Concurrent processing reveals competition between visual representation of faces

Corentin Jacques & Bruno Rossion

Neuroreport, 15, 2417-2421, (2004)

Related work

Rossion, B., Kung, C.-C., Tarr, M.J. (2004). **Visual expertise with nonface objects leads to competition with the early perceptual processing of faces in the human occipitotemporal cortex.** PNAS, 101, 14521-14526.

Rossion, B., Collins, D., Goffaux, V., Curran, T. (in press). **Long-term expertise with artificial objects increases visual competition with early face categorization processes.** Journal of Cognitive Neuroscience.

Jacques, C. & Rossion, B. (2006). **The time course of visual competition to the presentation of centrally fixated faces.** Journal of Vision, 6, 154-162.

Jacques, C. & Rossion, B. (in press). **Electrophysiological evidence for temporal dissociation between spatial attention and sensory competition during human face processing.** Cerebral Cortex.

Main ERP findings and conclusions

The N170 recorded in response to a peripherally presented face is strongly reduced in amplitude when subjects are fixating a central face picture, as compared with when they are fixating a non-face stimulus matched for low-level visual properties.

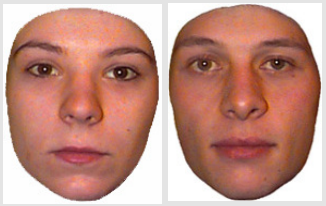
In line with single cell recording studies in the monkey brain suggesting that when multiple stimuli (faces or simpler visual stimuli) are presented simultaneously in the visual field, they compete for neural representation (e.g., Miller et al. 1993; Rolls and Tovee 1995; Reynolds et al., 1999). See also fMRI evidence (e.g. Kastner et al. 2001).

Introduction

Single-cell recording studies in the monkey inferotemporal cortex found that neurons exhibit a decrease of their response when more than one stimulus is present in the visual field (e.g., Miller et al. 1993; Rolls and Tovee 1995; Reynolds et al., 1999,…).
It was suggested that the neurons' responses to these stimuli is reduced because the stimuli activate neural populations that compete in a mutually suppressive way.

Goal of the present study:

Can we find signs of such competitive interactions between high-level face representations using event-related-potentials in humans?



Methods

Stimuli:

A

36 faces

B

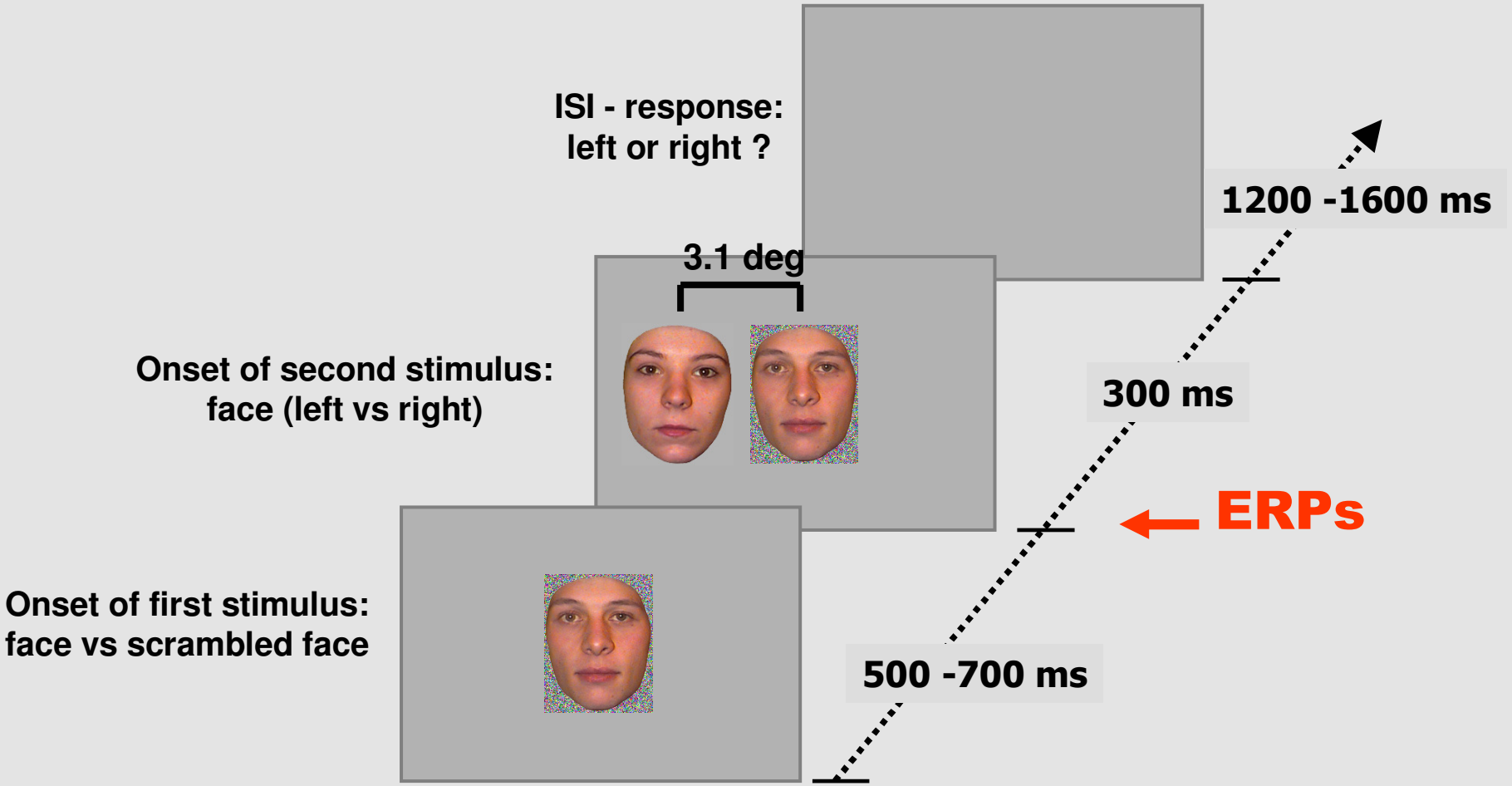
The same 36 faces embedded in colored white noise

