neuroReport

Website publication 22 September 1998

NeuroReport **9**, 2945–2948 (1998)

Does the face-specific N170 component reflect the activity of a specialized eye processor?

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EVENT-RELATED brain potentials (ERPs) to intact faces and to faces without eyes were compared to ERPs elicited by houses to find out whether the face-specific N170 component reflects the activity of a cortical eye processor. When compared to houses, face stimuli elicited a posterior negativity (N170) and a frontocentral positivity. N170 amplitude was not affected by the presence or absence of eyes, but N170 was delayed in response to faces without eyes. It is concluded that the N170 is not directly related to the activity of cortical regions sensitive to the presence of eyes, and is more likely to reflect processes involved in the structural encoding of face components *NeuroRepor t* 9: 2945–2948 © 1998 Lippincott Williams & Wilkins.

Key words: Event-related potential (ERP); Faces; Fusiform gyrus; Temporal lobe; Visual

Introduction

Evidence from behavioural,[1] neuropsychological,[2] functional imaging[3] and single cell recording studies[4] suggests that face perception is qualitatively different from the perception of other types of objects, and that specialized brain systems are devoted to the processing of face components and to face recognition.[5] It has been argued that the structural encoding of face components and the recognition of facial speech, identity and expression are independent processes.[6] Face recognition is assumed to be subserved by bilateral regions of the posterior fusiform gyrus,[7] while the analysis of facial expression or gaze direction may take place in different areas of temporal cortex.[8,9] Face-specific event-related potential (ERP) recordings may help to distinguish different processes involved in face perception. With subdural recordings, a face-specific N200 component was found in the fusiform and inferior temporal gyrus.[10] In surface ERPs, faces elicited a negativity at lateral temporal and occipital sites (N170) and a frontocentral positivity in the same latency range.[11–13] It has been argued[11] that the N200 and the N170 indicate different aspects of face processing. While the N200 may reflect the structural encoding of face components in the posterior fusiform gyrus, the N170 has been linked to the activity of an 'eye processor' in the occipitotemporal sulcus (OTS). Face-specific activations of the OTS have recently been reported.[14] The function of this 'eye processor' is to provide input to subsequent processes of face identification and expression analysis. Until now, this interpretation is primarily based on the finding[11] that N170 amplitude was equally large or larger for eyes presented in isolation and for intact faces. Linking face-specific ERP components to distinct processing stages and to underlying cortical generators is important for understanding the mechanisms of face perception. Therefore the present experiment tested the idea that the N170 reflects the activity of an eye processor. ERPs elicited in response to intact faces were compared with ERPs elicited to faces where the eye regions (eyes and eyebrows) were removed. If the N170 is generated by processes sensitive to the presence of eyes, it should be strongly attenuated in response to faces without eyes. Randomized sequences of faces and houses were delivered, and faces with and without eyes were shown in different blocks. Face-specific ERP effects were quantified by subtracting ERPs elicited by houses from ERPs to intact faces and to faces without eyes.

Subjects and Methods

Subjects : Twelve paid volunteers (seven female), aged 21–38 years (mean age 29.1 years) participated in the experiment. All subjects were right-handed and had normal or corrected-to-normal vision.

Stimuli and procedure Subjects were seated in a dimly lit, electrically shielded and sound attenuated

cabin, with response buttons under their left and right hands. Stimuli were photographs of faces and houses that were presented centrally on a computer monitor in front of a white background. Sixteen images of houses and 16 face images (eight male, eight female) were used. Intact faces or faces from which the eye regions had been removed (see Fig. 1 for an example) were shown in different blocks. Stimuli were presented for 100 ms, separated by intertrial intervals of 1300 ms, and occupied a visual angle of about $3° \times 4.5°$. The experiment consisted of two halves of four successive blocks, and the order of delivery of these halves was balanced across subjects. In one half (Intact Faces), houses were presented together with intact faces, and in the other half (No Eyes), faces without eyes and eyebrows were presented. Faces and houses were shown in random sequence, and subjects had to respond with a left-hand or right-hand response whenever a stimulus of a given category (faces or houses) was immediately repeated on successive trials. The relevant category and response were specified prior to the start of each block and were varied between blocks. Within each block, 20 immediate stimulus repetitions occurred, with an average of 10 repetitions for the relevant category. Non-repeated faces and houses each appeared on 40 trials, resulting in a total of 100 trials per block. Subjects were instructed to respond as quickly and accurately as possible to relevant repetitions, to withhold responses to all other stimuli, and to maintain central eye fixation. A practice block of 40 trials was delivered prior to each experimental half.

