The time course of visual competition to the presentation of centrally fixated faces

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A recent event-related potential (ERP) study showed that the occipitotemporal component N170 recorded to a face stimulus appearing in the peripheral visual field is strongly reduced when subjects are concurrently fixating another face stimulus. This suggests that concurrently presented face stimuli compete for neural representation in the occipitotemporal cortex between 100 and 200 ms following stimulus onset. We tested whether this competition can be observed for a foveally presented face stimulus appearing next to either two peripheral face pictures or two peripheral control stimuli. The N170 in response to the fixated central face stimulus was substantially reduced (~20% of signal) when it was presented next to peripheral face stimuli. The response suppression was smaller in magnitude than in a previous study where the competing stimulus was fixated and the target stimulus appeared in the periphery. Besides providing a better control for attentional and eye movement confounds, the concurrent stimulation paradigm for fixated face stimuli in ERPs offers a powerful tool to investigate the time course and the nature of the interactions between face and nonface object representations.

Keywords: event-related potential, N170, face processing, concurrent visual processing, neural representation of faces, sensory competition

Introduction

Electrophysiological recordings on the human scalp have shown that face stimuli elicit a larger visual event-related potential (ERP) than other objects, starting at approximately 130 ms and peaking at approximately 170 ms following stimulus onset over the occipitotemporal cortex, the N170 (e.g., Bentin, McCarthy, Perez, Puce, & Allison, 1996; Rossion et al., 2000). The N170 is thought to reflect multiple face categorization processes taking place in interlocked time courses in occipitotemporal areas (e.g., Henson et al., 2003; Rossion, Joyce, Cottrell, & Tarr, 2003). A recent study (Jacques & Rossion, 2004) showed that the N170 in response to a peripherally presented face is massively reduced in amplitude when subjects are fixating a central picture of a face as compared with when they are fixating a nonface stimulus of equivalent global low-level properties. This finding is in line with single-cell recording studies in the monkey inferotemporal (IT) cortex showing that neurons selective to faces exhibit a decrease in their response when more than one stimulus are present in the visual field (e.g., Miller, Gochin, & Gross, 1993; Rolls & Tovee, 1995). These effects are generally interpreted as reflecting a competition between visual stimuli for neural representation, to the extent that the two face stimuli recruit a common population of neurons (Desimone, 1998; Jacques & Rossion, 2004; Kastner & Ungerleider, 2001; Keysers & Perrett, 2002; Reynolds & Chelazzi, 2004).

The interest of using such a dual-stimulation paradigm during recordings of scalp ERPs is threefold. First, the effects of visual competition can be tested in humans, with an excellent temporal resolution. Second, the time course of the competition effect between visual stimuli can be addressed at a global level rather than on a limited population of neurons. Third, and most importantly, the paradigm can be used as a tool to test the extent and the time course of the interaction between different shape representations (e.g., faces and nonface objects in a domain of expertise; Rossion, Kung, & Tarr, 2004).

In previous ERP studies from our group, the N170 in the visual competition ERP paradigm was generally recorded in response to a face stimulus that appeared out of foveal fixation (Jacques & Rossion, 2004; Rossion et al., 2004). It is thus yet unclear whether the response to a face stimulus presented foveally can be suppressed by visual competition, and, if so, to what extent relative to the suppression observed for peripheral stimuli. Clarifying the effects of visual competition for foveally presented face stimuli is important because there are evidence that face-related ERPs such as the N170 and its positive counterpart at central sites, the vertex-positive potential (VPP; see Joyce & Rossion, 2005), are sensitive to eccentricity. For instance, Jeffreys and Tukmachi (1992) found little or no VPP response when subjects’ fixation point was moved horizontally off the face (see also Eimer, 2000). In these conditions, the N170 may also be substantially reduced in amplitude (Eimer, 2000; Rousselet, Husk, Bennett, & Sekuler, 2005).
although the decrease with eccentricity may be eliminated by scaling stimulus size according to V1 cortical magnification factor (Rousselet et al., 2005).

Most importantly, one may argue that the N170 reduction found for laterally presented faces is due to the subjects allocating less attentional resources to the periphery when a meaningful stimulus, such as a face (Jacques & Rossion, 2004) or a nonface object of expertise (Rossion et al., 2004), is shown concurrently at the fovea. That is, this decrease in N170 amplitude to faces presented off fixation may have more to do with spatial attention than visual competition. Although there are several arguments against such a simple spatial attentional account of the N170 modulation in these conditions (see Rossion et al., 2004), demonstrating empirically that the effects of competition can be observed on a foveally presented face stimulus would provide further support for the visual competition hypothesis.

