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The visual attention span deficit in Chinese children with reading fluency difficulty

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ABSTRACT

With reading development, some children fail to learn to read fluently. However, reading fluency difficulty (RFD) has not been fully investigated. The present study explored the underlying mechanism of RFD from the aspect of visual attention span. Fourteen Chinese children with RFD and fourteen age-matched normal readers participated. The visual 1-back task was adopted to examine visual attention span. Reaction time and accuracy were recorded, and relevant d-prime (d') scores were computed. Results showed that children with RFD exhibited lower accuracy and lower d' values than the controls did in the visual 1-back task, revealing a visual attention span deficit. Further analyses on d' values revealed that the attention distribution seemed to exhibit an inverted U-shaped pattern without lateralization for normal readers, but a W-shaped pattern with a rightward bias for children with RFD, which was discussed based on between-group variation in reading strategies. Results of the correlation analyses showed that visual attention span was associated with reading fluency at the sentence level for normal readers, but was related to reading fluency at the single-character level for children with RFD. The different patterns in correlations between groups revealed that visual attention span might be affected by the variation in reading strategies. The current findings extend previous data from alphabetic languages to Chinese, a logographic language with a particularly deep orthography, and have implications for reading-dysfluency remediation.

1. What this paper adds?

To our knowledge, the present study firstly investigate the visual attention span in Chinese children with reading fluency difficulty through a visual attentional task with non-verbal stimuli and no verbal response. The findings extend previous data from alphabetic languages to a logographic language with a particularly deep orthography (i.e. Chinese), by showing the importance of examining the visual attention span of children with reading fluency difficulty irrespective of the transparency of the language. Additionally, we found differences between groups in terms of the allocation of visual attention span resources, and the different patterns in attention distribution might be associated with variations in reading strategies, suggesting the presence of a close relationship between general cognitive processing of visuo-spatial attention and language processing. Accordingly, future intervention studies on reading disabilities could focus on visual attentional processing, by aiming at enlarging the visual attention span to improve reading proficiency.

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2. Introduction

Reading fluency is one of the critical reading skills, and it refers to reading rapidly and accurately with adequate comprehension (Langer, Benjamin, Minas, & Gaab, 2013). With increasing experience in reading, connections develop between orthographic input and phonological/semantic units. Through the generation of automatization, greater accuracy and enhanced speed (i.e. fluent reading) are achieved. However, some children have difficulty in reading fluency. For example, one of the most common symptoms for individuals with reading disabilities is a persistent failure to develop fluent reading skills (Fraga González et al., 2015). Many children continue to exhibit fluency deficit even after completing remediation (Lyon & Moats, 1997). Moreover, it has been indicated that up to 30% of the fourth graders exhibit reading fluency deficits in America (Lee, Grigg, & Donahue, 2007). Impairment in reading fluency can lead to severe academic, economic, and psychosocial consequences (Fraga González et al., 2015). However, the underlying mechanisms of reading fluency difficulty (RFD) have been studied less than other reading components.

Previous literature has mostly explored the relevant mechanisms of reading fluency impairment from the aspect of language processing (e.g. Norton & Wolf, 2012; Suárez-Coalla, Avdyli, & Cuetos, 2014). Behavioural and neuroimaging studies have reported that individuals with reading fluency disabilities show poor performance and abnormal brain activity in tasks involving the integration of orthographic and phonological representations, which is closely related to their disability in fluent reading (Blomert, 2011; Hasko, Bruder, Bartling, & Schulte-korne, 2012; Langer et al., 2013; Froyen, Willems, & Blomert, 2011; Wolf & Katzir-Cohen, 2001; Norton & Wolf, 2012; Zaric et al., 2014). These findings suggest that the quality of orthographic-to-phonological mapping is directly related to reading fluency, and that a deficient pattern of letter-speech sound integration may explain reading dysfluency (Froyen et al., 2011). However, it has been reported that reading fluency deficit is difficult to be completely remediated through interventions that focus on language skills, especially in which reading speed of reading fluency could not be validly improved (Lyon & Moats, 1997; Langer et al., 2013). These findings suggested that reading dysfluency might be attributed to some other deficits in addition to the problems in the language level. Given that visual processing is the first step in reading, and some researchers claimed that it should be traced back to visual decoding to explore the reading process (Grainger, Dufau, Montant, Ziegler, & Fagot, 2012; Rauschecker et al., 2011; Ziegler et al., 2013). Therefore, it might be better to investigate the basic mechanism of reading fluency from the aspect of visual processing.