C

36 Phase scrambled faces (from the faces in set « B »)

‘Face to face’ condition

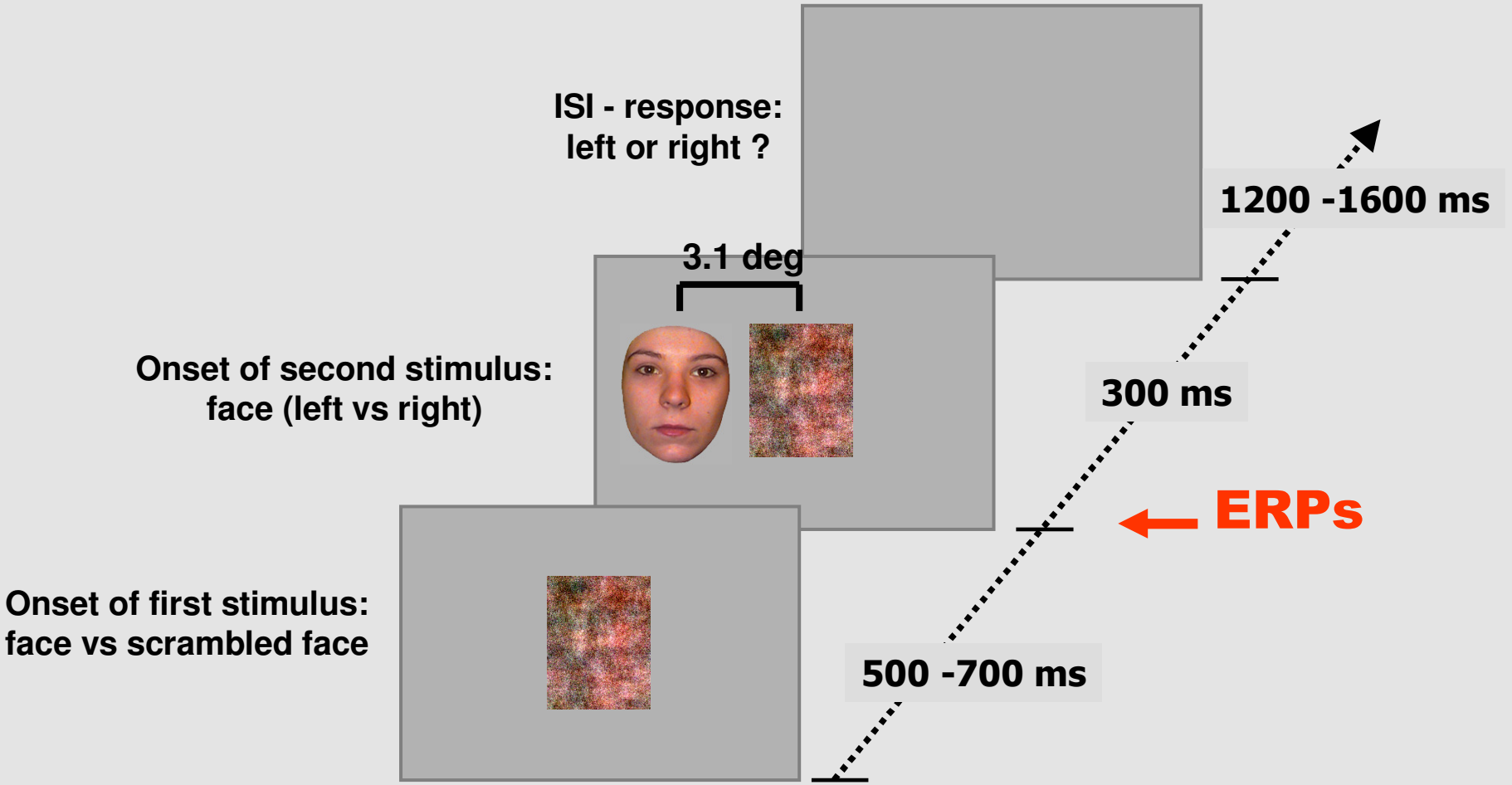
We measure the ERPs to the onset of the lateral face