ERP recording and data analysis: Recordings were made from Ag-AgCl electrodes at Fz, Cz, Pz, T5, O1, T6 and O2, referenced to an electrode positioned on the tip of the nose. Horizontal EOG was recorded bipolarly from electrodes at the outer canthi of both eyes; vertical EOG was recorded from electrodes above and below the right eye. Electrode impedance was kept below 5 kΩ. Amplifier bandpass was 0.10–40 Hz. EEG and EOG were sampled with a digitization rate of 200 Hz. ERP analyses were restricted to non-repetition trials. Trials with eyeblinks, lateral eye movements or overt responses were excluded. Repeated measures analyses of variance (ANOVAs) were performed on P1 and N1 peak amplitudes and latencies at lateral posterior electrodes measured relative to a 100 ms prestimulus baseline in the 90–130 ms (P110) and 140–190 ms (N170) post-stimulus intervals for the within-subject variables of stimulus type (face *vs* house), experimental half (Intact Faces *vs* No Eyes), recording site (temporal *vs* occipital) and recording hemisphere (left *vs* right).

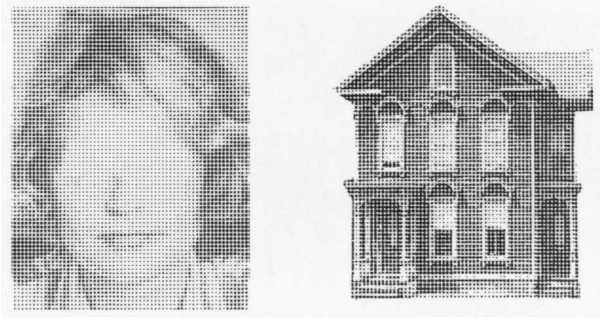

FIG. 1. Examples of face and house stimuli used in the No Eyes condition.

Results

Mean response times were 459 ms and 480 ms to face targets, and 463 ms and 481 ms to house targets, in the Intact Face and No Eyes conditions, respectively. None of these differences were significant. Response errors occurred on < 3% of all target trials.

When compared to houses, intact faces elicited enhanced negativities over lateral posterior sites (Fig. 2, top) and enlarged positivities at Fz and Cz,

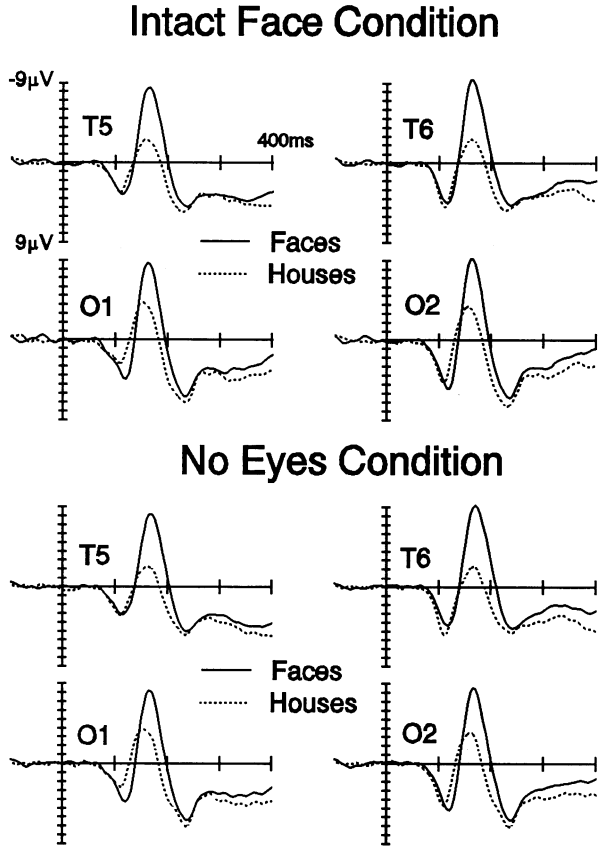

FIG. 2. Grand averaged ERPs at lateral temporal and occipital electrodes in response to faces (solid lines) and houses (dashed lines) in the Intact Face (top) and No Eyes (bottom) conditions.

between 150 ms and 200 ms post-stimulus (Fig. 3, bottom). Occipital P110 was larger for faces than for houses. A very similar pattern of effects was observed in the No Eyes condition. A recording site × stimulus type interaction ($F(1,11) = 16.09$, $ps < 0.002$) showed that P110 amplitude was larger for faces at occipital electrodes, but not at temporal sites, and this was confirmed by further analyses conducted separately for temporal and occipital electrodes. Lateral posterior N170 was larger for faces than for houses ($F(1,11) = 46.89$, $p < 0.001$). Most importantly, there was no indication of a stimulus type × experimental interaction for N170 amplitude ($F < 0.1$), suggesting that the presence or absence of eyes had no impact on face-specific lateral posterior negativity. The differential effect of faces *vs* houses on N170 amplitude at T5 and T6 (averaged over subjects) was 6.0 μV and 6.4 μV in the Intact Face condition, and 5.9 μV and 6.5 μV in the No Eyes condition.

