Face-related ERPs are modulated by point of gaze

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RUNNING HEAD: Face ERP Point of Gaze

This work was supported by the Anna Freud Centre (CC) and the Gustavus and Louise Pfeiffer Research Foundation (LCM).

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Abstract

Key words: Social perception, N170, event-related potential (ERP), electroencephalogram (EEG), psychophysiology, face perception, social neuroscience

Introduction

Efficient perception of the human face parsimoniously enabling sophisticated social communication by conveying information about identity, gender, age, and mental state. Behavioral and neural evidence indicate specialization for faces shortly after birth. Neuroimaging research reveals particular brain regions, including the fusiform gyrus (FG), supporting face perception, and event-related potential (ERP). Electrophysiological studies robustly demonstrate a face-sensitive negative component peaking approximately 170 ms after viewing a face. Compared to other visual stimuli, the N170 elicited by faces and face-like stimuli is larger in amplitude, usually right-lateralized, and occurs at shorter latency. Presentation of isolated facial features also elicits an N170; eyes elicit the greatest negative amplitude and fastest latency, followed by whole faces and then noses and mouths (Bentin et al., 1996). Based upon this differential responsiveness to the eyes and an accelerated developmental maturation of this “eye N170”, the component has been speculated to represent activity of an “eye detector”. Alternatively, because of its short latency, sensitivity to perturbations in the configuration of faces (e.g., face inversion), and relative insensitivity to identity and emotion, the component has been described as an index of structural encoding, an early stage of face perception. Despite ERP indices of face perception to varying with individual facial features, modulation of the early stages of face perception by attention to facial features *within the context of an intact face* has not yet been explored with this method. This is relevant, as fMRI studies have shown that manipulating attention to different facial features results in variable FG activation, with attention to the eyes most strongly activating the FG (Pelphrey; Dalton et al., 2005).

The current study sought to apply the temporal resolution of ERP to examine whether early stages of face perception, indexed by the N170, are modulated by visual attention to the face the face. We recorded ERPs as typical adults viewed neutral faces with a variable fixation crosshair directing attention to the upper face (eyes), mid-face (nose), or lower face (mouth). We also examined the effect of having no fixation crosshair. Following from fMRI studies and research on ERP response to isolated facial features, we hypothesized that visual fixations to the eyes would elicit N170 with enhanced amplitude and shorter latency relative to all other gaze directions. Based on existing literature, we did not anticipate variation in neural response to other fixation positions.

Methods

Participants included 20 college undergraduates enrolled in ongoing ERP research at the Child Study Center. Participants were screened for current or historical injury or disease, and excluded for conditions impacting the EEG. Three participants completed the study protocol but were excluded from analysis due to excessive artifact (> 25% of bad channels). The final sample included 17 individuals (8 females, 9 males; mean age 23 years; 16 right handed). All procedures were approved by the Human Investigation Committee at Yale School of Medicine, and this was in accordance with the Declaration of Helsinki (1975/1983).

Stimuli consisted of 204 distinct grayscale digital images from the categories of neutral faces (102 male, 102 female; drawn from (Tottenham 2009) and (Minear and Park 2004) and houses. All stimuli were presented in straight-on frontal view and were presented at a standardized viewing size (presented at 6.26° by 10.32°) on a black background. Faces were cropped within an oval frame to remove non-face features. At the beginning of each trial, a central fixation cross was presented for a time period varying randomly between 500 and 1000 ms. To manipulate visual attention, the horizontal position of the crosshair was held constant while the vertical position varied in random sequence to correspond to: upper stimulus (25% from top of stimulus), mid-stimulus (50% from top of stimulus), lower stimulus (75% from top of stimulus), and absent. An example stimulus with superimposed crosshair is displayed in Figure 1; crosshairs were not presented onscreen simultaneously with stimuli. The fixation crosshair was followed immediately by a randomly selected face or house stimulus for 500 ms and then a 670 ms blank screen. Target stimuli (10 houses/faces, 21 crosshairs, shaded red) were randomly interspersed. Participants pressed a button upon target detection, ensuring attention to fixation crosshairs and stimuli. Target trials were excluded from analysis. All participants detected at least 95% of targets in each condition, and none were excluded for inattention. There were 265 trials in total presented in a random sequence: 204 faces, 204 houses, 10 face targets, 10 house targets, and 21 crosshair targets. The experiment took approximately 10 minutes to complete.

[INSERT FIGURE 1 ABOUT HERE]

EEG data recording and processing were conducted using a 128 channel Geodesic Sensor net, NetStation 4.2 software for EEG collection, and EPrime 1.2 software for stimulus presentation, following Cheung (under review). N170 was extracted as the average minimum value (and corresponding latency) across six electrodes over the left (58, 59, 64, 65, 69, & 70) and right lateral posterior scalp (90, 91, 92, 95, 96, & 97) within a time window extending from 99 ms - 231 ms post-stimulus onset. N170 amplitude and latency to peak were separately analyzed using univariate repeated measures analyses of variance (ANOVA) with condition (face/house), hemisphere (left/right), and crosshair position (upper/central/lower/absent) as within-subject factors.

