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Face processing without awareness in the right fusiform gyrus

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Abstract

We investigated brain activity evoked by faces which were not consciously perceived by subjects. Subdural electrophysiological recordings and functional neuroimaging studies have each demonstrated face-specific processing in the fusiform gyrus (FFG) of humans. Using pattern masks, a stimulus can be presented but not consciously perceived, and thus can be used to assay obligatory or automatic processes. Here, using event-related functional magnetic resonance imaging and pattern masking, we observed that masked faces but not masked objects activated the right FFG. Other regions activated by consciously perceived unmasked faces were not activated when faces were masked. These data provide strong evidence for an automatic face-processing region in the right FFG.

Keywords: Face processing; FMRI; Perception

A briefly exposed visual stimulus may not be consciously perceived if it is preceded and followed by a dissimilar visual pattern, or mask. Masked facial expressions have been shown to influence the activation of the amygdala by subsequent visible faces (Whalen et al., 1998) thus demonstrating that some aspects of face processing can occur without conscious awareness. It has been suggested in these studies that the amygdala is responding to a primitive face representation that bypasses processing in extrastriate cortical regions such as the fusiform gyrus (FFG). Functional MRI studies have demonstrated that visible faces selectively activate focal regions of the FFG (e.g., Kanwisher, McDermott, & Chun, 1997; McCarthy, Puce, Gore, & Allison, 1997; Puce, Allison, Gore, & McCarthy, 1995); however, whether masked faces similarly activate these regions has not yet been examined. Here, we compared activation evoked by masked and unmasked faces and non-face objects to determine whether the FFG and other brain regions are activated by faces without a subject's awareness.

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1. Methods

1.1. Subjects

Twenty healthy young adults (10 males) served as subjects in the fMRI study. Two groups of 10 additional healthy young adults (9 male) participated in two separate behavioral studies that were conducted outside the scanner. All subjects provided written informed consent.

1.2. Materials and procedure

Subjects were informed that they would be participating in a color discrimination task. Subjects wore LCD goggles through which they viewed a continuous stream of stimuli in which a different mosaic pattern was presented every 100 ms. Most of the mosaics were gray and white, but a colored mosaic occurred infrequently and required a button press. Unknown to the subjects, gray-scale faces and non-face objects (sports equipment such as soccer balls) appeared in intermixed order every 12–18 s and were exposed for 33 ms. Critical stimuli were locked to the onset of the refresh of the LCD display.

One hundred stimuli (50 faces, 50 objects) were presented in the seven masked runs that each subject experienced. After the completion of the masked runs, each subject was presented with three additional runs in which the same faces and objects presented at the same duration and with the same intervals, but with the mosaics replaced by a black rectangle. Thus, the faces and objects were consciously perceived. These unmasked runs were used as functional localizers to identify face-specific regions that could be compared to the masked trials.

In the first behavioral task conducted outside the scanner, subjects were told that they would be presented with masked faces and objects on an LCD monitor, and that they were to press one button when they thought they saw a face and a second button when they thought they saw an object. The stimulus durations were the same as those used in the fMRI experiment, and were verified by connecting a photocell to the LCD monitor. However, the intertrial intervals were shorter than those used in the fMRI study, so that more stimuli could be presented more rapidly. Subjects were not cued as to when the stimuli would be presented. For the purposes of analysis, we considered responses that occurred within 2 s after the onset of any stimulus as a "detection". The second behavioral task used the same methodology but stimuli were presented on the same LCD goggles used in the fMRI experiment.

1.3. Functional magnetic resonance imaging

Scanning was performed on a General Electric Health Technologies, 4T LX NVi MRI scanner system equipped with 41 mT/m gradients. A quadrature birdcage radio frequency (RF) head coil was used to transmit and receive. The subject's head was immobilized using a vacuum cushion and tape. Sixty-eight high-resolution images were acquired using a 3D fast SPGR pulse sequence (TR = 500 ms; TE = 20 ms; FOV = 24 cm; image matrix = 256^2; voxel size = 0.9375 mm × 0.9375 mm × 1.9 mm) and used for coregistration with the functional data. These structural images were aligned in the near axial plane defined by the anterior and posterior commissures. Whole brain functional images were acquired using a gradient-recalled inward spiral pulse sequence (Glover & Law, 2001) sensitive to blood oxygenation level dependent (BOLD) contrast (TR, 1500 ms; TE, 35 ms; FOV, 24 cm; image matrix, 64^2; $\alpha = 62°$; voxel size, 3.75 mm × 3.75 mm × 3.8 mm; 34 axial slices). These functional images were also aligned with the plane defined by the anterior and posterior commissures. A semi-automated high-order shimming program ensured global field homogeneity. Runs consisted of the acquisition of 206 successive brain volumes and began with 4 discarded RF excitations to allow for steady state equilibrium. An experimental session contained 10 runs.

