Cerebral Network for Implicit Chinese Character Processing: An fMRI Study

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ABSTRACT

Recent event-related fMRI studies suggest that a left-lateralized network exists for reading Chinese words (to contrast two-character Chinese words and figures). In this study, the authors used a 3T fMRI to investigate brain activation when processing characters and figures in a visual discrimination task. Thirteen Chinese individuals were shown two Chinese characters (36 pairs) or two figures (36 pairs). The control task (two figures) was used to eliminate non-linguistic visual and motor confounds. The results showed that discrimination of Chinese characters is performed by a bilateral network that processes orthographic, phonological, and semantic features. Significant activation patterns were observed in the occipital region (BA17, 18, 19, and 37), temporal region (BA22 and 38), parietal region (BA7, 39, and 40), and frontal region (BA4, 6, 10, and 46) of the brain and in the cerebellum. The study concludes that a constellation of neural substrates provides a bilateral network that processes Chinese subjects.

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INTRODUCTION

Recent event-related fMRI studies have indicated that a left-lateralized network exists for processing Chinese logographs (Kuo, Yeh, Duann, Wu, Ho, Huang, Tzeng, Hsieh 2001). Written or spoken language activates certain parts of the brain. Previous neuroimaging studies using functional magnetic resonance imaging (fMRI) or positron emission tomography (PET) showed different activation patterns during alphabetic language processing (e.g., English) and logographic language processing (e.g., Chinese characters) (Kuo et al., 2001, Kuo, Yeh, Lee, Chen, Lee, Chen, Ho, Hung, Tzeng, Hsieh 2004, Petersson, Reis, Askolof, Castro-Caldas, Ingvar 2000, Petersson, Reis, Ingvar 2001, Tan, Liu, Perfetti, Spinks, Fox, Gao 2001, Tan, Spinks, Feng, Siok, Perfetti, Xiong, Fox, Gao 2003). Alphabetic language processing preferentially involves the left inferior frontal cortex (IFC), the left medial temporal lobe (MTL), and the left temporal occipital area (Booth, Burman, Meyer, Gitelman, & Parrish, 2002; Jobard, Crivello, & Tzourio-Mazoyer, 2003). Chinese logographic characters have different square configurations of a similar size that are packed by numerous stokes and map onto morphemes rather than direct phonemes (Tan et al., 2003). Accordingly elaborate visuospatial processing is necessary to process the Chinese logographic system (Tan, Spinks, Gao, Liu, Perfetti, Xiong, Stofr, Pu, Liu, & Fox, 2000; Tan, Chan, Ka, Khong, Yip, & Luke, 2008).

Language, as an important part of cognitive neuroscience, is influenced by the socio-cultural background. Previous studies have elucidated a left-lateralized network for processing Chinese words (two-character Chinese words and two figures) (Kuo et al., 2001). Therefore, the pattern of interactions between large-scale functional-anatomical networks for language processing may differ during certain language tasks. Different regions of the brain are activated in behavioral and functional neuroimaging studies. To process alphabetic subjects, the functional architecture of the brain is adjusted by literacy and education. Kuo et al. reported that a left-lateralized network exists for reading Chinese words and figures (Kuo WJ et al., 2001). Whereas Tan et al. reported an extensive activation of bilateral hemispheric structures during Chinese character processing in semantic and a homophone tasks (Tan LH et al., 2003).

Moreover, our previous study found activation differences when processing Chinese characters by a visual modality in the left superior temporal gyrus (BA39/40), right inferior parietal lobe (BA40) and right middle frontal gyrus (BA10). Such differences are more obvious and easier to determine visually because lexical processing is nearly non-existent. Individuals receive information by through visual or auditory routes. Thus, we performed a visual fMRI study to investigate character processing by Chinese individuals. We hypothesized that there is a bilateral cortical network for Chinese character processing during judgment tasks through a visual modality.

In our study, we used whole-brain 3T fMRI to observe brain responses during the judgment of Chinese characters and figures. The goals of the current study are threefold: (1) to inspect the commonality and particularity of brain organization used for processing Chinese characters relative to that used for alphabetic languages. (2) to use a control task to eliminate non-linguistic visual and motor confounds. (3) to propose that Chinese word recognition might mandate perceptual and attention mechanisms that target the bilateral hemisphere. These provide advantageous sensitive analysis of the spatial properties of Chinese characters.

LANGUAGE

Language is succinctly defined in our Glossary as a “human system of communication that uses arbitrary signals, such as voice sounds, gestures,
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