Methods

control condition (scrambled face)

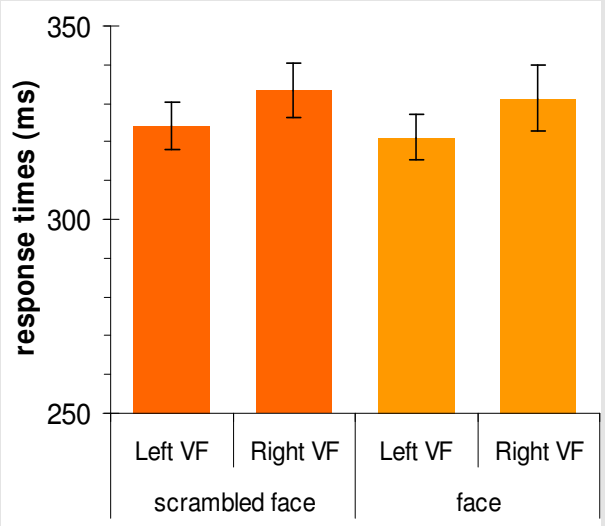
We measure the ERPs to the onset of the lateral face

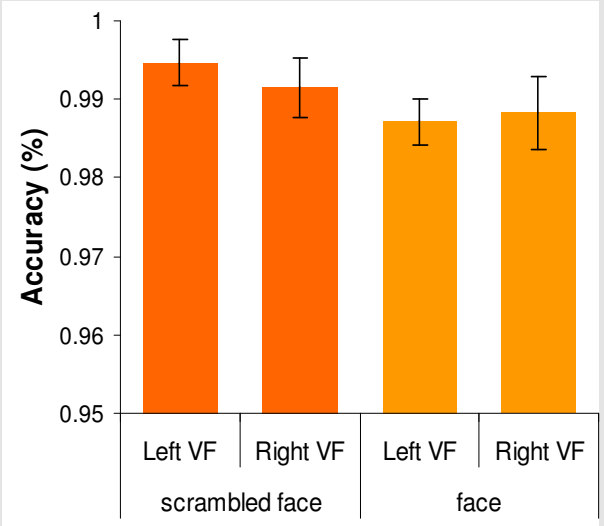


Methods

Task & Behavioural results

Task: Speeded detection: press a key corresponding to whether the lateralized face appears on the left or on the right of the first stimulus.

