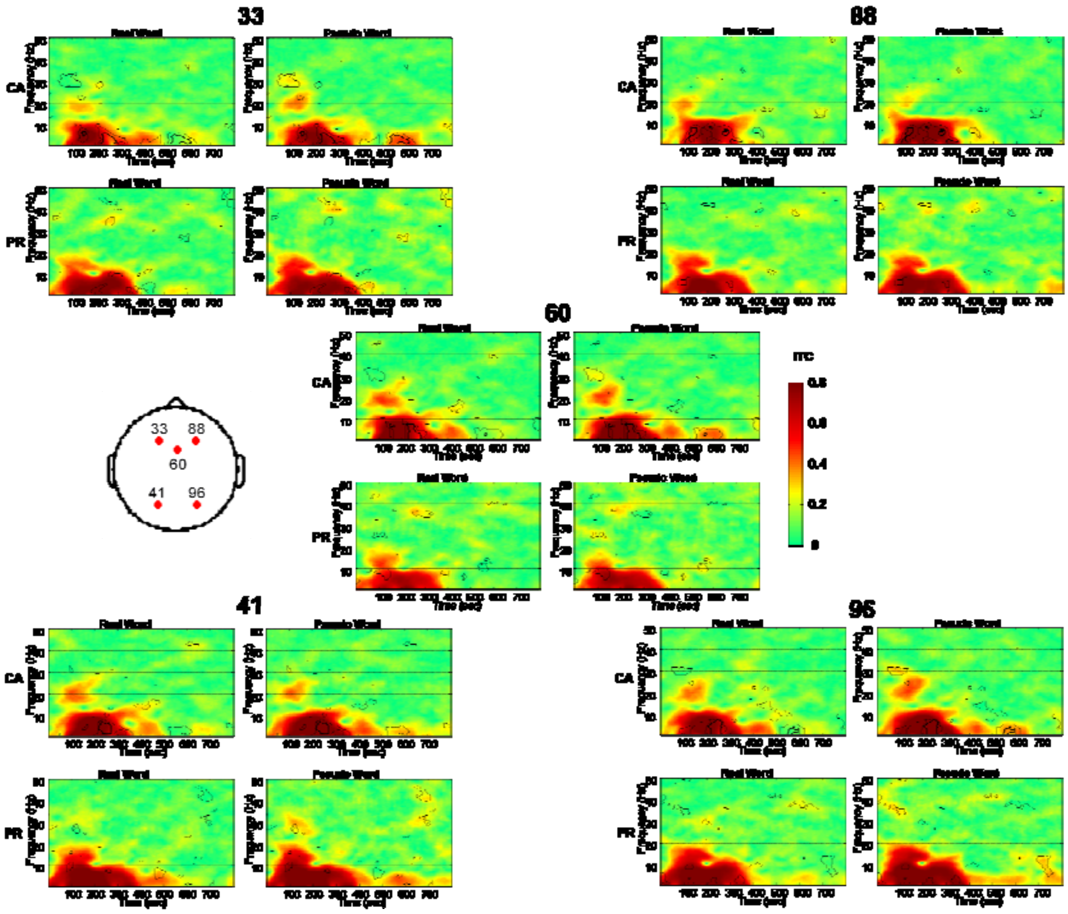

Figure 4. Inter-Trial Coherence (ITC) graphs showing phase resetting of real and pseudo words across frequency bands for CA and PR. (*Significant bootstrap differences encircled by thin lines, and with FDR correction by thick lines*)

4. Discussion

Results from both ERPs and TFA indicate that only CA showed sensitivity to the lexicality of a character. The distinction could be based on differences in familiarity of the orthographic form, and/or the availability of phonological and meaning information associated with the item.

The ERP patterns reveal greater negativity at occipital sites and greater positivity in frontal region for real characters, and greater negativity at the central electrode for pseudo characters. The polarities of the ERP components at these sites are correlated with ease of processing as previously reported (Bentin, Mouchetant-Rostaing, Giard, Echallier, & Pernier, 1999; Braun, Jacobs, Hahne, Ricker, Hofmann, & Hutzler, 2006). The time windows of the components show a pattern of activities early on in left occipital and right frontal, followed by activities in right occipital and left frontal, respectively, and responses beginning around 400ms post-stimulus in the central region. The involvement of the right hemisphere in processing Chinese characters and that of the left visual area preceding the right homologue are compatible with observations of brain activities of adult Chinese bilinguals during processing of high and low frequency Chinese characters in delayed naming (Liu & Perfetti, 2003) and semantic judgments (Perfetti & Liu, 2005). We speculate that the comparable time windows of occipital (greater negativity) and frontal activities (greater positivity) are associated with the same underlying cognitive processes, perhaps orthographic processing of the stimuli.