To measure and characterize the effects of visual competition for face stimuli appearing at the fovea, we recorded ERPs to a central face stimulus, presented in the context of either a pair of parafoveal faces or a pair of parafoveal nonface control stimuli. We also compared the results obtained in the present study with those obtained in a previous experiment using the very same set of stimuli but with the first stimulus appearing at the fovea and the second face stimulus appearing peripherally (Jacques & Rossion, 2004).

Methods

Subjects

Fourteen paid volunteers (six females; two left-handed) with normal or corrected vision participated in this study (mean age = 24.3 years, SD = 4.5 years).

Stimuli

The same stimuli as in our previous study were used (Jacques & Rossion, 2004). Briefly, 36 colored photographs of full front faces (Set A) without external features were used. An additional set (B) was composed of the faces from Set A embedded in a rectangular colored white noise (Figure 1). A second additional set (C) was built by scrambling the faces from Set B using a Fourier phase randomization procedure (see Nasanen, 1999). The phase randomization procedure replaces the phase spectrum with random values, keeping the amplitude spectrum of the image unaltered. This procedure yields images that preserve the global low-level properties of the original image (luminance, contrast, spectral energy, etc.) while degrading completely any category-related information (Figure 1A). Stimuli from Set B were embedded in colored white noise so that they subtended equal shape, size, and contrast against the background as the phase-scrambled faces (Set C). All stimuli subtended approximately 2.8 × 3.7 deg of visual angle.

Procedure

Subjects were instructed to fixate the center of the monitor (viewing distance = 100 cm) during the presentation of two blocks of 82 trials. In each trial, two stimuli (faces [Set B] or phase-scrambled faces [Set C]) appeared peripherally (3.1 deg away from the center of the screen) on either side of a fixation point for approximately 900 ms. We presented two identical peripheral stimuli on either side rather than a single stimulus to avoid having the subjects pay more attention or make eye movements to a single stimulus that would appear in the periphery. Approximately 600 ms (randomized between 500 and 700 ms) after the onset of the lateralized stimuli, a face stimulus (Set A)
was presented for 300 ms in the center of the screen, replacing the fixation point (Figure 1B). The offset of the three stimuli was simultaneous and was followed by a blank screen with a fixation point for approximately 1400 ms (randomized between 1200 and 1600 ms). Half of the 164 trials were made of a lateral faces + central face sequence; the other half, of a lateral phase-scrambled faces + central face sequence. Lateralized stimuli were always identical, whereas the identities of the lateralized faces and the central face were always different. The subject’s task was to press a response key whenever the central face appeared upside down, as accurately and as fast as possible. This happened in 20 of the 164 experimental trials. These upside-down face trials were included to maintain subjects’ attention constant during the experiment and were not further analyzed. Therefore, the experiment included 72 trials per condition presented in random order. Subjects were instructed to maintain eye gaze fixation to the center of the screen during the whole trial.

**EEG recordings and ERP analyses**

EEG was recorded from 58 tin electrodes, mounted in an electrode cap (Quick Cap, Neuromedical Supplies) adapted from the 10-20 standard montage. Vertical and horizontal eye movements were monitored using four additional electrodes placed above and below the left orbit and on the outer canthus of each eye. During EEG recording, all electrodes were referenced to the left earlobe and electrode impedances were kept below 10 kΩ. EEG was digitized at a 1024-Hz sampling rate. After a 30-Hz low-pass filtering of the EEG, epochs in which the standard deviation of the EEG on any electrode within a sliding 200-ms time window exceeded 35 μV were removed, and blink artifacts were corrected by subtraction of a vertical EOG propagation factor, based on PCA-transformed EOG components (Nowak & Pfeifer, 1996). For each subject, for correct trials only, averaged epochs ranging from 200 ms before the onset of the second stimulus (central face) to 800 ms after stimulus onset were computed for each condition separately and then baseline corrected using the 200-ms prestimulus epoch. Subjects’ averages were referenced to a common average reference and filtered using a 1-Hz high-pass filter to cut off slow anticipatory waves that may be elicited before the onset of the second stimulus (Jacques & Rossion, 2004; Rossion et al., 2004).

