

論文内容要旨

Comparison of Activation in the Prefrontal Cortex of Native Speakers of Mandarin by Ability of Japanese as a Second Language Using a Novel Speaking Task

(独自スピーキングタスクを用いたネイティブ中国語話者の前頭前野における活性化の比較：日本語能力の影響)

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Humans learn their first language (L1) naturally from their parents in parallel with lateralization of the brain. A mostly right-handed person has their language center in the left hemisphere. Both the Wernicke and the Broca areas in the left hemisphere become active when people are trying to understand or express something in language. Furthermore, patterns of brain activation were associated with age of second language (L2) learning, task difficulty, and proficiency of L2 ability. The onset of dementia in bilinguals is about 4-6 years later than in monolinguals, according to a large-scale investigation. The reason is believed to lie in cognitive processes involved in inhibition of one language in favor of another while code-switching between languages. It was suggested that use of multiple languages over many years requiring code-switching and inhibition affects cognitive function. Nowadays, with increasing longevity world-wide, and considering the onset of dementia is delayed in second language speakers, the relation between brain activation and language proficiency is an important area of research. Regarding this, there have been studies of bilinguals including Japanese/English (L1/L2) and English/Mandarin (L1/L2) speakers. Among these languages, English uses phonetic characters, whereas Mandarin and Japanese use ideographs. It can be expected that brain activation patterns may differ slightly due to the differences among these languages, and that brain activity patterns may change when the code-switching function is activated or repeatedly employed. There are many differences between Mandarin and Japanese languages due to their different historical backgrounds and cultures. It would be useful to clarify how L2 proficiency affects prefrontal cortex activation in people speaking Mandarin/Japanese (L1/ L2). As far as the authors are aware, no previous study has investigated this.

Here in this work, twenty-four right-handed, healthy Chinese speakers of Mandarin with Japanese as a second language were divided into low and high L2 ability groups determined by self-evaluation questionnaire with both L1 and L2 scored on a scale of 1 to 10 in all four domains listening, speaking, writing, and reading. A novel speaking task was developed wherein Mandarin/Japanese (L1/L2) speakers had to describe stimuli using L1 or L2. Simultaneously, cerebral blood flow changes in the prefrontal cortex as proxy for prefrontal cortex activation were measured by functional near-infrared spectroscopy (fNIRS). Comparisons between groups were assessed using Student's t-test with differences with a probability of $P < 0.05$ deemed significant. Also, the correlations between the L2 ability and the cerebral blood flow changes while speaking each

language were obtained by linear regression analysis using the least-squares estimation. Furthermore, the maps of brain regions involved in both tasks were obtained using a Statistical Parametric Mapping software package (NIRS-SPM). Finally, the relationships between such activation and L2 proficiency were discussed.

As the result, people with low L2 ability showed much more brain activation when speaking L2 than L1. People with high L2 ability showed high-level brain activation when speaking either L2 or L1. Almost the same high-level brain activation was observed in both ability groups when speaking L2. The high-level of activation in people with high L2 ability when speaking either L2 or L1 suggested strong inhibition of the non-spoken language. A wider area of brain activation in people with low than high L2 ability when speaking L2 is considered to be attributed to the cognitive load involved in code-switching L1 to L2 with strong inhibition of L1 and the cognitive load involved in using L2. The above results suggest that learning a second language of Japanese would be helpful for Chinese speakers of Mandarin to delay the onset of dementia by changing brain activation pattern. This effect should also be furtherly confirmed through a wider area analysis on the brain of more subjects using the fNIRS measurement as well as other techniques. Furthermore, the implications for the field of neurolinguistics and language education are also expected. An effective method for language education in enhancing the cognitive function might be important.