Neural mechanism of reading Chinese characters and pictures by Korean native speakers

H. Yoon[1], K. Kim[1], S. Lee[1], M. Song[1], J. Chung[1], H. Park[1]

[1]fmri laboratory, KAIST, Daejeon, Daejeon, Korea, Republic of

Abstract

Functional magnetic resonance imaging technique was used for the investigation of neural mechanisms in perception of Chinese characters and pictures by Korean native speakers. Our results show that right hemisphere is dominant within occipito-temporal region for the perception of both Chinese characters and pictures. The activation of the left middle frontal area (BA 9) was observed during the perception of pictures, but not during that of the Chinese characters. The activation of left middle frontal area was reported typically for the perception of Chinese characters by other studies with native Chinese speakers. We suggest that the neural mechanisms for reading Chinese characters by Korean people would be quite different from that by the native Chinese speakers.

Introduction

Many people from Asian Pacific region use similar writing system, namely Chinese characters. Whereas alphabetic systems are based on the association of phonemes with graphemic symbols (they have linear structure), Chinese characters are based on the association of meaningful morphemes with graphic units (they have a square, nonlinear configuration). It has been assumed and suggested that the cognitive processes underlying the perception of Chinese characters may differ from that of alphabetic perception and may be underlying similar cognitive processes of picture perception. Former studies using visual hemifield paradigm demonstrated that the right cerebral hemisphere was more effective in processing single Chinese characters than the left cerebral hemisphere. This leads to a Chinese character-word dissociation hypothesis in lateralisation pattern. In our study, functional magnetic resonance imaging (fMRI) was performed to investigate the neural correlates during perception of single Chinese characters and pictures by native Korean speakers. It is worth noting that the Korean language has its own alphabetic system, but the Chinese characters are still used in their writing system.

Methods

Fourteen healthy right-handed subjects (seven male and seven female having mean age of 22 years and standard deviation of 0.8 year) volunteered for our study. As stimuli, total of 24 single-word Chinese characters and pictures with precise meaning (nouns) were chosen. There were four stimuli blocks, where the baseline task was put in between the stimuli blocks. Each block consists of eight single-word Chinese characters and pictures. Images were acquired by using 3 Tesla MRI scanner (ISOL Technology, Korea). Following a T1-weighted scout image, the high-resolution anatomic images were acquired using an MPRAGE (Magnetization-Prepared RApid Gradient Echo) sequence with TE = 3.7 ms, TR = 8.1 ms, flip angle = 8°, and image size of 256 x 256. T2*-weighted functional data were acquired by using echo planar imaging (EPI) with TE of 37 ms, flip angle of 80°, TR of 3000 ms, and image size of 64 x 64. We obtained 30-slices EPI images with slice thickness of 5 mm and no gaps between slices for the whole brain. Image data were analyzed using SPM99 (Wellcome Department of Cognitive Neurology, London). Significant changes in hemodynamic response for each subject and condition were assessed using t-statistics. For the group analysis, single subject contrast images were analyzed using a random effect model. For evaluating laterality effects, peak activation was chosen in regions of interest (fusiform area) for both hemispheres independently. In these peak activations, parameter estimates were extracted for each subject independently and then statistically analyzed (Wilcoxon test).

Results

Bilateral activations of fusiform temporal area (BA 37, 19) for single Chinese characters and pictures to baseline conditions were observed. There were significant right lateralisation effects of activation during both experiments with single Chinese characters and pictures. The most interesting finding from our results is the activation of the left hemispheric middle frontal lobe (BA 9) during the picture perception.

Discussion

Our results can support the results of former studies indicating the right hemisphere dominance of occipital or temporal visual systems during character perception. The activation pattern of occipito-temporal area during picture perception seems to underlie similar visual processing. The fact that picture semantic processing produced more intense BOLD signals in right occipito-temporal areas than left occipital region was reported by other fMRI studies. The most interesting finding from our results is the activation of the left hemispheric middle frontal lobe (BA 9) during the picture perception. According to the former PET or fMRI studies, the activation of this brain area was known during perception of single or two-word Chinese characters , implicating that the left middle frontal area was recruited as common regions to access semantic information in reading Chinese. Our experimental results show that the picture perception is underlying similar neural mechanisms of the single Chinese character perception. Other interesting finding is that there is no activation in the left frontal cortex during the perception of single-word Chinese character by our subjects. Most of the PET or fMRI studies of Chinese character perception with the Chinese native speakers as subjects indicated the left frontal cortex activation regardless of single or two words character. We would speculate that the perceiving pattern of Chinese characters by Korean people is different from the native Chinese speakers. It seems that recognition of the picture is much easier than that of the character, since the semantic processing of Chinese characters has lower response accuracy and longer reaction times than that of pictures. Perception of Chinese characters by Korean seems to be quite different mechanisms from that by native Chinese speakers.
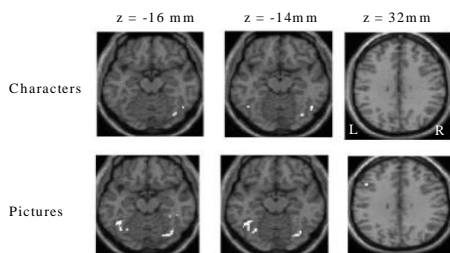

Fig.1. Activation is shown after post-processing using SPM in the left middle frontal lobe for the contrast Chinese character minus baseline (upper three images) and pictures minus baseline (below three images) task (p < 0.05, corrected on single voxel level).
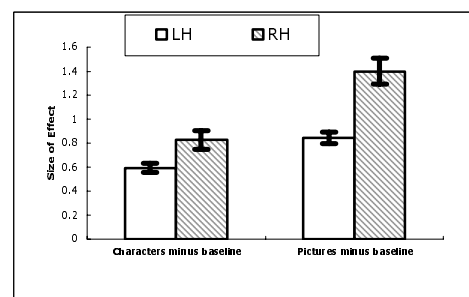

Fig.2 . Comparisons of size of effect (parameter estimates) in the left and right fusiform area. For both perception of pictures (p = 0.004) and Chinese characters (p = 0.03) the activations are right lateralised.

References

O.J.L. Tzeng, et al, Visual lateralisation effect in reading Chinese characters, Nature 282 (1979) 499 – 501.
L.H. Tan, et al, Brain activation in the processing of Chinese characters and words: a functional MRI study, Human Brain Mapping 10 (2000) 16 – 27.
L.H. Tan, et al, The neural system underlying Chinese logograph reading, NeuroImage 13 (2001) 836 – 846.