Implicit Distinction of the Race Underlying the Perception of Faces by Event-Related fMRI

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A few studies have shown that the function of fusiform face area is selectively involved in the perception of faces including a race difference. We investigated the neural substrates of the face-selective region called fusiform face area in the ventral occipital-temporal cortex and same-race memory superiority in the fusiform face area by the event-related fMRI. In our fMRI study, subjects (Oriental-Korean) performed the implicit distinction of the race while they consciously made familiar-judgments, regardless of whether they considered a face as Oriental-Korean or European-American. For race distinction as an implicit task, the fusiform face areas (FFA) and the right parahippocampal gyrus had a greater response to the presentation of Oriental-Korean faces than for the European-American faces, but in the conscious race distinction between Oriental-Korean and European-American faces, there was no significant difference observed in the FFA. These results suggest that different activation in the fusiform regions and right parahippocampal gyrus resulting from superiority of same-race memory could have implicitly taken place by the physiological processes of face recognition.

Index words : Fusiform face area (FFA)
Race
Event-Related fMRI

Introduction

Face perception is the most developed visual perceptual skill in humans and plays a critical role in social interactions. (1) The fusiform gyrus, part of the medial temporal cortex, is specialized for face perception (2) and lesions to occipito-temporal brain areas can lead to an impairment in face perception (prosopagnoisa). This functionally defined region varies

across individuals in precise location and extent, but is typically in the fusiform gyrus or adjacent sulci and has been called the fusform face area (FFA). The exact role of the FFA in face processing remains a matter of debate but has been shown that this region is also sensitive to experience (3), level of categorization (4), priming, attention (5), and is involved in individual face discrimination. (6) It seems that FFA might be involved not only during the retrieval of faces from long-term memory but also during the encoding of new faces into memory. People are better at recognizing faces of their own race than faces of other races. (7-8) The same-race advantage that results from greater experience with faces from one's own race has been demonstrated with behavioral studies involving a wide variety of protocols, face stimuli, participants and cultural settings. (9, 10) This is consistent with the finding that in the Korea the race effect is stronger for Oriental-Koreans who generally have greater experience with Oriental-Korean faces than European-Americans who may limited experience with European-American faces. There are several lines of evidence that expertise in face processing is a skill that develops over many years of practice. (11) This specialization is thought to be a neurobiological solution to the perceptual challenge of identifying individual faces from among many similar faces that share common features (eye, nose, mouth) and that differ on the basis of relatively subtle configural relationships among those features. Golby et. al (2001) showed differential responses in the fusiform region to same-race and other-race faces using conventional block paradigm fMRI with gray photographs of European-American and African-American. (6) In our case, gray photographs of Oriental-Korean and European-American are a little similarity to the contrast of faces compared to those of European-American and African-American. We present finding called same-race memory superiority from the fusiform gyrus, event-related functional magnetic resonance imaging (fMRI) study that directly compared the perception of Oriental-Korean face versus European-American face.

Materials and Methods

Subjects

The study was performed with informed consent on 12 right-handed normal, healthy Korean adults (six males and six females; aged 22–40 years, median 32.5 years). None had a history of psychiatric or neurological disorders or head trauma with loss of consciousness, or intake of tranquilizing drugs in the last 3 days. All subjects gave written informed consent. Data from one subject were not analyzed because of movement; thus the data were combined for analysis. Kangnam St. Mary's Hospital Subcommittee on Human Studies in College of Medicine, the Catholic University of Korea, approved the study.