**Statistical analyses**

Two clear visual ERP components time locked to the onset of the central face were analyzed: the P1 and the N170 (Figure 2). Amplitudes were quantified as the mean voltage measured within 30-ms time windows centered on the grand average peak latencies of the components’ maximum, for each condition separately (see Figure 2; Table 1). This procedure was intended to account for differences in the components’ latencies with respect to the experimental condition and hemisphere. For the P1 component, amplitude values were measured at 10 occipitotemporal electrodes (right hemisphere: O2, P8, P6, PO8, PO6; left hemisphere: O1, P7, P5, PO7, PO5) where this component was the most prominent. For the N170 component, amplitude values were measured at eight occipitotemporal electrodes (right hemisphere: P8, P6, PO8, PO6; left hemisphere: P7, P5, PO7, PO5; Figure 3). Amplitude values of each component were then submitted to repeated-measure analyses of variance (ANOVA), with lateral stimuli (face vs. scrambled face), hemisphere (right vs. left), and electrode (P1: five electrodes; N170: four electrodes) as factors. Greenhouse-Geisser adjustments to the degrees of freedom were used when appropriate and polynomial contrasts were performed for post hoc comparisons.

In addition to the ANOVAs, the precise time course of the competition effect was assessed at the same four pairs of occipitotemporal electrodes by running intersubject t tests (df = 13, p < .05) at each time point of the ERP difference waveform obtained by subtracting ERP response to a face in face context from the ERP to a face in scrambled face context (Figure 2; Jacques & Rossion, 2004; Thorpe, Fize, & Marlot, 1996). An effect was considered significant if 15 consecutive t values (~14.7 ms at a 1024-Hz sampling rate) were below the p < .05 level to compensate for multiple comparisons (Rugg, Doyle, & Wells, 1995).

An additional analysis was performed on the amplitude of the N170 to compare the results from the present experiment (lateral to central), in which the N170 is recorded to a face appearing centrally in the context of peripheral stimuli, with the results obtained in our previous experiment (central to lateral; Jacques & Rossion, 2004). In this previous experiment, the N170 was recorded in response to a face appearing peripherally in the context of a central stimulus. The present and previous experiments were matched with respect to all other parameters such as stimulus set, stimulus size, lateral stimuli eccentricity, and data analyses. Amplitude values of the N170 measured in each condition in both experiments were normalized to the mean amplitude of all conditions to account for amplitude difference across different groups of subjects. The ANOVA was then computed with factors target location (central vs. lateral) as a between-subject factor and context (face vs. scrambled face context) and hemisphere (left vs. right) as within-subject factors. This analysis was performed on the same eight occipitotemporal electrodes (see above) that were pooled according to the hemisphere.

**Results**

**Behavioral results**

Subjects detected upside-down central faces with a mean accuracy of 100% in the lateral face context and 98% (SD = 5%) in the lateral scrambled face context.
Mean reaction times were 485 (±62) ms in the face context and 482 (±51) ms in the scrambled face context. There was no significant difference between conditions for accuracy and reaction times (all $p > .2$).

**ERP results**

**P1 amplitude**

When elicited by the central face, the P1 component peaked at approximately 105 ms in both hemispheres. The averaged P1 peak amplitudes over the five pairs of electrodes were 4.6 $\mu$V in the face context and 4.9 $\mu$V in the scrambled face context in the right hemisphere and 3.7 $\mu$V in the face context and 3.5 $\mu$V in the scrambled face context in the left hemisphere. Thus, the P1 amplitude appeared largely independent of the context in which the central face stimulus was presented (Figure 2). This was confirmed by the absence of any context effect, $F(1, 13) = 0.87, p = .77$, or any interaction between context and electrode, $F(1.9, 24.4) = 2.2, p = .13$. Except for the main effect of electrode, $F(1.8, 23.9) = 7.2, p < .005$, due to larger P1 amplitudes on the more posterior electrodes (PO5/PO6, PO7/PO8, and O1/O2), all other effects were nonsignificant. These results thus confirmed our previous finding (Jacques & Rossion, 2004) that sensory competition between face stimuli for neural representation—as reflected by the difference between face and scrambled face contexts in the concurrent processing paradigm—does not start within the P1 latency range.