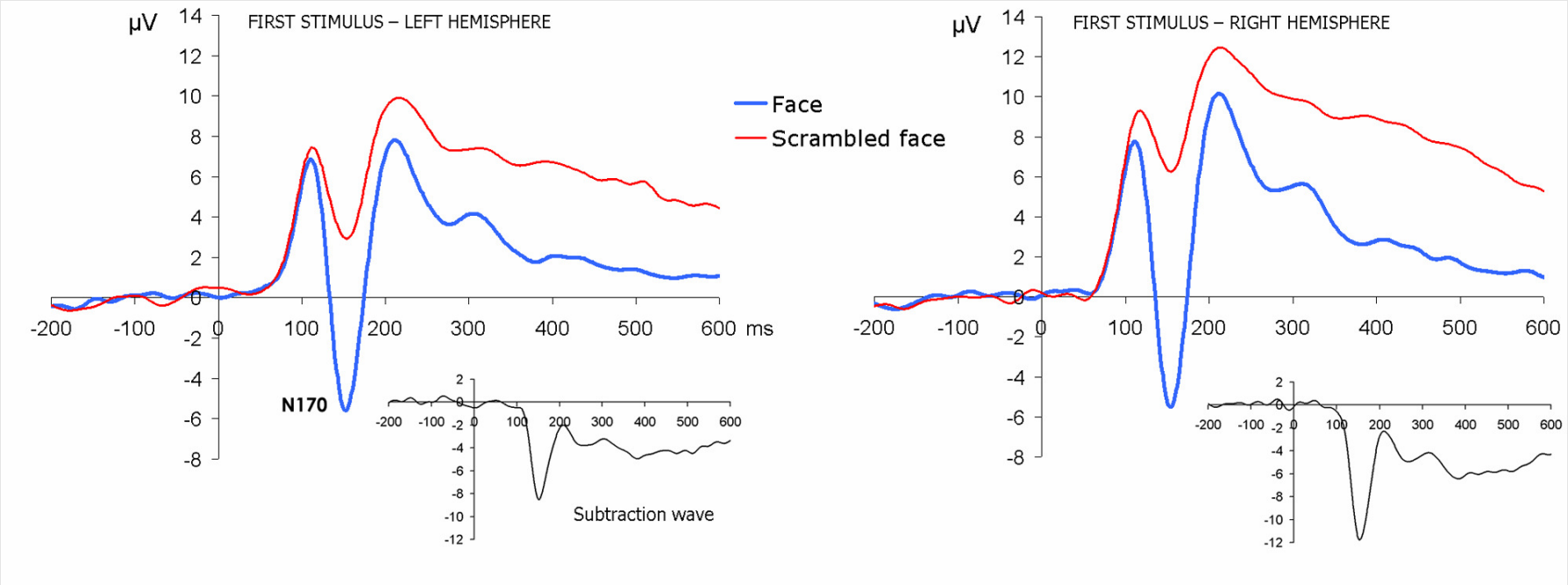


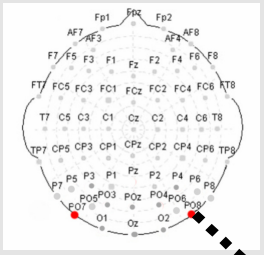


No significant effect.
Trend for faster response when face appear in the Left visual field (p = .09)

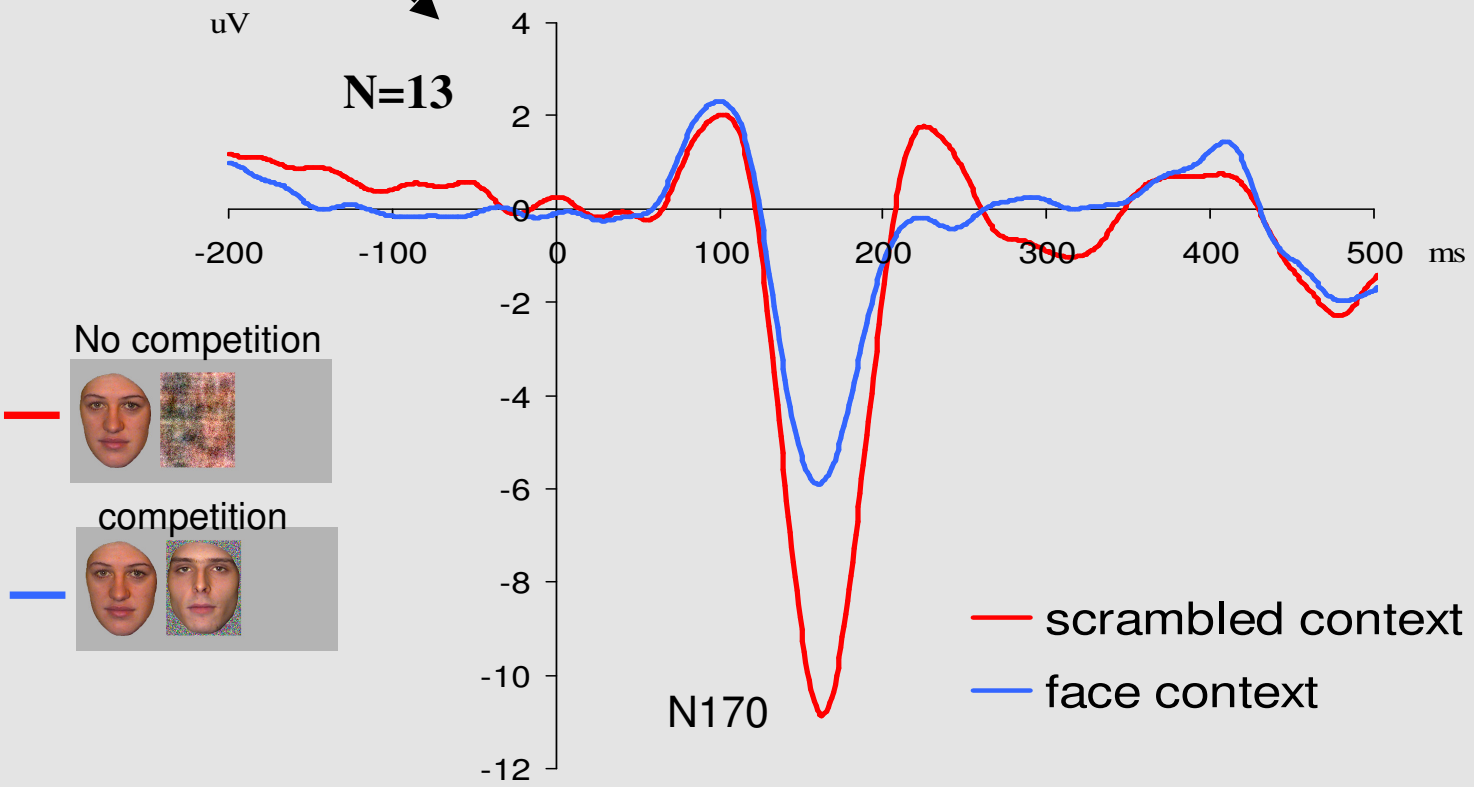
Results

ERP response to **first stimulus** (central face vs central scrambled face) + subtraction waves (face – scrambled face)