Procedure

The stimuli consisted of gray photographs of 100 Oriental-Korean and 100 European-American and each 100 faces were split into 50 familiar and 50 unfamiliar groups. Four different categories of faces were presented: Oriental-Korean familiar faces (actors, actresses, singers, public readers), Oriental-Korean strangers, European-American familiar faces (actors, actresses, singers, public readers), and European-American strangers. The order of each face from four groups was a random sequence. The faces were presented for 1000 ms, replacing a baseline of an oval chequerboard present throughout the interstimulus interval, with a stochastic distribution of stimulus onset asynchrony (SOA) determined by a minimal SOA of 4.5 sec and 100 randomly intermixed null events. (12) All visual stimuli were projected onto a half transparent screen using a projector connected to a personal computer. The subjects saw the stimuli through a tilted mirror attached to the head coil of the scanner and scanned during one session, In the session named fame-judgment (implicit task), subjects were instructed to press one of two possible buttons with either the index or middle finger of their right hand to indicate whether a face was familiar or not, regardless of whether they considered it as Oriental-Korean or European-American. Incorrect answers including response outside between 200 and 4000 ms from stimulus onset or false response (familiar face considered as unfamiliar face or unfamiliar as familiar) were ignored.

Scanning Parameters

A 1.5 Tesla whole body MRI System (Siemens Corps., Iselin, NJ) with a standard quadrature RF head coil was

used to acquire 24 T2-weighted transverse echoplanar (EPI) images (240 mm Field-of-view, 64×64 in-plane resolution 3.75×3.75 mm, TE = 60 ms) with blood oxygenation level dependent (BOLD) contrast. EPIs comprised contiguous slices of 5 mm thickness, acquired sequentially in a descending direction and continuously during one session. Tight but comfortable foam padding was placed around the subject's head to minimize to motion. After discarding the first 5 volumes due to the unsteady longitudinal magnetization, 450 volumes were collected with an effective repetition time (TR) of 3 s / volume. Prior to functional scan, high-resolution T1 weighted anatomical data was acquired to provide anatomical reference.

Data Analysis

After the off-line reconstruction, data were analyzed using statistical parametric mapping (SPM99) (13) based on the Matlab5 computing environment. Data was realigned with respect to the first volume and time-series for voxels within each slice realigned temporally to acquisition of the middle slice. Resulting volumes were normalized to a standard EPI template based on the MNI reference brain in Talairach-Tournoux space and resampled to 3×3×3 mm³ voxels. No subject moved more than (2 mm in any direction during a task.
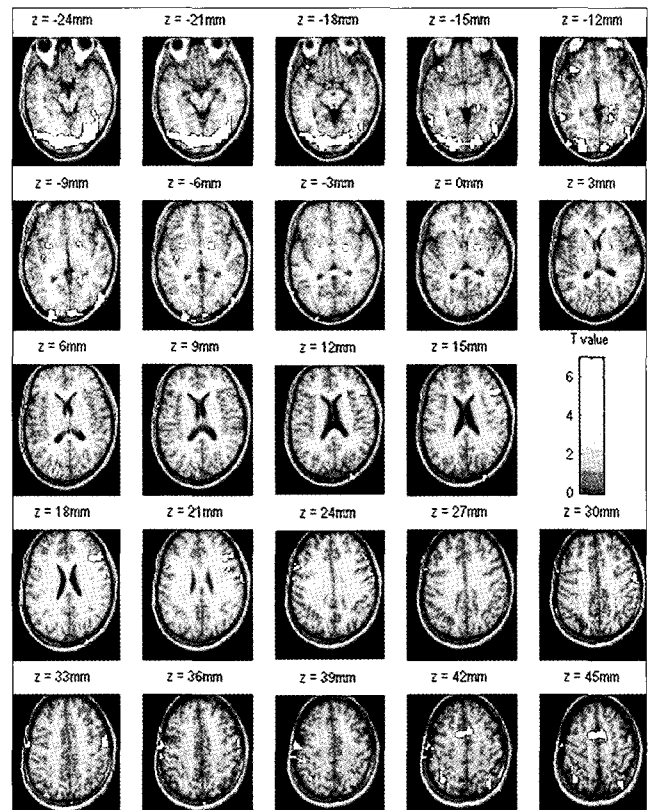

Fig. 1. Horizontal slices of the group activation map for the implicit distinction of race (familiar-judgment task). The statistical threshold was p < 0.001,uncorrected for multiple comparisons at the cluster level. The left side of the brain corresponds to the left side of the image and the frontal region to the top.