**N170 amplitude**

The N170 elicited by the first lateral stimuli, either faces or scrambled faces, peaked at approximately 160 ms. Faces

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<th>Face context</th>
<th>Scrambled face context</th>
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<tr>
<td></td>
<td>Left hemisphere</td>
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<tr>
<td>Latencies (ms)</td>
<td>164</td>
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<tr>
<td>Amplitudes ($\mu$V)</td>
<td>$-7.9$</td>
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Table 1. Mean peak latencies and amplitudes of the N170 recorded in response to the second stimulus (central face) at two electrode sites (PO7, left hemisphere, and PO8, right hemisphere).
evoked a much larger N170 than scrambled faces in both hemispheres (for the left and the right hemisphere, respectively: faces, $-3.0$ and $-5.7 \mu V$; scrambled faces, $2.7$ and $1.5 \mu V$). Because our hypotheses focused on the ERPs related to the onset of the central face (second stimulus), the ERPs in response to these first lateral stimuli were not further analyzed.

On average, the N170 elicited by the central face peaked at approximately 160 ms when it appeared in the context of lateralized scrambled faces and at approximately 165 ms when it appeared in the context of lateralized faces (Figures 2 and 3; Table 1). Most importantly, the N170 was reduced in amplitude when the central face stimulus was presented concurrently with lateralized face stimuli relative to when it was presented in the context of lateral scrambled faces (Figures 2 and 3; Table 1).

Statistical analyses conducted on mean N170 amplitude confirmed these observations. The main effect of lateral stimuli, $F(1, 13) = 17.8, p = .001$, reflected the N170 amplitude reduction when the central face was presented concurrently with lateralized faces. This effect was qualified by a significant Lateral Stimuli × Electrode interaction, $F(1.5, 19) = 7.5, p = .007$, the reduction effect being significant on all electrodes but larger on inferior electrodes ($P7/P8: p = .0007$; $PO7/PO8: p < .0002$) than on more medial electrodes ($P5/P6: p = .015$; $PO5/PO6: p = .016$).

Sample-by-sample t tests
Differential ERP activity between face and scrambled face contexts first started to differ significantly from zero ($df = 13, p < .05$) at 136 ms in both hemispheres, a similar latency as previously found ($\sim 125$ ms in Jacques & Rossion, 2004). The difference was maximal at 150 ms (right hemisphere = 2 $\mu V$, left hemisphere = 1.8 $\mu V$, $p < .005$) and remained significant until 166 and 173 ms in the right and the left hemisphere, respectively. As can be seen in Figure 2, a second significant difference between conditions occurred first in the right hemisphere at 183 ms with a maximum at 206 ms ($p < .001$) and 30 ms later (213 ms) in the left hemisphere (maximum = 233 ms, $p < .001$). Note that the earlier difference observed in the right hemisphere is most likely due to latency differences in the ERP waveforms, which are not present in the left hemisphere. The onset latency of this second difference in the left hemisphere is similar to the latency found in our previous study ($\sim 210$ ms).

**N170 amplitude: Central versus peripheral presentation**

Comparing the N170 amplitude found in the present experiment with that measured in our previous study (Figure 4), the significant main effect of context, $F(1, 25) = 87.74, p < .00001$, confirmed that, in both experiments, the N170 elicited by the second stimulus (central or lateral face) was strongly reduced when presented in the face context, relative to the scrambled face context (Figure 4). However, the significant interaction between the factors context and target location, $F(1, 25) = 27.07, p < .00005$, revealed that the effect of context was much larger in the central-to-lateral experiment ($p < .00001$) than in the lateral-to-central experiment ($p = .006$; Figure 4).

A significant Target Location × Context × Hemisphere interaction, $F(1, 25) = 11.42, p < .005$, showed that the N170 amplitude reduction in the face context was stronger in the right hemisphere, but only in the central-to-lateral experiment. Finally, on average in both experiments, the N170 was larger in the right hemisphere than in the left hemisphere, $F(1, 25) = 7.17, p = .013$.

**Discussion**

The N170 response to the onset of a face presented at fixation is reduced when it appears in the context of task-irrelevant peripheral face stimuli. This result extends
whereas a positive value indicates a smaller N170 in the face context relative to the scrambled face context for the present face in the present case). To our knowledge, no ERP study directly investigated the effect of presenting multiple competing stimuli with simultaneous onset times on high-level visual ERPs (i.e., the N1 or the N170). However, as an indirect manifestation of competition for neural resource, a number of ERP studies have consistently found that approximately 200–300 ms after the onset of a visual search display containing multiple stimuli, the ERP response is more negative in the hemisphere contralateral to the target location (Luck & Hillyard, 1990; for recent reviews, see Hopf, Schoenfeld, & Heinze, 2005; Luck, 2005). This ERP component—termed the N2pc—is thought to represent the filtering out of competing distractor stimuli (Luck, Girelli, Mc Dermott, & Ford, 1997) and has thus been related to attentional modulation of neural response found in IT cortex neurons of monkeys when multiple stimuli are present in a neuron’s receptive field (Chelazzi et al., 1998; Reynolds & Chelazzi, 2004; Reynolds et al., 1999).