ERP to lateralized face
Left visual field - Right hemisphere



N170 reduced at 130 ms

Results

ERP response to lateralized face for each visual field x hemisphere

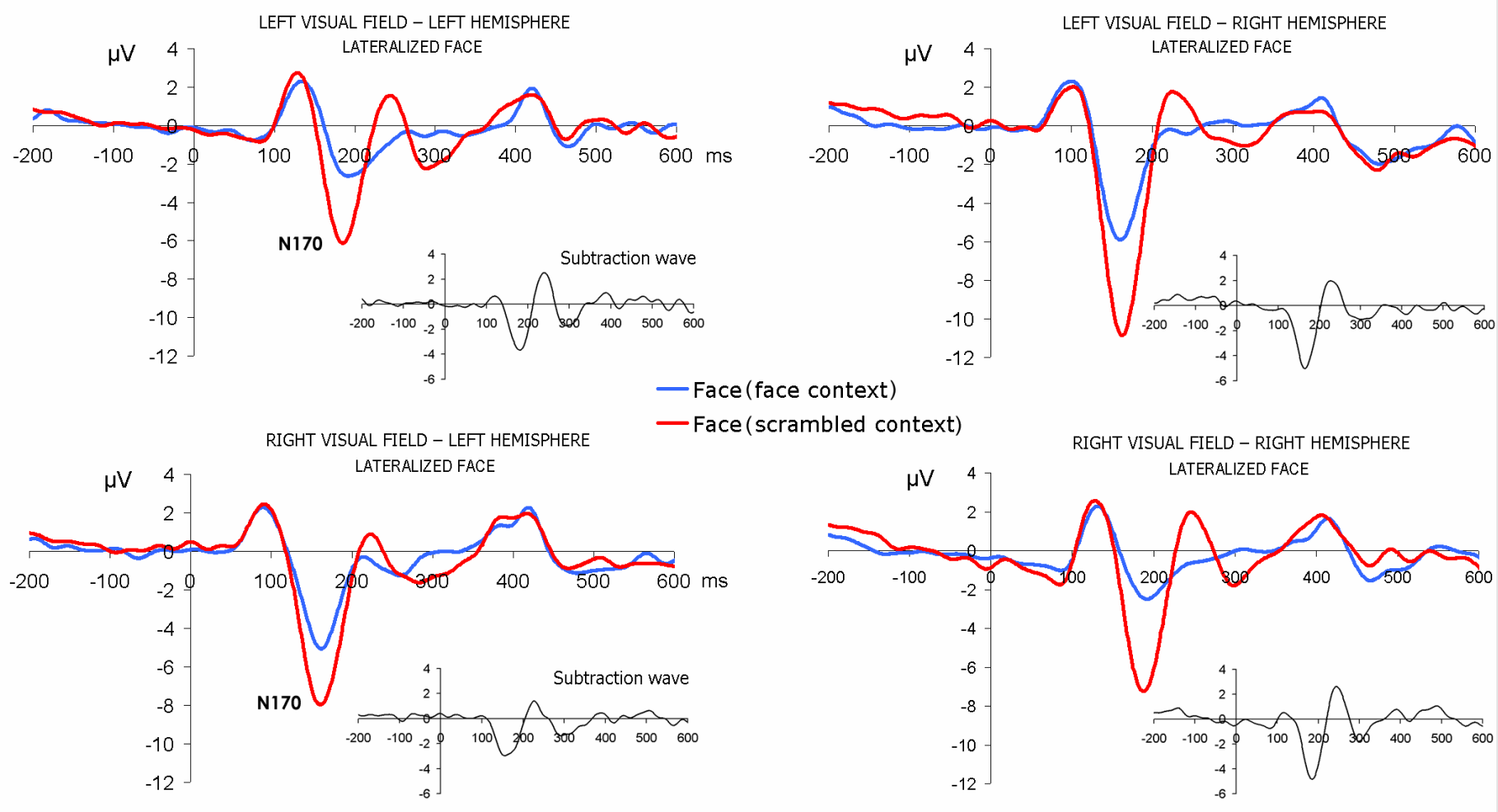
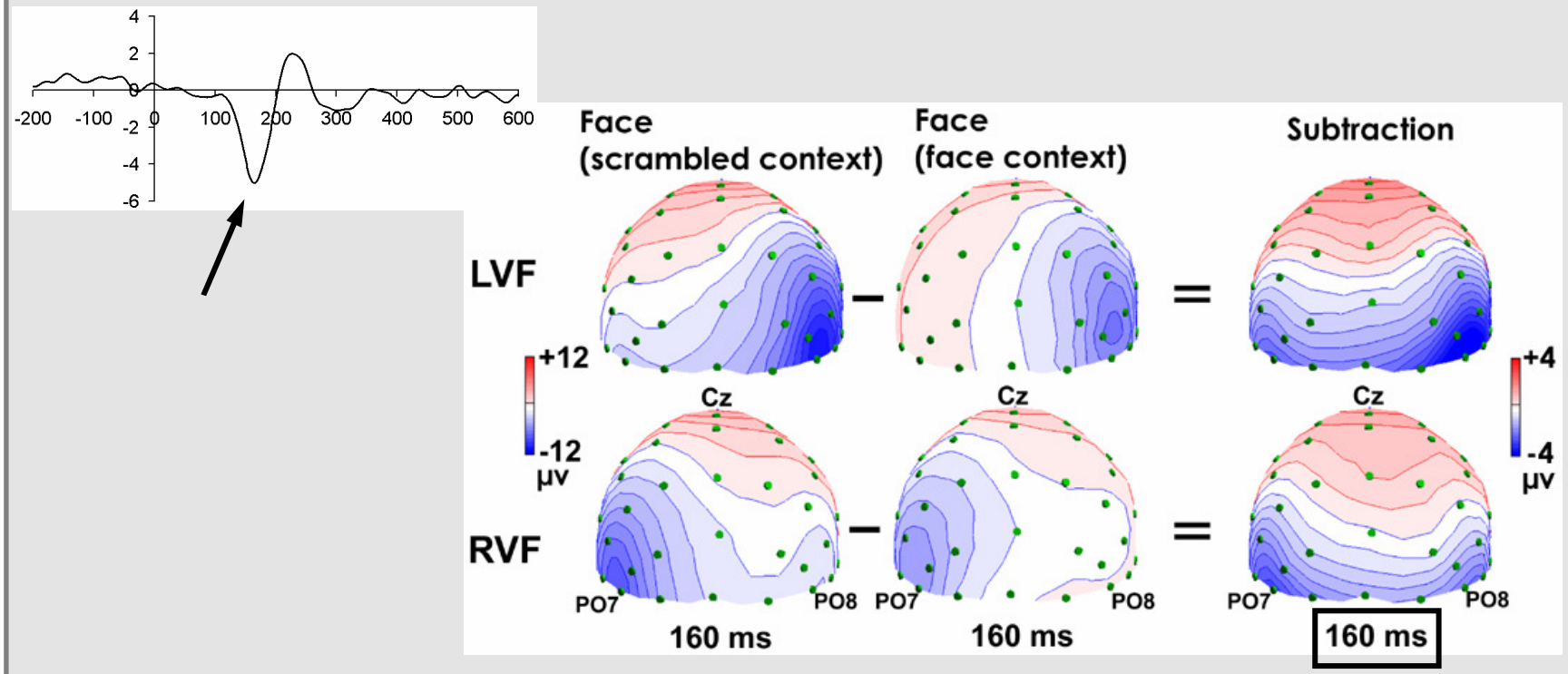