Results

N170 Amplitude

Table 1 lists N170 amplitude for each crosshair position for both stimulus conditions and both hemispheres. A main effect of fixation position indicated that N170 amplitude varied with point of gaze across stimuli and hemispheres ($F(1, 16)=4.4$, $p<.01$). Post-hoc tests revealed that amplitude elicited by eyes was equivalent to mouths and both were larger than mid-face or absent crosshair, which were equivalent. A main effect of condition indicated that faces elicited N170 with larger amplitude than houses across hemisphere and fixation position ($F(1, 16)=27.8$, $p<.01$). A main effect of hemisphere indicated that amplitudes were greater in the right hemisphere irrespective of condition or crosshair position ($F(1, 16)= 4.59$, $p<.05$). A fixation by condition by hemisphere interaction indicated that N170 amplitude to mouths were larger in the right hemisphere for faces ($F(1,16)=3.57$, $p <.05$). Figure 2 displays waveforms collapsed across hemisphere illustrating variation in N170 response for each crosshair position.

[INSERT TABLE 1 ABOUT HERE]

N170 Latency

Table 2 lists N170 latency for each crosshair position for both stimulus conditions and both hemispheres. A main effect of fixation position indicated that N170 latency varied with point of gaze across stimuli and hemispheres ($F(1,16)=15.9$, $p<.01$). Post-hoc tests revealed that latency to absent crosshair was faster than all other stimuli, followed by upper and mid-face, with mouth being slowest. Contrary to prior research, the difference in latency between faces and houses (approximately 4 ms) did not attain significance). A condition by hemisphere interaction indicated that N170 latency indicated that, while faces elicited comparable latencies across hemispheres, houses showed faster latency in the left hemisphere ($F(1,16)=6.25$, $p <.05$).

[INSERT TABLE 2 ABOUT HERE]

Discussion

Conclusion

Acknowledgements

This work was supported by the Anna Freud Centre (CC) and the Gustavus and Louise Pfeiffer Research Foundation (LCM). The authors thank Christopher Bailey for technical assistance and Kevin Pelphrey for theoretical consultation in preparation of the manuscript.

References

Tables

Table1

N170 Amplitude

Table2

N170 Latency

Figure Captions

Figure 1. Example stimuli with overlaid crosshair displaying variable positions (upper face, mid-face, lower face). A fourth fixation condition entailed no crosshair display.

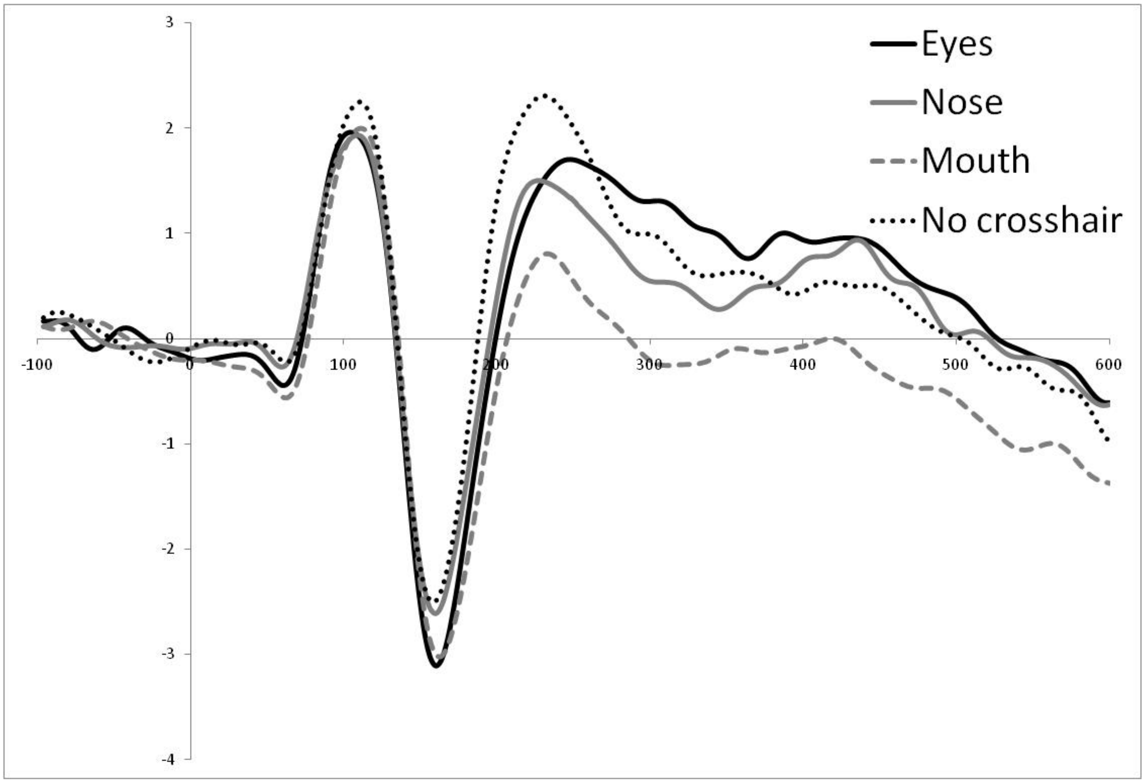
Figure 2. Face N170 averaged over left and right occipitotemporal scalp, displaying variable response to visual attention to eyes, nose, mouth, and without a fixation crosshair.

FIGURE 1

TOP

FIGURE 2

TOP


3
2
1
0
-1
-2
-3
-4
-100
0
100
200
300
400
500
600
Eyes
Nose
Mouth
No crosshair