Electrophysiological basis of reading related phonological impairment in Chinese speakers with schizophrenia: An ERP study

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1. Introduction

Schizophrenia is a common mental disorder, which also affects several cognitive domains, for example, memory, executive function and language (Bagner et al., 2003; Koike et al., 2013; Salisbury, 2008). The prevalence of schizophrenia in the population is generally estimated between 0.5% and 1.0% (American, 2000; Erritty and Wydell, 2013). Indeed, the incidence of schizophrenia in China is said to be about 0.65% (Chen et al., 1998). Many studies found that language-related cognitive deficits were associated with clinical symptoms, such as auditory hallucinations and thought disorders (Oertel-Knoechel et al., 2013; Tsao et al., 2013). Several behavioral studies also detected the deficits in phonological processing abilities in patients with schizophrenia with alphabetic language users (Arnott et al., 2011; Whitford et al., 2013). However, the phonological processing abilities in Chinese patients with schizophrenia and their underlying mechanisms were yet to be investigated. Note that Chinese is a tonal language, and each tone determines the meaning of a word, which otherwise would be homophonic to several other words. However since the Chinese language uses a logographic orthography, orthographic awareness plays a more dominant role than phonological awareness in the early stage of reading acquisition in Chinese, which is contrary to English-speaking children (Wei et al., 2014). In English it is often seen that schizophrenic patients exhibit a phonological processing deficit (Arnott et al., 2011; Whitford et al., 2013). Given the characteristics of the Chinese language/orthography a relationship between schizophrenia and phonological processing deficit might not be expected. This provides the rationale for investigating the relationship between Chinese patients with schizophrenia and their phonological processing skills. The present study, using the behavioral measures and Event-Related Potentials (ERP) method, investigated the link between phonological processing abilities and their underlying electrophysiological responses in the Chinese patients with schizophrenia.

1.1. Phonological processing deficits in schizophrenia

As early as the 1980s, researchers have been interested in language problems associated with schizophrenia however it was found that...
patients with schizophrenia have normal single word reading ability (Dalby and Williams, 1986). With the increased interest in research into schizophrenia, more detailed analyses of language problems in schizophrenia started to emerge including failure of language lateralization in auditory speech perception (Bagni et al., 2003; Ngan et al., 2003; Rockstroh et al., 2001; Tsao et al., 2013) and visual language, i.e., reading related ability, including phonological and semantic processing (Angrilli et al., 2009; Arnott et al., 2011; Kayser et al., 1999; Revheim et al., 2006; Rockstroh et al., 1998; Salisbury, 2002; Spironelli et al., 2008). To date, more and more studies have taken the viewpoint that reading impairment in schizophrenia has reached a similar level to that of dyslexia (Arnott et al., 2011; Revheim et al., 2006; Whitford et al., 2013), whose core deficit lies in phonological processing skills (Ramus et al., 2003). Phonological processing skills involve not only high-level phoneme discrimination skills but also low-level general auditory processing skills (Ramus et al., 2003; Wagner and Torgesen, 1987).

In alphabetic languages, several studies indicated that patients with schizophrenia had phonological processing deficits, including deficits in rapid naming, and phonological awareness skills (Arnott et al., 2011; Whitford et al., 2013). Arnott et al. (2011), for example, employed various cognitive behavioral tasks to detect any impairment in task performance of patients with schizophrenia, and found that patients with schizophrenia were impaired in reading comprehension, rapid naming and phonological awareness skills. Further, positive correlations were found between phonological awareness and reading comprehension. Arnott et al. also suggested that patients with schizophrenia might experience problems with reading comprehension that could have a phonological basis (Arnott et al., 2011). Many behavioral studies thus suggest phonological processing deficits in schizophrenic individuals (e.g., Arnott et al., 2011; Whitford, et al., 2013). However, it is less clear if there might be a neural basis of phonological processing deficits in patients with schizophrenia. Therefore this paper explored this possibility. It should be further noted that although the current paper is the first paper to explore a neural basis of phonological processing deficits in patients with schizophrenia in Chinese, there already exist studies investigating the neural correlates of these deficits in Chinese dyslexics as in the alphabetic languages (Meng et al., 2005; Ramus et al., 2003). Meng et al. (2005) for example used Event-Related Potentials (ERP) as well as behavioral measurements to detect Chinese dyslexic children’s phonological processing abilities. Their behavioral data showed that Chinese children with developmental dyslexia had deficits in phonological awareness skills, and in turn these deficits were observed in their ERP data, namely the auditory temporal processing of the Chinese dyslexic children was atypical compared to that of the healthy controls.

