Implicit and explicit processing of kanji and kana words and non-words studied with fMRI

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Introduction

Price and colleagues, in their PET study, demonstrated that even though subjects were simply required to detect the occurrence of a specific letter in a series of written words, subjects read the words without their awareness. This "automatic" word processing is called the implicit processing of language [1]. Although a number of lesion and functional imaging studies have shown the different neural substrates for explicit reading of kanji (morphograms) and kana (syllabograms) of Japanese language [2,3,4], there has been no neuroimaging evidence about their implicit processing. The present study attempted to demonstrate the implicit activation of language networks involving kanji and kana scripts by engaging subjects in a size judgment task for character stimuli. We also used a size judgment task for pseudo-characters and a semantic decision task as control tasks.

Material and Methods

Twelve right-handed healthy volunteers (4 females, 8 males, age range 21-29 years) who gave written informed consent participated in this study. Each subject participated in three experiments. Each experiment employed one block-designed scanning run [(rest/task-1/rest/task-2) x 4 /rest, 30 sec per block]. Stimuli were two different size kanji-characters (task-1), kana-characters (task-2). We also created scrambled-characters from the original characters (Fig. 1). Stimuli were presented to the subjects with a rate of one per sec. (0.5 sec. exposure time, 0.5 sec. interval). Experiment 1: Size judgment for characters; judge on which side the presented character was bigger. Experiment 2: Size judgment for scrambled-characters; the same as Experiment 1, except that scrambled-characters were used as stimuli. Experiment 3: Semantic decision; decide whether stimuli were words or non-words. The order of task 1 and task 2 in one scanning run, and three runs were counterbalanced across subjects. The fMRI scanning was performed with a 3T MRI scanner (GE Signa VH/i 3.0T). A T2* weighted gradient recalled echo EPI sequence was employed. The imaging parameters were; TR 5 sec, TE 30 ms, FA 90 deg, 3 mm thick, 1mm gap, matrix 64 x 64, FOV 22 cm, 30 axial slices. The fMRI data were analyzed using SPM99. Images were realigned, spatially normalized to standard brain template, and smoothed (FWHM 8mm). Individual-based analysis: p <0.05, corrected multiple comparison. For group analysis, a random-effect model was applied with a height threshold of $p < 0.01$, uncorrected.

Results

The size judgment for the scrambled-characters activated the bilateral posterior lingual gyri, bilateral superior and inferior parietal lobules (BA 7/40), and occipitotemporal regions (BA 19/37). The left inferior frontal areas (BA44/45) and the left posterior inferior temporal cortex (PITC, BA 37) were additionally activated during size judgements for characters. These activations were replicated during semantic decisions. No significant activation was observed in the comparison between scrambled-kanji and scrambled-kana. Kanji versus kana with size judgment for characters and semantic decision gave activation of bilateral fusiform gyri (BA19/37). Kana versus kanji with size judgment for characters revealed activation in the left supramarginal gyrus (SMG, BA40). Kana minus kanji with semantic decision activated the left inferior frontal regions (BA 44/45, Broca's area) and the left middle temporal gyrus (BA 21) (Fig.2)..

Discussion

Previous studies have showed that the left PITC plays an important role for reading kanji and the left SMG is used for phonological processing involved in kana reading [2,3]. The fact that the size judgments for characters, not scrambled-characters, activated a widespread neuronal network covering Broca's area, the left PITC and SMG strongly implied that the subjects read kanji and kana words obligatorily. Greater activation of the left fusiform gyrus in kanji processing confirms again that this area plays a more important role in kanji semantic processing. Comparing with kanji, kana processing required activation in Broca's area and SMG/ Wernicke's areas. These results suggested that kana processing involved in stronger phonological conversion and articulation**.**

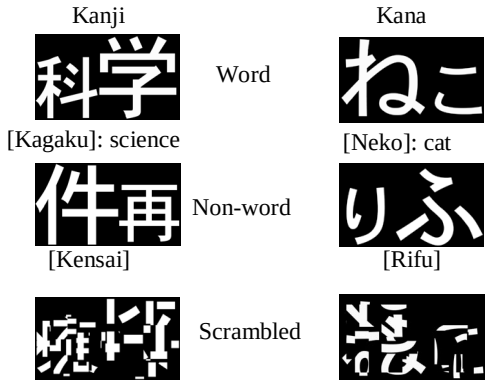

Figure1

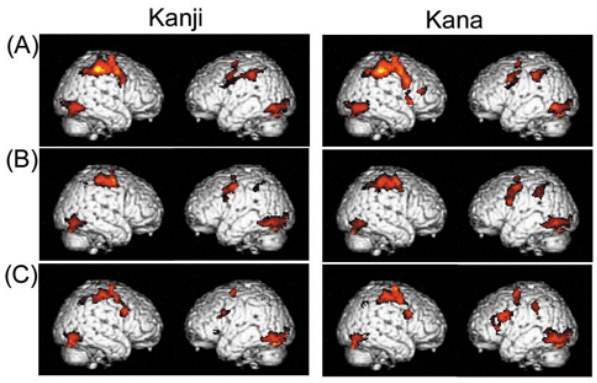

Figure 2: Significant brain activation during three experiments. (A) Scrambled, (B) Implicit, (C) Explicit

References

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