Chapter 21

Language Processing in the Human Brain of Literate and Illiterate Subjects

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ABSTRACT

Using functional magnetic resonance imaging (fMRI) or positron emission tomography (PET), much knowledge has been gained in understanding how the brain is activated during controlled experiments of language tasks in educated healthy subjects and in uneducated healthy subjects. While previous studies have compared performance between alphabetic subjects, few data were about Chinese-speaking individuals. In alphabetic subjects, studies indicate that the literates surpass the illiterates, especially in tasks involving phonological processing, and that different activation regions in fMRI are located between Broca's area and the inferior parietal cortex, as well as the posterior-mid-insula bridge between Wernicke's and Broca's area. In Chinese subjects, the results were shown in silent word recognition tasks (the left inferior/middle frontal gyrus and bilateral superior temporal gyri) and in silent picture-naming tasks (the bilateral inferior/middle fontal gyri and left limbic cingulated gyrus). In this study, the authors use some recent fMRI data to investigate language processing in the human brain of literate and illiterate subjects.

INTRODUCTION

Language, as an important part of cognitive neuroscience, is influenced by socio-cultural backgrounds. 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

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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 homophone tasks (Tan LH et al., 2003).

Languages are remarkable systems that allow people to communicate an unlimited combination of ideas using highly structured streams of sounds, written signs, and manual or facial gestures. One of the earliest studies on language processing in the brain dates back to 1861, when Pierre Paul Broca found that the inferior part of left frontal lobe (Broca's area) was related to speech production in a lesion study. Almost simultaneously, Carl Wernicke (1874/1969) found that a posterior region (Wernicke's area) in the left hemisphere—an area in and around where the temporal and parietal lobes meet—was related to language comprehension. Broca's and Wernicke's work laid the foundation for later studies in the field of language processing in the brain.

Language, whatever type it is, can activate certain parts of our brain by either visual input or auditory input. Previous neuroimaging studies using functional magnetic resonance imaging (fMRI) or positron emission tomography (PET) have shown the different activation patterns of alphabetic languages (e.g. English) and logographic languages (e.g. Chinese characters) (Gabrieli et al., 1998; Petersen et al., 1988; Petersson et al., 1999, 2000, 2001; Kuo et al., 2001; Tan et al., 2001, 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 et al., 2002; Jobard et al., 2003). Chinese logographic characters differ in that they each have a square configuration of similar size that are packed by a number of strokes and map onto morphemes rather than direct phonemes (Rayner and Pallatsek, 1989; Tan et al., 2001). Accordingly elaborate visuospatial processing is necessary in the Chinese logographic system (Tan et al., 2000, 2008; Wai Ting Siok et al. 2008). While some areas (the frontal and temporal lobes) are involved in both Chinese and English stimuli, other regions (the bilateral occipital cortex, the superior and inferior parietal lobes, and the left fontal cortex) are uniquely activated due to the visual-spatial localization and complex integration of semantic and phonological processing in reading Chinese characters. The processing of Chinese words is different to and often more complicated than that of alphabetic words. For example, previous studies have shown that depending on overt or covert reading of different fMRI stimulation tasks, brain activation during the reading of Chinese characters is bihemispheric or left hemisphere dominated (BA9 in particular) (Tan et al., 2001; Kuo et al., 2001). An absence of a left-lateralized network tendency, which was shown in Kuo's study of Chinese word reading, could be attributed to the difference in tasks. The present study showed a greater difference in activation regions compared to Li's study, which used silent word recognition tasks in Chinese literates and illiterates.

Word recognition is a procedure of cognitive language processing of all levels, including phonological, orthographic and semantic aspects. Of these three, phonology and semantics may have the biggest impact. However, the overall discriminating process for Chinese characters in general, can be decomposed into component processes, including early visual processing, sublexical orthographic and/or phonological processing, and lexical orthographic and/or semantic word-form selection. Lexical orthographic may be the key aspect of character discrimination. Chinese is a logographic system (although not pure) which differs from alphabetic systems significantly in orthography by visual input processing. Further clarification of the affected activation patterns of language processing in Chinese literates by literacy may benefit most from the lexical aspect during discrimination of high-frequency charac-