1.2. ERP studies in schizophrenia

In the event-related-potential (ERP) studies, the P300 response occurs at around 300 ms from the onset of stimuli in the oddball paradigm in which presentations of sequences of repetitive auditory or visual stimuli are interrupted unexpectedly by a deviant stimulus. The P300 component is understood to reflect a higher cognitive response to unexpected and/or cognitively salient stimuli (Sutton et al., 1965). Previous studies using pure tones as stimuli in an active oddball paradigm found that patients with schizophrenia evoked a lower amplitude and longer latency of P300 (Mar’ina et al., 2012; Qiu et al., 2014). Furthermore, P300 is thought to be an endophenotype, reflecting the actions of genes predisposing an individual to a specific disorder even in the absence of any diagnosable pathology of schizophrenia (Turetsky et al., 2007). Chang et al. (2014) revealed a significant correlation between the severity of the psychopathology (reflected in total PANSS1 scores) and the P300 amplitude, even controlling for age, sex and duration of illness. However, a correlation between the P300 amplitude and phonological processing ability in patients with schizophrenia has not yet been established.

1.3. Characteristics of Chinese language and orthography

Chinese Mandarin, using a logographic writing system, is different from alphabetic languages. A Chinese character/word cannot phonologically/phonetically be decomposed in the way alphabetic orthographies can. Thus the phonology of a Chinese character/word is retrieved as a whole, rather than computed piece-meal fashion in English (e.g., ‘eat’ > /e/ , /a/ , /t/ > /e/at/). In addition lexical tones (Mandarin has four distinct tones) can distinguish a word from the others with the same pronunciation/sound value, otherwise, they would become homophones (i.e., different characters with the identical pronunciation) to each other (Wei et al., 2014).

Thus the different lexical tones of the same syllables can have different meanings. For example, the syllable of “shu”, can mean “book” in the first lexical tone (普通话), “ripe” in the second lexical tone (熟), “mous” in the third lexical tone (熟) or “tree” in the forth lexical tone (树). Lexical tone represents phonological information at a suprasegmental (or syllabic) level and its role is as critical as segmental (consonant and vowel) features in determining a word’s meaning (Zhang et al., 2012a, 2012b).

Studies investigating the impact of these lexical tones on reading acquisition and development in Chinese identified that lexical tone awareness was considerably important for learning Chinese characters especially when Orthography-Phonology (OPC) conversions take place (Li and Ho, 2011; Zhang et al., 2012a, 2012b). For example, Chinese characters with the same phonetic components are often homophones, and therefore good tone discrimination is essential when applying the OPC conversions effectively in reading (Li and Ho, 2011). Further, studies have shown that Chinese children with developmental dyslexia had the deficits in lexical tone awareness (Li and Ho, 2011; Zhang et al., 2012a, 2012b). Therefore in order to explore phonological processing skills in Mandarin-speaking Chinese, especially those with schizophrenia in the current study, the lexical tone discrimination task was chosen as the experimental paradigm.

1.4. Reading-related abilities in Chinese schizophrenia

To date, the studies conducted by Yang et al. (2012) and Tsao et al. (2013) were the only two behavioral studies that investigated the level of lexical tone perception in schizophrenia. Yang et al. found patients with schizophrenia had impairments in lexical tone matching task, which correlated with both word identification and discrimination (Yang et al., 2012). Tsao et al. showed that adults with schizophrenia were less accurate than healthy controls in discriminating the lexical tones, and furthermore the lexical tone accuracy was negatively correlated with the severity of schizophrenic symptoms (Tsao et al., 2013).

Thus a further behavioral investigation coupled with an electrophysiological investigation into lexical tone processing skills in schizophrenia in more detail may lead to a better understanding of the clinical symptoms of Chinese patients with schizophrenia in China.

The aim of the present study was to ascertain the neural correlates of phonological processing skills in Chinese healthy individuals, and then to compare these with the neural correlates of these skills in Chinese schizophrenic individuals using lexical tone judgments. As shown in the other studies (Mar’ina et al., 2012; Qiu et al., 2014), there might be some differences in terms of amplitude and duration of the auditory P300 between the schizophrenic and healthy Chinese individuals, thus revealing neural evidence for phonological impairment in Chinese schizophrenic individuals.

Therefore, in the current study we hypothesized that (1) the
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