Self-face recognition in attended and unattended conditions: an event-related brain potential study

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only in an unattended condition. A recent positron emission tomography (PET) study examined attentional effects on neural representation of self-faces by comparing regional cerebral blood flow between the conditions when active or passive self-face recognition was required [15]. The researchers found increased activity in the prefrontal cortex and right anterior cingulate in the active relative to the passive viewing condition. As stimulus familiarity was not matched between self-faces and other faces, it is unclear whether the neural activity observed reflected the enhanced recognition of self-faces or familiar faces *per se*. The PET results also lacked temporal information of self-face recognition because of the long latency of PET signals. It has been proposed that self-face processing demands less attention resources than that of other faces [2]. We assessed this proposal by having participants identify head orientations of self-faces or other faces in separate blocks of trials, and thus self-faces and other faces could be task relevant (attended) or task irrelevant (unattended). Self-specific processing was identified by comparing ERPs to self-faces and familiar faces. The process of face familiarity was examined by comparing ERPs to familiar and unfamiliar other faces.

Materials and methods

Study participants

Eighteen healthy participants (eight men, 10 women, aged between 20 and 29 years; mean 24.7 ± 2.46 years) took part in this study as paid volunteers. All participants had normal or corrected-to-normal vision and were right handed. Three participants were excluded from data analysis because of excessive artifacts during electroencephalogram (EEG) recording. Informed consent was obtained from all participants before the study. This study was approved by a local ethics committee.

Stimuli and procedure

Each participant was presented with images of self-face, one familiar other face, and one unfamiliar other face matched for sex and age. Thus, stimulus probability of self-face, familiar, and unfamiliar faces was identical. The familiar face stimuli were taken from the classmates or roommates of the participants, whom the participants had known for at least 3 years. Ten face pictures of each participant, with a neutral facial expression, were taken using a digital camera. Participants' heads were oriented to the left (from 45°–90°) in five pictures and to the right in the others. All images were calibrated in luminance and contrast and were converted into jpg format. Each face stimulus was presented in color and subtended a visual angle of $3.0^\circ \times 3.0^\circ$ at a viewing distance of 120 cm.

The stimuli were presented on a black background of a 21-inch color monitor. Each trial began with the presentation of a fixation cross for 900 ms, which was followed by a blank screen for 100 ms. A face image was then displayed for 300 ms, overlapping the fixation and followed by a blank screen for 700 ms. Twelve blocks of 40 trials were included. In four blocks of trials, participants identified head orientations of self-faces, familiar faces, or unfamiliar faces by pressing the left or right buttons using the left and right index fingers while ignoring other faces. The order of the tasks was counterbalanced across participants. Instructions emphasized both accuracy and response speed.

Electrophysiological data recording and analysis

The EEG was recorded from electrodes placed at 10–20 standard positions and five other pairs of nonstandard sites. Recordings were made with respect to the left and right mastoid references. The electrode impedance was kept below 5 kΩ. The EEG was amplified by using a bandpass of 0.1–75 Hz (1/2 amplitude cutoffs), digitized at 250 Hz/channel. The vertical electrooculogram was monitored from two electrodes placed above and below the right eye. The horizontal electrooculogram was recorded from electrodes placed about 1.5 cm lateral to the left and right external canthi. ERPs were averaged offline using a computer program that extracted epochs of EEG beginning 200 ms before stimulus onset and continuing for 1000 ms. Trials containing eye blinks, eye movement deflections exceeding $\pm 50\,\mu v$ at any electrode, or incorrect behavioral responses were excluded from the ERP averages. The baseline for ERP measurements was the mean voltage of a 200-ms prestimulus interval and the latency was measured relative to the stimulus onset.

Reaction times and response accuracy to different faces were compared using a paired *t*-test. The mean ERP amplitudes were submitted to repeated-measures analyses of variance with face owner (self, familiar, unfamiliar faces), attention (task relevant vs. irrelevant), and hemisphere (electrodes over the left vs. right hemispheres) as independent variables.