1.4. Data analysis

Image preprocessing was performed with custom programs and SPM 99 modules (Wellcome Department of Cognitive Neurology, UK). Head motion was detected by center of mass measurements. No subject had greater than a 3 mm deviation in the center of mass in any dimension. Images were time-adjusted to compensate for the interleaved slice acquisition and realigned to the tenth image to correct for head movements between scans. The realigned scans were then normalized to the Montréal Neurologic Institute (MNI) template found in SPM 99. The functional data were high-pass filtered and spatially smoothed with an

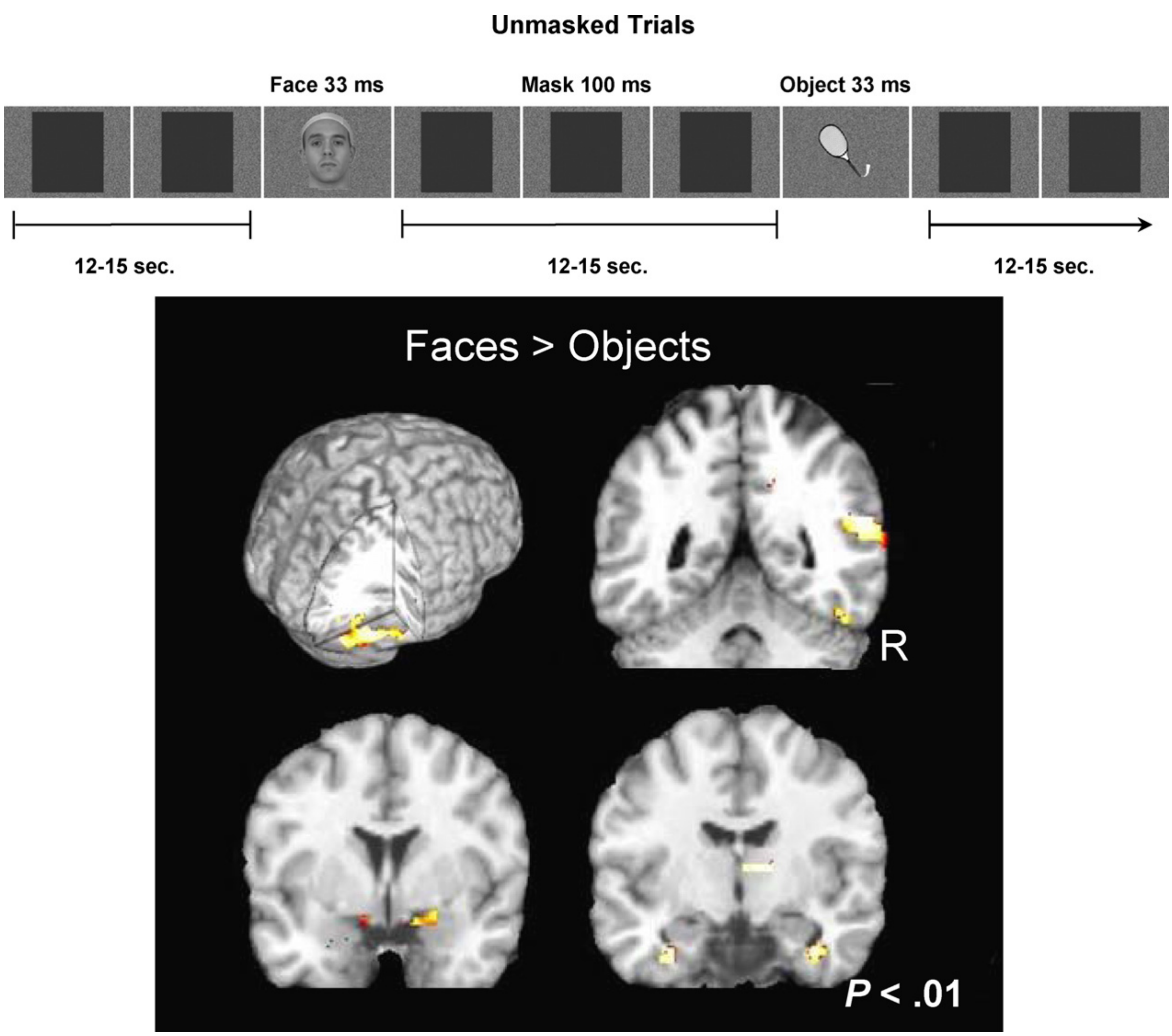

Fig. 1. Unmasked trials. Faces and objects were presented for 33 ms and preceded and followed by a static black mask, which allowed for conscious perception. The red/yellow color map reflects the results of a random-effects analysis demonstrating regions of the brain where peak amplitude evoked by faces was significantly greater than that evoked by objects. Regions showing this significant difference included the right fusiform gyrus, right superior temporal sulcus, right amygdala, and bilateral parahippocampal gyrus.