The current ERP findings may be important for several reasons. First, this paradigm may be used to investigate the interactions between face representations when high visual acuity and/or fast and accurate judgements on the target stimulus are needed. For instance, face identification will be faster and more accurate if the stimulus is presented at the fovea (Makela, Nasanen, Rovamo, & Melmoth, 2001). Processing letters and words efficiently (Nazir, Heller, & Perrett, 2002; Reynolds & Chelazzi, 2004; Reynolds et al., 1999). In the monkey brain, the initial neural response to competing stimuli located within the receptive field of a neuron is a weighted average of the responses to each individual stimulus presented alone (Reynolds et al., 1999). If one of the stimuli in the display is identified as the target or is presented at an attended location, then the neuron’s response is biased toward the response elicited by the attended stimulus when presented alone (Chelazzi, Duncan, Miller, & Desimone, 1998; Reynolds et al., 1999; for a recent review, see Reynolds & Chelazzi, 2004). Because ERPs reflect the complex mixture of activation of multiple sources located in various brain areas possibly eliciting current flow of opposite polarity, it is hazardous to compare ERP data elicited by stimuli that differ in their low-level properties, those elicited by displays that differ in the number of stimuli, and those elicited by stimuli located in different parts of the visual field. Hence, to circumvent this limitation, in the present and previous experiments from our laboratory, we presented the two competing stimuli with an onset asynchrony to isolate the response to a single stimulus while varying the stimulus context in which this second stimulus appears (face vs. scrambled face in the present case). To our knowledge, no ERP study directly investigated the effect of presenting multiple competing stimuli with simultaneous onset times on high-level visual ERPs (i.e., the N1 or the N170). However, as an indirect manifestation of competition for neural resource, a number of ERP studies have consistently found that approximately 200–300 ms after the onset of a visual search display containing multiple stimuli, the ERP response is more negative in the hemisphere contralateral to the target location (Luck & Hillyard, 1990; for recent reviews, see Hopf, Schoenfeld, & Heinze, 2005; Luck, 2005). This ERP component—termed the N2pc—is thought to reflect the filtering out of competing distractor stimuli (Luck, Girelli, McDermott, & Ford, 1997) and has thus been related to attentional modulation of neural response found in IT cortex neurons of monkeys when multiple stimuli are present in a neuron’s receptive field (Chelazzi et al., 1998; Reynolds & Chelazzi, 2004; Reynolds et al., 1999).

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2004), the target stimulus is presented in the periphery and may appear either on the left or on the right visual field. Although the side of stimulus presentation is not predictable, subjects may anticipate the forthcoming location of the face stimulus by shifting their gaze, contaminating the EEG signal (Kazai & Yagi, 2003). Such artifacts and/or ERPs related to eye movements are even more unlikely to occur when the stimulus of interest is presented foveally, exactly where it is expected, as in the present study.

Third, and most importantly, the current results provide further support to the view that the N170 reduction effect is largely due to sensory competition rather than to the subjects allocating less attentional resources to the location where the second stimulus appears. In previous experiments, the subjects were instructed to fixate the competing stimulus (first stimulus) throughout the whole trial. Because faces and possibly objects of expertise are behaviorally relevant stimuli eliciting longer fixation durations (Guo, Robertson, Mahmoodi, Tadmor, & Young, 2003), they may have captured subjects’ attention more than a control stimulus such as a scrambled face or a novel object, causing a reduction of the N170 to the forthcoming lateralized target stimulus. Here, subjects knew exactly where the target stimulus was going to appear and maintained fixation to this central location. Yet, a substantial suppression of the N170 response to this fixated face stimulus was observed. Previous ERP studies testing the effects of attention on the face N170 component observed sizeable effects of spatial attention for visual stimuli presented outside the fovea (Holmes, Vuilleumier, & Eimer, 2003) but either very small effects of IT neurons to an effective stimulus, providing that it is fixated—the effects of attention on the neurons’ responses becoming evident only when the monkey is fixating more than a few degrees away from the stimulus (Rolls, Aggelopoulos, & Zheng, 2003). Altogether, these observations reinforce the view that the N170 reduction observed previously and in the present study—where faces were presented at fixation—results from sensory competition and not from spatial attention being differentially allocated to the face and to the scrambled face stimuli.