Table 1. Group Activation Results across 11 Subjects for Implicit Distinction of the Race (Familiar-judgment Task)

Anatomy	BA	Side	x	y	z	Z value
Supplementary motor area	6	L	-6	15	45	4.89
Supplementary motor area	6	R	9	18	45	4.28
Fusiform gyrus(FFA)	37	L	-45	-51	-15	4.85
Inferior temporal gyrus	39	L	-48	-42	-12	4.01
Cerebellum		R	39	-72	-27	4.76
Cerebellum		R	42	-60	-33	4.67
Fusiform gyrus(FFA)	37	R	42	-39	-24	4.54
Middle frontal gyrus	8	R	51	39	21	4.32
Middle frontal gyrus	8	R	39	36	21	3.87
Inferior parietal lobule	40	R	36	-51	48	4.15
Precentral	4	R	57	6	33	4.06
Precentral	4	R	63	6	24	4.02
Precentral	4	L	-48	3	48	4.06
Precentral	4	L	-45	-3	39	3.83
Pallidum		R	21	6	0	3.48
Putamen		R	18	12	-9	3.93
Middle occipital gyrus	18	R	30	-87	18	3.91
Parahippocampal gyrus	36	R	21	-42	-12	3.76

BA, Brodmann area; XYZ coordinates of local maxima are listed according to the MNI coordinate system (18). This contrast was performed using a threshold (P < 0.001, uncorrected).

The normalized images were smoothed with an isotropic 8 mm full-width half-maximum Gaussian kernel. The time-series in each voxel were highpass-filtered to 1/230Hz to remove low-frequency noise. Statistical analysis was performed in two-step. In the first step, 10 event-types were defined for the task, four of these represented correct responses to the four basic event-types when matched for time of occurrence. The BOLD impulse response to events of each type was modeled by a canonical hemodynamic response function (HRF). (14) This function was convolved with a sequence of delta functions for events of each type in a high-resolution time space and downsampled at the midpoint of each scan to form covariates for the general linear model. Also included for the task were six covariates to capture to residual movement-related artifacts (the three rigid-body translations and rotations determined from the realignment stage) and a single covariate representing the mean over scans. Parameter estimates for each covariate were determined by a
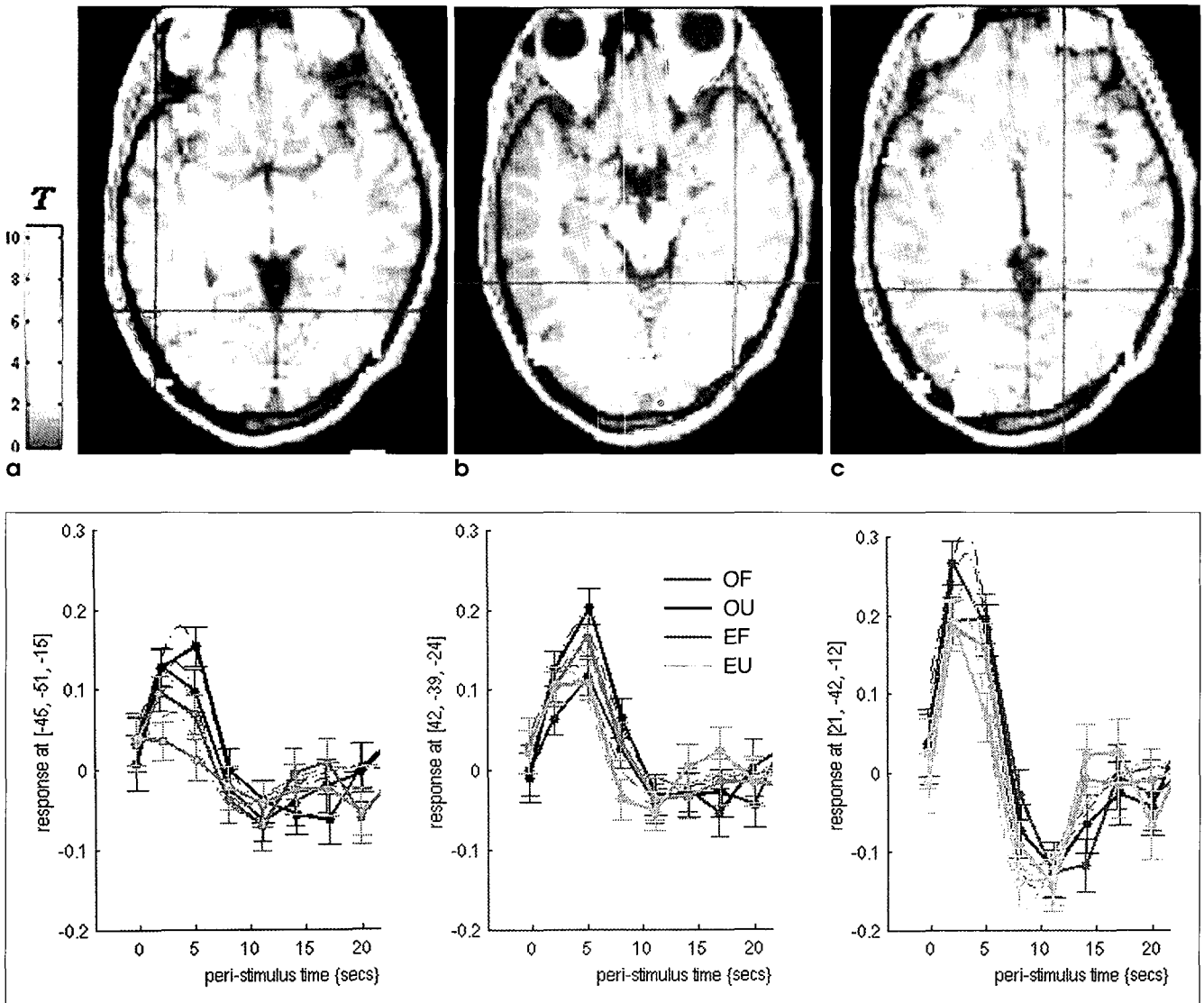