The TFA results reveal a consistent pattern of significantly greater event-related synchronization (ERS) and greater phase-resetting for pseudo characters in theta and gamma bands, only for CA. The findings can be interpreted as greater cognitive demand in processing pseudo characters in a system that is sensitive to the familiarity of the lexical item. Comparable time windows of greater ERS in theta band in right occipital and central sites were followed by activity in right frontal in a later period. Similarly, greater phase coherence across trials was exhibited in comparable time windows in theta band at all electrode sites, immediately preceded by responses in central and bilateral frontal regions and followed by synchronous activities in right occipital, left frontal and central locations later on. Greater theta ERS for visually presented pseudowords over the occipital region echoes the findings of lexicality effects in Krause et al. (2006), although the temporal window of activity that we observed took place much earlier. The mechanism underlying early neural responses reflected in greater ITC over the central and bilateral frontal regions is also unclear.

Taking together the patterns of ERSP and ITC, the involvement of occipital, central and frontal regions can be hypothesized to form a reading network, along the line of Liu and Perfetti (2003) and Perfetti and Liu (2005), in Chinese young readers. The idea of a reading network finds tentative support from greater gamma ERS in occipital sites (albeit uncorrected) early on (left), then around 300-400ms (right) and finally after 550ms (left), and for extended periods across the post-stimulus time window at the central electrode, and during 350-550ms in right frontal. Gamma activities have been argued to play an important role in synchronizing activities across cortical regions at a network level (Bastiaansen & Hagoort, 2003).

Our discussion thus far has focused on lexicality effects in CA. The null findings of PR can be taken as deficient orthographic analysis as well as access to phonology and semantics of real characters; alternatively, they may indicate poor early orthographic processing which has cascading negative effects on subsequent language/cognitive processes. Either scenario is consistent with insignificant increase of theta activities for pseudowords at occipital sites exhibited by children with dyslexia (Klimesch et al., 2001b). Note however that such observations differ from delay of processing as predicted by the speed of processing deficit hypothesis.

While our observations of using ERP and TFA in single case studies to investigate developmental dyslexia are preliminary and our interpretation of the findings remains speculative, we have highlighted the potentials of this methodological approach in understanding a disorder that is neurological and possibly heterogeneous in nature.

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References

Bastiaansen, M. C. M., & Hagoort, P. (2003). Event-induced theta responses as a window on the dynamics of memory. *Cortex,* 39, 967-992

Bentin, S., Mouchetant-Rostaing, Y., Giard, M. H., Echallier, J. F., & Pernier, J. (1999). ERP manifestations of processing printed words at different psycholinguistic levels: time course and scalp distribution. *Journal of Cognitive Neuroscience,* 11(3), 235-260

Bishop, D. V. M., & Hardiman, M. J. (2010). Measurement of mismatch negativity in individuals: a case study using single-trial analysis. *Psychophysiology,* 47, 697-705

Booth, J. R., & Burman, D. D. (2001). Development and disorders of neurocognitive systems for oral language and reading. *Learning Disability Quarterly,* 24, 205-215

Booth, J. R., Perfetti, C. A., McWhinney, B., & Hunt, S. B. (2000). The association of rapid temporal perception with orthographic and phonological processing in children and adults with reading impairment. *Scientific Studies of Reading,* 4, 101-132

Bosse, M.-L., Tainturier, M.-J., & Valdois, S. (2007). Developmental dyslexia: The visual attention span deficit hypothesis. *Cognition*, 104, 198-230

Braun, M., Jacobs, A. M., Hahne, A., Ricker, B., Hofmann, M., & Hutzler, F. (2006). Model-generated lexical activity predicts graded ERP amplitudes in lexical decision. *Brain Research*, 1073-1074(1), 431-439

Breznitz, Z., & Misra, M. (2003). Speed of processing of the visual–orthographic and auditory–phonological systems in adult dyslexics: The contribution of "asynchrony" to word recognition deficits. *Brain and Language*, 85, 486-502

Cheung, H., Chung, K.K.H., Wong, S. W. L., McBride-Chang, C., Penney, T.B., & Ho, C. S.-H. (2009). Perception to tone and aspiration contrasts in Chinese children with dyslexia. *Journal of Child Psychology and Psychiatry,* 50, 726-733

Chung, K. K. H., McBride-Chang, C., Wong, S. W. L., Cheung, H., Penney, T. B., & Ho, C. S.-H. (2008). The role of visual and auditory temporal processing for Chinese children with developmental dyslexia. *Annals of Dyslexia,* 58, 15-35

Csepe, V., (2003). Auditory event-related potentials in studying developmental dyslexia. In V. Csepe (Ed.), *Dyslexia: Different brain, different behaviour* (pp. 81-112). New York, US: Kluwer Academic

Delorme, A., & Makeig, S. (2004). EEGLAB: an open source toolbox for analysis of single-trial EEG dynamics. *Journal of Neuroscience Methods,* 134, 9-21

Farmer, M. E., & Klein, R. K. (1993). Auditory and visual temporal processing in dyslexic and normal readers. *Annals of the New York Academy of Sciences,* 682, 339–341