While the presence or absence of eyes did not affect N170 amplitude, it had an effect on its latency. As can be seen in Fig. 3 (top), the negative peak in the faces–houses difference waves was delayed in the No Eyes condition. This was reflected in a stimulus type × experimental half interaction ($F(1,11) = 7.93$, $p < 0.017$) for N170 peak latency. N170 to intact faces was slightly, but consistently earlier than to faces without eyes (161 *vs* 164 ms and 158 *vs* 162 ms at temporal and occipital electrodes, respectively), while no difference between experimental halves was found for the N170 elicited by houses.

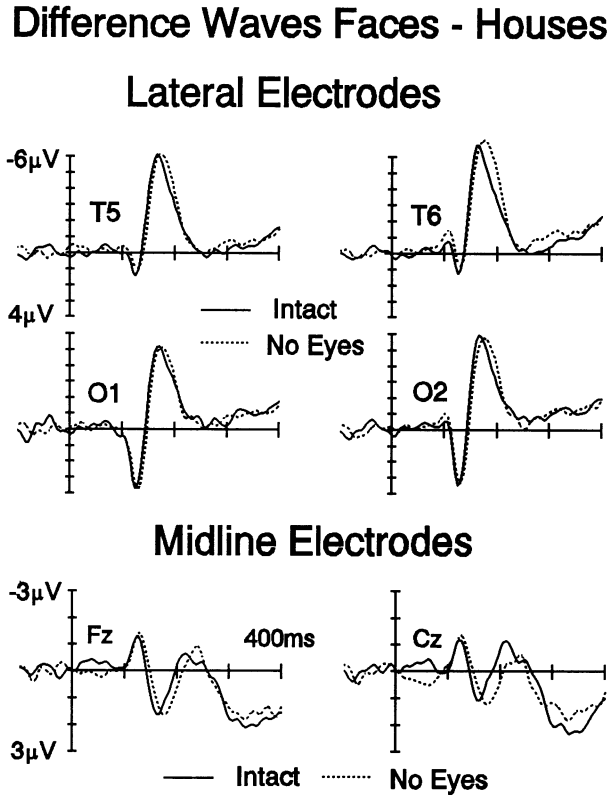

FIG. 3. Difference waveforms obtained by subtracting ERPs to houses from ERPs to intact faces (solid lines) or faces without eyes (dashed lines) at lateral temporal and occipital electrodes (top and middle) and at midline electrodes Fz and Cz (bottom).

Discussion

Face-specific ERP effects were measured by comparing ERPs elicited by faces and by houses. Faces elicited an enlarged P110, but the latency of this effect and the fact that it was confined to occipital electrodes suggests that it was related to perceptual differences between houses and faces rather than to face-specific processing. In contrast, the differential ERP modulations observed between 150 ms and 200 ms post-stimulus were analogous to the pattern of face-specific effects reported in previous studies,[11–13] where a wide range of non-face stimulus categories was employed. Faces elicited a negativity at lateral posterior electrodes (N170) and a frontocentral positivity in the same latency range. Most importantly, N170 amplitude was virtually identical for intact faces and for faces where eyes and eyebrows were removed. If the N170 elicited in response to faces stimuli primarily reflected neural activity specific to the detection and the analysis of eyes, it should have been strongly attenuated or even been absent in the No Eyes condition. The finding that the presence or absence of eye regions did not affect the amplitude of lateral posterior face-specific negativities at all is thus conclusive evidence against the idea that the N170 is caused by the activity of a specialised eye processor.

A small but highly consistent delay in N170 latency was observed in response to faces without eyes and eyebrows. Similar delays have been found when intact faces were compared with isolated face components or with inverted faces.[11] This suggests that the timing of the processes indexed by the N170 is affected when the configuration of face components is altered. Structural encoding processes are assumed to be affected by the lack of one or more face components or by variations of the prototypical spatial configuration of a face.[15,16] The N170 may thus be related to processes involved in the structural encoding and configurational analysis of faces. The finding that isolated eyes can elicit a N170 equivalent to the N170 triggered by intact faces[11] may indicate that the presence of single salient face components is sufficient to activate such structural encoding processes.

Conclusion

In contrast to previous suggestions,[11] the face-specific N170 component does not primarily reflect the activity of brain areas sensitive to the presence of eyes. Rather than being linked to processes devoted to the detection of single features, the N170 is more likely to be caused by the structural encoding of different face components.

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ACKNOWLEDGEMENTS: This research has been been supported by a grant from the Human Frontier Science Program (HFSP). The author thanks Renate Tschakert for technical assistance, and Nancy Kanwisher and Frank Tong for allowing the use of images from the Harvard Vision Science Laboratory.

Received 24 June 1998; accepted 7 July 1998