Visual Perception of Known and Unknown Ideographic Characters - An fMRI Study

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Introduction

Recognition of an idiographic character more depends on the visual perception of its formal pattern than that of an alphabetical character does. Then, how does visual perception of an ideographic character depend on its *a priori* knowledge? Although the number of Japanese ideograms (Kanji) commonly used is approximately three thousand out of fifty thousand in total, the ones not commonly used share elements with those commonly used, and their meaning or phonetic reading can be often guessed. In order to remove *a priori* knowledge of the characters, an ideogram system (Seika) which was derived from Chinese characters and has similar structural designs, but the semantics and phonetics are unknown to the subjects was employed. Visual recognition of these ideograms was compared with that of random line drawings.

Material and Methods

Fifteen normal Japanese volunteers (all right handed, 4 females), who gave written informed consent, participated in this study. Three character sets were prepared (Fig.1), 1) **K-task**: Kanji characters selected from the basic list for elementary school education, 2) **S-task**: Seika characters; a historical ideogram morphologically similar to Kanji but the phonetic reading and meaning are completely different and unknown to the subjects, 3) **M-task**: Random line drawings made from Kanji by rearranging the position of each line stroke. Three sessions for each character set were performed in a block design (4 task and 5 rest blocks, 30 sec each). Each character was projected for 1 second at every 2 seconds, and 60 characters were presented in a session. The characters were randomly rotated for 0, 90, 180 or 270 degrees at each presentation, and the volunteers responded whether the character was in the correct direction or not using a response button box. Functional imaging was performed on a 3T MRI scanner (GE Signa VH/i). A gradient recalled echo spiral k-space trajectory sequence was employed. The imaging parameters were TR 3000 ms, TE 30 ms, FA 90 deg, 30 axial slices, thick 4 mm, FOV 22 cm, and the in-plane resolution was 3.06 mm. The functional data were realigned, transformed into an MNI template and spatially smoothed using SPM99. A random effect model was applied for a group study ($p < 0.005$).

Results

Performance data: The volunteers could 100% distinguish the correct direction of the characters in both K-task and S-task, but the response was at chance level in M-task. It was indicated that the characters used in S-task were morphologically recognized as systematic structures of ideograms.

General Activation (Fig.2): The following regions were commonly activated in the three conditions; right M1(BA4), bilateral PMA (BA6, dorsal and ventral), SMA (BA6), CG (BA32/24), SPL (BA7), IPL (BA39/40), SMG (BA40), PIT (BA37), MFG (BA46/9), frontal operticulum FOp, visual areas (BA17/18/19, V1/V2/V3/V5), thalamus, globus pallidus, island, and cerebellum. Fig.2 shows a set of rendered map obtained by K-task.

Differential Activation (Fig.3): K-M (the contrast of K against M): bilateral IPL (BA39/40) and posterior STG (BA22/37). M-K: bilateral SPL (BA7), OcG (BA18/19; V3/V5), PIT (BA37), SMA (BA6), PMA (BA6; dorsal and ventral), ACG (BA32/24), MFC (9/46), FOp and thalamus. K-S: rt IPL (BA39/40) and posterior STG (BA22/37). S-K: bilateral SPL (BA7), OcG (BA18/19; V3/V5), PIT (BA37), SMA (BA6), PMA (BA6, dorsal), ACG (BA32), MFC (9/46) and FOp. S-M: None. M-S: SMA (BA6), bilateral SPL (BA7) and ACG (BA32).

Discussion

It is assumed that a priori knowledge of ideograms consists of three elements, visual memory of the morphology, phonetics and semantics, which are mutually related. The differential activation between the visual recognition of known characters (K-task) and unknown characters (S-task) was equivalent to that between known characters and random line drawings (M-task). It was suggested that phonetically and semantically known characters demand less visual processing and spatial rotation to identify the correct direction. Although the performance data have shown that the structure of an unknown ideographic character can be identified as systematic structure of strokes, the demand for its visual perception was almost identical to that for random line drawings. This observation suggested that not morphological pattern but a priori knowledge of the ideogram assists its visual perception.

It was reported that the BA37 is a multimodal language region in the ventral visual pathway (2), which is associated with visual recognition of words (1) or Kanji (3). The augmented activation in the bilateral BA37 in S-task or M-task may represent the higher demand for visual processing to associate the morphology with phonetics or semantics, since the visual objects can not be associated with those informations. The activation at the junction of bilateral BA22 and BA37 was significantly increased in K-task than M-task. This region may be related to the further processing to integrate the recognized idiographic character with semantics or phonetics.

Kanji (K) Seika (S) Line (M)

Figure 1

References

(1) Price C, TICS, 8, 281-287, 1998
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(3) Dinh et al., NeuroImage, 16, S-109, 2003

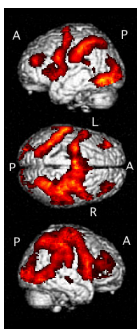

Figure 2

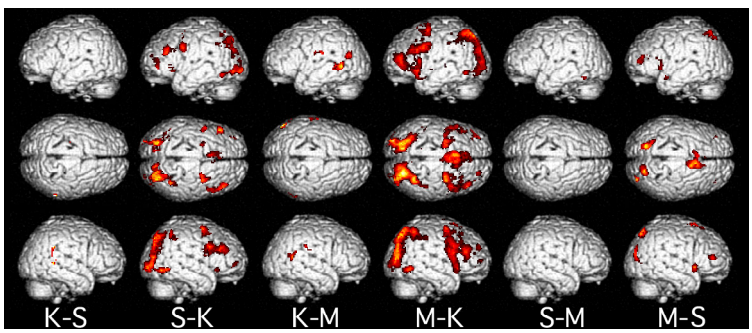

Figure 3