Interestingly, the mean percentage of N170 reduction between face and scrambled face contexts in the present study is two to three times smaller than when the first stimulus is being fixated and the ERPs are recorded to the second peripheral face (Jacques & Rossion, 2004; Figure 4). This difference may be a direct consequence of differences in cortical representation between foveally and peripherally presented stimuli. More precisely, in retinotopic visual areas, the cortical surface devoted to process information appearing at the fovea far exceeds the surface devoted to the periphery (the so-called cortical magnification factor; see Levi, Klein, & Aitsebaomo, 1985). This may have affected ERP responses in two ways. First, earlier human ERP studies found that the VPP/N170 is reduced or abolished when faces are horizontally displaced a few degrees away from the fovea (Eimer, 2000; Jeffreys & Tukmachi, 1992), suggesting that faces appearing parfoveally may not recruit face-selective processes to the same extent as faces appearing at the fovea. In addition, the selectivity of the N170 for faces versus nonface objects is reduced for stimuli appearing approximately 3.5 deg from fixation (Eimer, 2000) and becomes marginally significant at 10 deg of eccentricity (Rousselet et al., 2005). This effect appears to be linked to the reduced cortical representation of peripheral visual field locations, as compensating for cortical magnification differences between fovea and periphery by enlarging the peripheral stimuli leads to a recovery of the N170 amplitude difference between faces and nonface objects (Rousselet et al., 2005). This suggests that peripheral faces—as compared with central faces of the same size—might not engage competitive mechanisms to the same extent as foveally presented faces. Second, as discussed above, ERPs were measured in response to a face appearing at fixation in the present study, whereas they were recorded to a face appearing in the peripheral visual field in the previous experiments (3.1 deg away from fixation—the same distance between lateral stimuli and fixation used here). Because the fovea is overrepresented in the retinotopic cortex, information appearing in this area of the visual field may be given a competing advantage over information coming from the periphery. Consistent with this idea, there is evidence that when an effective stimulus is presented together with an ineffective stimulus within the receptive field of an IT neuron, the response of the cell tends to be biased toward the response of the stimulus located closest to the fovea, regardless of whether this stimulus is task relevant or not (Rolls & Tovee, 1995; Rolls et al., 2003). Moreover, it was found that in a visual search task in natural visual scenes, a large percentage of recorded IT neurons did not respond until the effective target stimulus was in close vicinity of the fovea and was the goal for the next saccade (Sheinberg & Logothetis, 2001). At a behavioral level, in visual search tasks, the idea of a foveal bias determined by cortical magnification is supported by the fact that response times and error rates increase with target eccentricity, unless the peripheral stimuli are scaled according to the cortical magnification factor (Carrasco & Frieder, 1997).

In summary, this cortical magnification account suggests that, here, foveally presented faces may have been more immune to competitive interactions arising from faces located in the underrepresented peripheral visual field, therefore resulting in a reduction in the magnitude of the competition effect observed at scalp level. As an additional explanation for the reduced competition effect, faces appearing at the fovea may be more immune to competition as a result of a bias of high-level areas responding preferentially to faces toward the central part of the visual field (Hasson, Levy, Behrmann, Hendler, & Malach, 2002; Levy, Hasson, Avidan, Hendler, & Malach, 2001). More precisely, these
areas respond more to any visual stimulation presented in the central visual field than in the periphery, suggesting that they receive more inputs from the foveal representation in V1 and retinotopic extrastriate areas.

Conclusions

In summary, electrophysiological processes time locked to the onset of a face stimulus presented at fixation are substantially suppressed in the presence of task-irrelevant peripheral face stimuli. This visual competition takes place as early as 130 ms at the level of the N170. Competitive suppression found for fixed target face stimuli supports the view that the N170 suppression effect described here and previously is largely related to sensory competition rather than to a reduced allocation of attention to the target stimulus. Comparison of the present and previous findings brings support to the view that the processing of faces is dependent on eccentricity, with a competing advantage being given to faces appearing at the fovea. Finally, the paradigm may be used to investigate the interactions between face representations when high visual acuity and/or fast and accurate judgements on the target stimulus are needed.

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