Fig. 2. (A) The group activation map at left fusiform area and (B) at right fusiform area (C) at right parahippocampal gyrus and a lower statistical threshold was used (p<0.001, uncorrected). (D) Event-related data, adjusted for confound (OF as Oriental-Korean familiar face, OU as Oriental-Korean unfamiliar face, EF as European-American familiar face, EU as European-American unfamiliar face), binned every 3s and averaged over subjects from corresponding regions (at left fusiform; x=-45, y=-51, z=-15; at right fusiform; x=42, y=-39, z=-24; at right parahippocampal gyrus; x=21, y=-42, z=-12) based on peristimulus time (PST).

least-mean-square fit of the model to data. The parameter estimates for the canonical HRF comprised the data for second step of analyses. The individual contrasts images for the effect of interest (the implicit distinction of the race through familiar-judgment) were entered into one-sample t-tests to determine the group-level activation, treating subjects as a random variable. The resulting statistical parametric maps of t-statistics at the each voxel were transformed to Z values and thresholded at P < 0.001 uncorrected for multiple comparisons.

Results

Under the control condition (familiar-judgment task), the mean ((SD) percentage of correct responses was 89.5 (4.4(, and the mean reaction time (RTs) was 650.7 (87msec. RTs were longer to unfamiliar than familiar faces. More errors were made to familiar than unfamiliar faces. All subjects successfully underwent the designated event-related functional magnetic resonance imaging. One subject with significant motion (more than 2mm from the first image set) was excluded from further data analysis. In the group analysis, areas of significant activation during the overall familiar-judgment task were the bilateral supplementary motor areas [Brodmann areas (BA) 6], bilateral fusiform gyri (BA 37), left inferior temporal gyrus (BA 39), cerebellum, right middle frontal gyrus (BA 8), inferior parietal lobuli (BA 40), precentral (BA 4), pallidum, putamen, middle occipital gyrus (BA 18) parahippocampal gyrus(BA 36) (P < 0.001, uncorrected; Table 1; Fig. 1). The event-related responses of the bilateral fusiform region and the right parahippocampal gyrus of interests that play a role in the retrieval of faces from long-term memory are shown in Figure 2D. These regions showed a greater response to the presentation of Oriental-Korean than European-American faces. This pattern was observed in the race discrimination as an implicit task, but not in our preliminary experiment as an explicit task, at those time, seven right-handed normal, healthy Korean adults participated.