Figure:
Grand averaged ERPs elicited by the second stimulus of the trial sequence (lateralized face) for two occipito-temporal electrodes (PO7, PO8). Below, in black: difference waveforms obtained for each visual field and hemisphere separately by subtracting ERPs for faces presented in a face context to ERPs for faces presented in a scrambled face context (red curve minus blue curve)

Results

Topography of the N170 and competition effect at the N170 (160 ms)



Scalp topographies depicting the distribution of the N170 at 160ms following the onset of the second stimulus (lateralized face) for the left visual field (LVF - top) and the right visual field (RVF - bottom) stimulation. Left: response to faces presented in a scrambled face context. Middle: response to faces presented in a face context. Right: topography of the di¡erential activity obtained by subtracting the response elicited by faces in a face context to the response evoked by faces in a scrambled-face context.

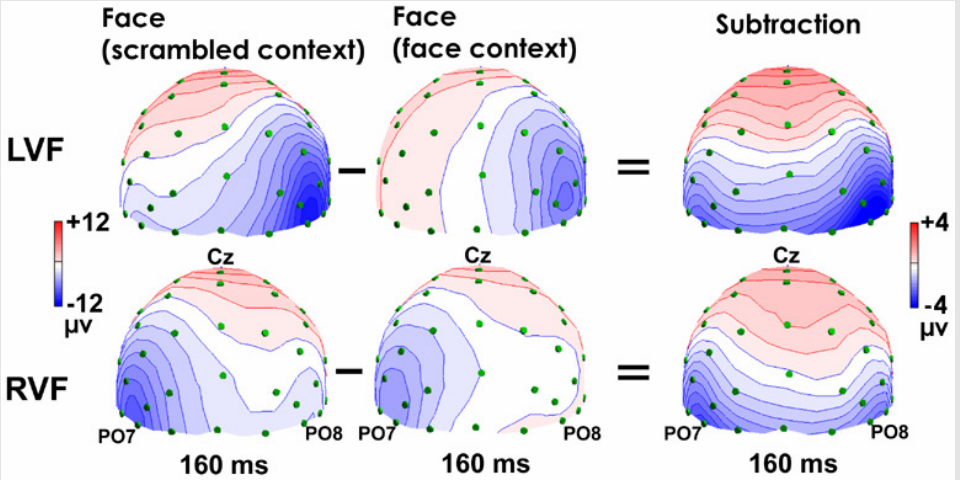
Results

Discussion

If two faces are presented concurrently in the visual field, they compete for neural representation…
(e.g. Miller et al., 1993; Rolls & Tovee, 1995)

… to the extent that they are recruiting a common population of neurons
(Desimone, 1998; Reynolds et al., 1999; Keysers & Perrett, 2002)

Topography of competition effect is similar to the topography of the N170.