An important aspect of fluent reading is the necessity to visually process several orthographic units in a very short time frame (i.e. visual rapid simultaneous processing), and visual attention span is usually considered as an index of the visual rapid simultaneous processing (Bosse, Tainturier, & Valdois, 2007). Visual attention span is defined as the number of distinct visual elements that can be processed in parallel, in a multi-element array such as a letter string, presented to the eye briefly (Bosse et al., 2007; Lobier, Zoubrinetzky, & Valdois, 2012, 2013). Thus, participants with a larger visual attention span can allocate attention on more letters/characters simultaneously, which corresponds with higher reading speed (Lobier, Dubois, & Valdois, 2013).

Studies in alphabetic languages have reported that the visual attention spans of typically developing children and skilled readers were closely related to fluent reading performance at word and text levels (Awadh et al., 2016; Lobier et al., 2013; van den Boer, Bergen, & de Jong, 2014; van den Boe, van Bergen & de Jong, 2015). A developmental study found a sustained influence of visual attention span on reading speed through primary school (Bosse and Valdois, 2009). Research on dyslexics has also revealed the relationship between visual attention span and reading fluency (e.g. Bosse et al., 2007; Chen, Schneps, Masyn, & Thomson, 2016). Bosse et al. (2007) proposed the visual attention span deficit hypothesis, which purports that reading disabilities might be due to impaired visual attention span. Several studies have found that some dyslexics with lower reading speed exhibited smaller visual attention span as compared to age-matched controls, and the poor reading performance was significantly correlated with their visual attention capacity (Lobier et al., 2012; Germano, Reilhac, Capellini, & Valdois, 2014; Saksida et al., 2016; Lallier, Valdois, Lassus-Sangosse, Prado, & Kandel, 2014; Zoubrinetzky, Bielle, & Valdois, 2014). Meanwhile, neuroimaging studies reported that dyslexic children with poor reading fluency showed less activation in the bilateral superior parietal lobule (particularly in the right hemisphere) as compared to age-matched normal readers in tasks related with visual attention span, such as a multi-element categorization task (Lobier, Peyrin, Pichat, Le Bas, & Valdois, 2014), a flanked visual categorization task (Peyrin, Demonet, N'Guyen-Morel, Le Bas, & Valdois, 2011; Peyrin et al., 2012, and a perceptual matching task (Reilhac, Peyrin, Demonet, & Valdois, 2013). The superior parietal regions were suggested to control visual spatial attention (Lobier et al., 2014; Peyrin et al., 2011; Peyrin et al., 2012; Reilhac et al., 2013). These findings thus provide evidence for the relationship between visual attention span and reading fluency from the neural aspect. Moreover, an intervention study (Valdois et al., 2014) reported that a dyslexic child with a visual attention span deficit exhibited a severe deficiency in text reading speed, and that the visual attention span intervention enhanced her reading fluency. This result revealed a causal role of visual attention span in reading fluency.

In contrast to these findings, several studies have failed to observe differences in the visual attention span of dyslexics with reading fluency deficit and control participants. Specifically, dyslexics with lower reading speed did not differ from non-impaired readers in terms of visual attention span (Collis, Kohnen, & Kinoshita, 2013; Ziegler, Pech-Georgel, Dufau, & Grainger, 2010; Shovman & Ahissar, 2006; Yeari, Isser, & Schiff, 2017; Hawelka and Wimmer, 2008). These conflicting results might be due to the heterogeneity of the dyslexic population. It has been suggested that a high prevalence and severity of phonological deficits in one subtype of dyslexia might weaken the role of the visual attention span deficit in reading disabilities (Saksida et al., 2016).

Additionally, the discrepancy between the two sets of findings might be associated with orthographic transparency. Relevant studies have revealed potential modulation of visual attention span depending on the orthographic-to-phonological regularity of the language (Awadh et al., 2016; Lallier, Carreiras, Tainturier, Savill, & Thierry, 2013; Lallier & Carreiras, 2017). According to the psycholinguistic grain size theory (Ziegler and Goswami, 2005), the size of the units upon which lexical representations are built is inversely proportional to the regularity of orthographic-to-phonological correspondence. In transparent orthographies, the