Discussion

Three primary conclusions can be drawn from this event-related fMRI study. First, the FFAs play any role in the retrieval of faces from long-term memory. Second, we observed implicit recognition of race in the FFA during explicit perceptual of faces. Third, Our results showed that the bilateral fusiform gyri were greater activation to same-race than other-race faces. These are in accord with many other studies showing superior recognition memory for same-race compared to other-race faces (6-9).

The bilaterality of fusiform gyrus in our experiment is consistent with other studies (6, 7) and is involved, not only in face perception, but in a certain aspect of face recognition memory and may be interpreted in terms of hemispheric asymmetry in visual processing (16). Right-hemisphere pathways may mediate coordinated visual processes that maximize individuation between examples in a category, whereas left-hemisphere pathways may mediate categorical visual processes that maximize similarities among examples in a category (16).

The result of our experiment also is in accordance with the fact that differential recruitment of face-processing areas in the fusiform region by faces of different races is due to difference in perceptual expertise derived from long-term differences in exposure to same-race and other-race faces (6). There is converging evidence that the fusiform region mediates experience-dependent processes of visual expertise required to individuate members of large, visually similar populations, such as faces, birds, cars or artificially constructed objects (3, 4, 11, 17).

Our finding could be an important clue to understand a relationship between brain activity and behavioral race bias, and it will provide an insight into how variations in social experience may guide the organization of the neural systems that process the faces we encounter on a daily basis

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Event-related 기능적 MRI 영상을 통한 얼굴인식과정에서 수반되는 무의식적인 인종구별

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기능적 자기공명영상기법(functional MRI; fMRI)을 통해서 인간의 뇌에 대한 연구가 지난 수년 동안 활발하게 진행되어 왔다. 이러한 기능적 자기공명영상기법의 파라다임에는 Block-diagram 방법과 최근에 개발되어 이용되는 Event-related 방법이 있다. Block-diagram 방법은 여러 블록으로 구성하여 피험자들에게 자극을 인가하여 뇌의 반응신호들을 통해 뇌의 기능을 설명해 주는 데, 이러한 뇌의 기능이 얼굴인식과 관련하여 여러 조건을 포함한 자극인 경우 뇌의 인지 시스템을 설명을 해 주는 데 한계가 있다. 따라서 Event-related 방법을 이용하여 얼굴인식에 관여하는 뇌의 인지시스템에 관련된 부분을 설명하고, 또한 그 영역에서 인종구별과 같은 의식적으로는 관찰되지 않지만 무의식적으로 관찰되는 뇌의 생리적인 현상을 보여주고자 한다. 본 연구는 Event-related 방법에 대한 이해와 얼굴 인식에 적용되는 파라다임 알고리즘을 개발하여 피험자들을 통해 해당조건들은 (유명한국인, 무명한국인, 유명 백인 미국인, 무명 백인미국인) 각 Event로 구성하여 한 블록인 Event-related 파라다임으로 변경하여 얼굴을 인식하는 데 주로 담당하는 영역인, Ventral occipital-temporal cortex 내의 fusiform face area(FFA)를 확인하고 그 영역에서 의식적으로 반응하는 뇌의 활동과 무의식적으로 반응하는 뇌의 활동을 생리학적 또는 심리학적으로 해석하는 데 용이하도록 여러 파라미터들 (즉, Event 간격, Event의 수, Null Event, TR 간격 등)을 최적화 하였다. 자기공명영상기법을 이용한 이러한 뇌 기능 연구는 의학적인 응용연구로서 신경 과학분야와 정신의학적인 측면에서 널리 이용될 것으로 보이며 더 나아가 심리학적측면의 기초 연구로서 발전의 토대가 될 것으로 사료된다.

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