→ Competition takes place in occipito-temporal regions that participate in generating the N170

Discussion

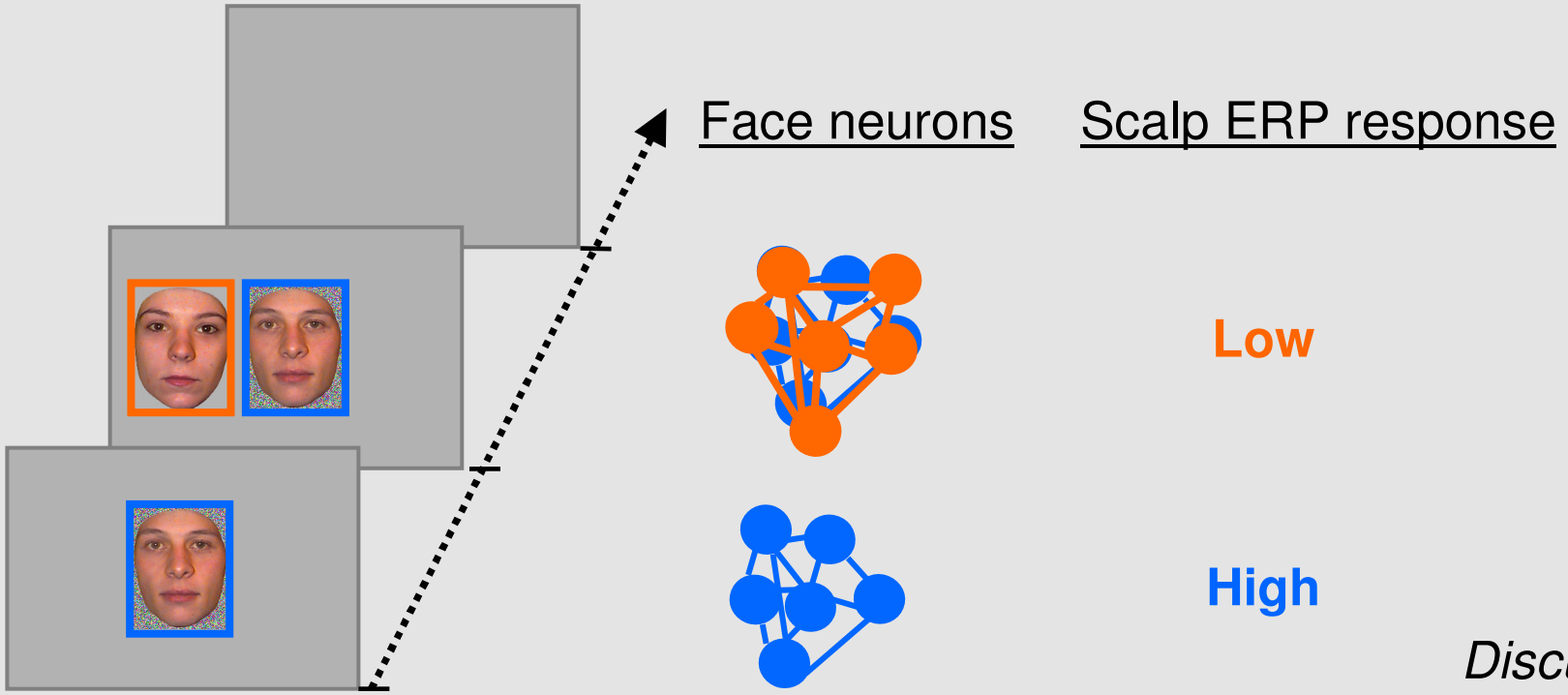
Sensory competition: Neurophysiological mechanisms

At least 2 possible mechanisms

1. Partially overlapping face representations

First face: high sustained response in sub-populations of face cells.

Second face: Neurons that would have been recruited by the second face are only partially available (response id saturated), causing a reduction of signal in response to this lateral face. Because ERP reflect mostly post-synaptic neural activity, ERP competition effect may be correlated to response saturation at post-synaptic level rather than in the neurons' firing rate.