Results

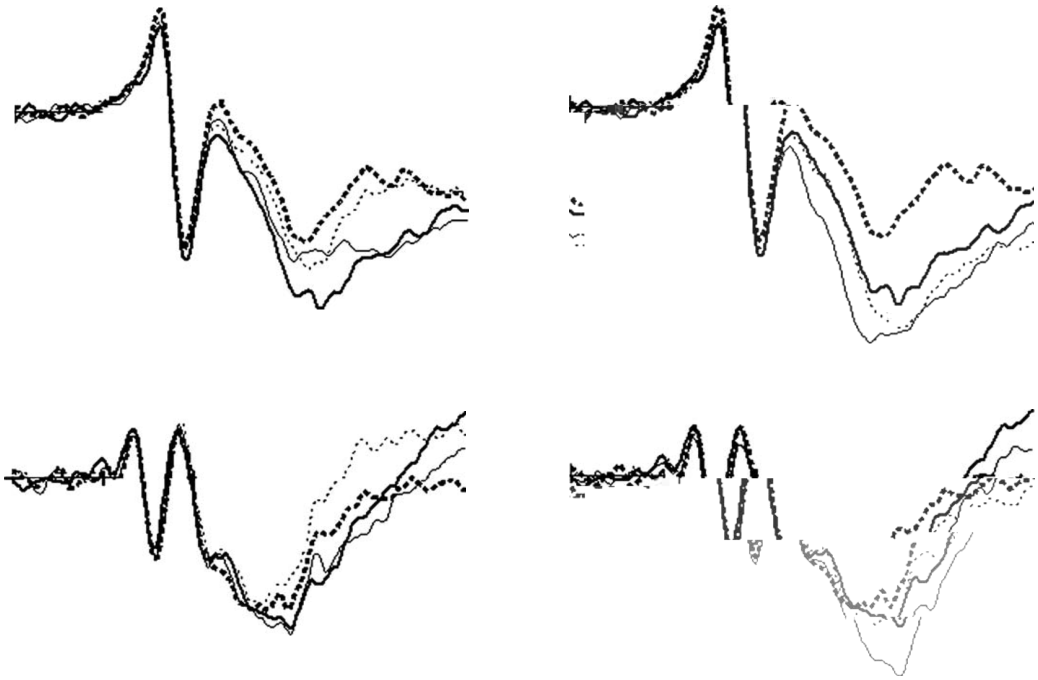
Behavioral data

A main effect of face owner on reaction times [$F(2,28)=5.44$, $P<0.05$] was observed. Responses to self-faces (551 ms) were faster than those to familiar faces (596 ms) [$t(14)=4.340$, $P<0.001$] and unfamiliar faces (588 ms) [$t(14)=2.283$, $P<0.05$]. Reaction times, however, did not differ between the familiar and unfamiliar faces [$t(14)=0.469$, $P>0.05$]. The response accuracy did not differ among the three conditions [99%, 96%, and 98%, to self-faces, familiar faces, and unfamiliar faces, respectively, $F(2, 28)=3.59$, $P>0.05$].

Electrophysiological data

Figure 1 illustrates the grand-average ERPs to familiar and unfamiliar faces, and self-faces. ERPs to both self-faces and other faces were characterized by a negativity peaking at 148 and 188 ms (N170), which was followed by a negative-going wave at 220 and 300 ms (posterior N2). A positivity at 148–188 ms [vertex positive potential (VPP)] at middle, central, and frontal sites and a negative-going component at 220–300 ms (anterior N2) were observed. A long-latency positive component at 300–700 ms was evident over the frontal, central, and parietal areas.

The analyses of variance of the mean ERP amplitudes did not show any significant effects before 300 ms. To examine the ERP effects of face familiarity, we compared ERPs elicited by familiar and unfamiliar faces. A main effect of attention at 300–700 ms at FCz, Cz, CPz, Pz, FC3–FC4, C3–C4, CP3–CP4, and P3–P4 [$F(1,14)=5.96$–37.26, all $P<0.05$] was observed; familiar and unfamiliar other faces elicited a long-latency positivity with larger amplitudes in the attended than in the unattended conditions. Neither the main effect of face owner (familiar vs. unfamiliar faces) nor the interaction between attention and face owner was significant ($P>0.05$).



To examine the self-specific ERP effects, ERPs to self-faces were compared with those to familiar faces. A significant main effect of face owner at 220–700 ms at FCz, Cz, CPz, Pz, FC3–FC4, C3–C4, CP3–CP4, and P3–P4 [$F(1,14)=6.65–54.49$, all $P<0.05$] was found, indicating that the long-latency positivity was of larger amplitudes to self-faces than to familiar faces. A reliable main effect of attention at 220–700 ms at FCz, Cz, CPz, Pz, FC3–FC4, C3–C4, CP3–CP4, and P3–P4 [$F(1,14)=5.46–31.14$, all $P<0.05$] was observed, suggesting that the long-latency positivity was of larger amplitudes in the attended than in the unattended conditions. A reliable interaction was also noted between face owner and attention at 500–700 ms at Cz, CPz, Pz, and CP3–CP4 [$F(2,28)=4.27–7.62$, all $P<0.05$]; the self-face ERP effect during this time window was reduced in the attended relative to the unattended condition. This interaction stemmed from the fact that the mean amplitude to familiar faces was increased in the attended relative to the unattended conditions at Cz, CPz, Pz, and CP3–CP4 [$F(1,14)=9.75–20.55$, all $P<0.005$], whereas attention did not influence the amplitude to self-faces ($P>0.05$). The voltage topographies of the difference waves obtained by subtracting ERPs to familiar faces from those to self-faces showed that the enhanced positivity in association with self-face recognition had a focus over the frontocentral scalp sites in both attended and unattended conditions (Fig. 2).

Discussion

Consistent with previous observations [1,2], our behavioral data showed that responses were faster to self-faces than to unfamiliar or familiar other faces, suggesting either more salient or earlier representation of self-faces [2]. Our ERP results showed, first, that both self-faces and other faces elicited a posterior N170 and an anterior VPP. In addition, we found that the amplitudes of the N170 and VPP did not differ between familiar and unfamiliar faces. The results are consistent with previous research [16–18] and indicate that the N170 and VPP mainly reflect the process of structural encoding of face stimuli [19]. We showed further that the N170 and the VPP did not differ between self-faces and other faces, suggesting that self-faces could not be distinguished from other faces at the early stage of face structural encoding.

We found, however, that a long-latency positivity over the frontocentral area was involved in dissociating self-faces from other faces. The long-latency positivity over the frontocentral area at 220–700 ms was of larger amplitude

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