Goswami, U. (2003). Phonology, learning to read and dyslexia: A cross-linguistic analysis. In V. Csepe (Ed.), *Dyslexia: Different brain, different behaviour* (pp. 1-40). New York, US: Kluwer Academic

Ho, C. S. H., & Bryant, P. (1997). Phonological skills are important in learning to read Chinese. *Developmental Psychology,* 33, 946-951

Ho, C. S.-H., Chan, D. W.-O., Lee, S.-H., Tsang, S.-M., & Luan, V. H. (2004). Cognitive profiling and preliminary subtyping in Chinese developmental dyslexia. *Cognition,* 91, 43-75

Ho, C. S.-H., Chan, D. W.-O., Tsang, S.-M., & Lee, S.-H. (2000). *The Hong Kong Test of Specific Learning Difficulties in Reading and Writing*. Hong Kong: Hong Kong Specific Learning Difficulties Research Team

Klimesch, W., Doppelmayr, M., Wimmer, H., Gruber, W., Rohm, D., Schwaiger, J., & Hutzler, F. (2001a). Alpha and beta band power changes in normal and dyslexic children. *Clinical Neurophysiology,* 112, 1186-1195

Klimesch, W., Doppelmayr, M., Wimmer, H., Schwaiger, J., Rohm, D., Gruber, W., & Hutzler, F. (2001b). Theta band power changes in normal and dyslexic children. *Clinical Neurophysiology,* 112, 1174-1185

Krause, C. M., Gronholm, P., Leinonen, A., Laine, M., Sakkinen, A.-L., & Soderholm C., (2006). Modality matters: the effects of stimulus modality on the 4- to 30-Hz brain electric oscillations during a lexical decision task. *Brain Research,* 1110, 182-192

Leung, M.-T., Lai, A., & Kwan, E. S. M. (2008). *The Hong Kong Graded Character Naming Test.* Hong Kong: Centre of Communication Disorders, University of Hong Kong

Leung, M.-T., & Lee, A. (2002). The Hong Kong corpus of primary school Chinese. Paper presented at the Ninth meeting of the International Clinical Phonetics and Linguistics Association

Liu, Y., & Perfetti, C. A. (2003). The time course of brain activity in reading English and Chinese: an ERP study of Chinese bilinguals. *Human Brain Mapping,* 18, 167-175

Liu W., Shu, H., & Yang, Y. (2009). Speech perception deficits by Chinese children with phonological dyslexia. *Journal of Experimental Child Psychology*, 103, 338-354

Makeig, S., Debener, S., Onton, J., & Delorme, A. (2004). Mining event-related brain dynamics. *Trends in Cognitive Neuroscience,* 8, 204–210

Meng, X., Sai, X., Wang, C., Wang, J., Cha, S., & Zhou, X. (2005). Auditory and speech processing and reading development in Chinese school children: Behavioral and ERP evidence. *Dyslexia,* 11, 292-310

Perfetti, C. A., & Liu, Y. (2005). Orthography to phonology and meaning: Comparisons across and within writing systems. *Reading and Writing,* 18, 193-210

Penolazzi, B., Spironelli, C., & Angrilli, A. (2008). Delta EEG activity as a marker of dysfunctional linguistic processing in developmental dyslexia. *Psychophysiology*, 45, 1025-1033

Raven, J. C. (1986). *Hong Kong supplement to guide to the standard progressive matrices.* H.K.: HKSAR Government, Education Department

Siok, W. T., & Fletcher, P. (2001). The role of phonological awareness and visual-orthographic skills in Chinese reading acquisition. *Developmental Psychology,* 37, 886-899

Siok, W. T., Perfetti, C. A., Jin, Z., & Tan, L. H. (2004). Biological abnormality of impaired reading is constrained by culture. *Nature*, 431, 71-76

Spironelli, C., Penolazzi, B., & Angrilli, A. (2008). Dysfunctional hemispheric asymmetry of theta and beta EEG activity during linguistic tasks in developmental dyslexia. *Biological Psychology,* 77, 123-131

Tallon-Baudry, C., Bertrand, O., Delpuech, C., & Pernier, J. (1996). Stimulus specificity of phase-locked and non-phase-locked 40 Hz visual responses in human. *Journal of Neuroscience,* 16, 4240–4249

Valdois, S., Bosse, M.-L., & Tainturier, M.-J. (2004). The cognitive deficits responsible for developmental dyslexia: Review of evidence for a selective visual attentional disorder. *Dyslexia,* 10, 339-363

Wu, S., Packard, J. L., & Shu, H. (2009). Morphological deficit and dyslexia subtypes in Chinese. In S.-P. Law, B. S. Weekes, & A M-Y. Wong (Eds.), *Language disorders in speakers of Chinese* (pp. 112-137). Bristol, UK: Multilingual Matters

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