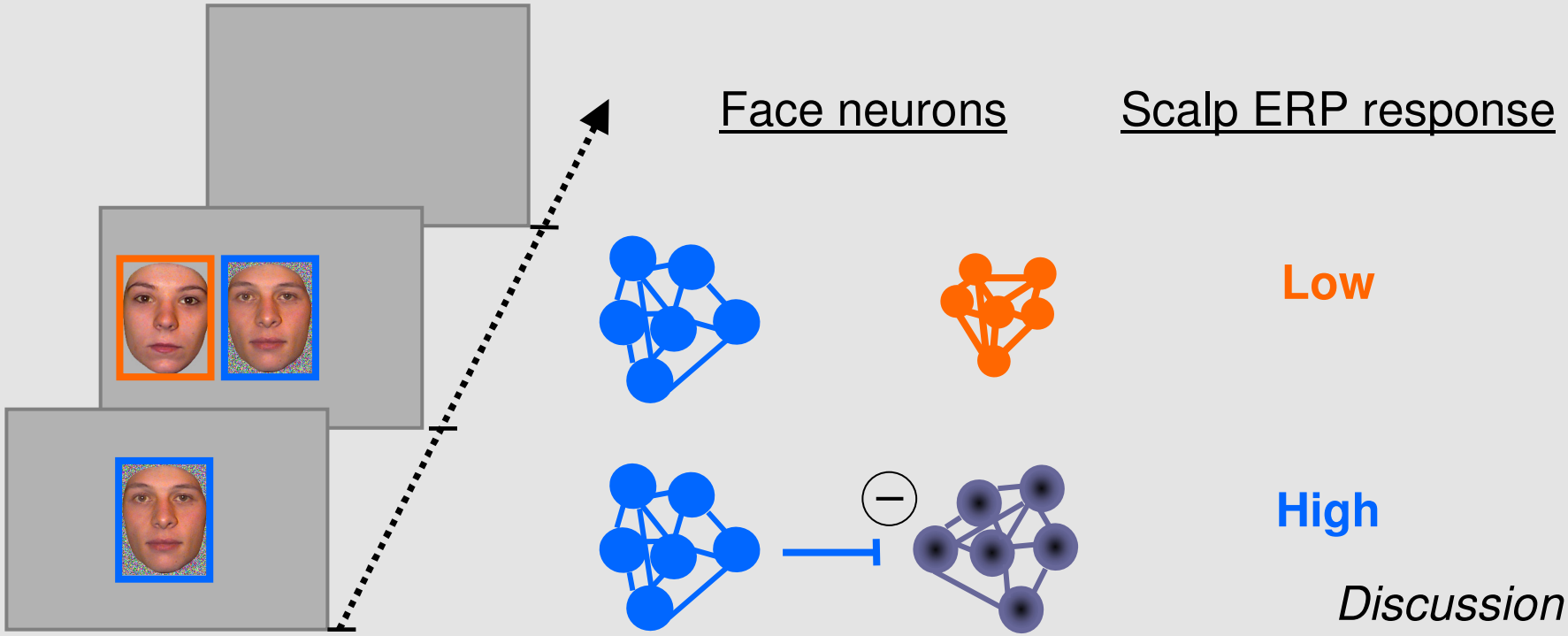


Sensory competition: Neurophysiological mechanisms

At least 2 possible mechanisms

2. First face inhibit respond to second face

Neurons coding for the first-central face suppress the response of neurons in their vicinity by means of lateral inhibitory connexions.



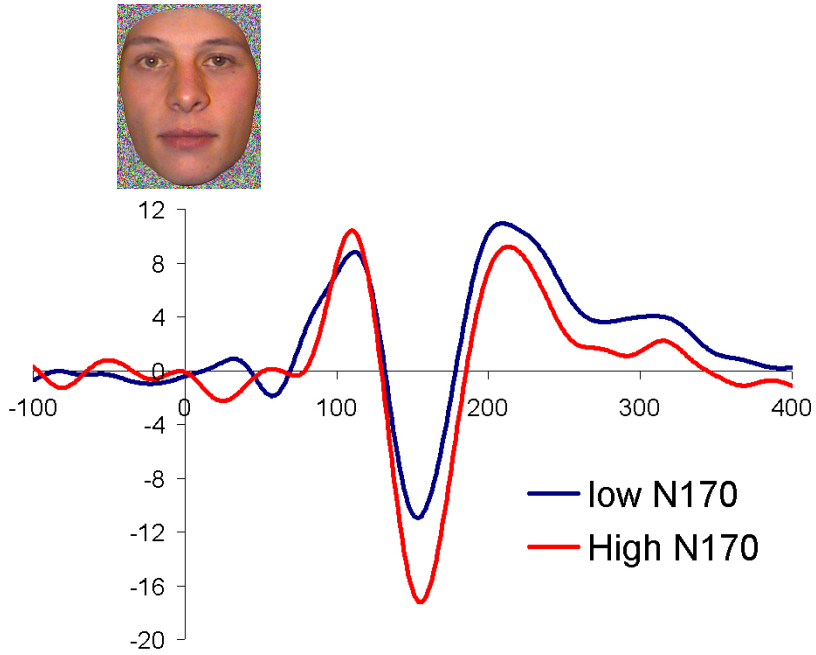
Discussion

The magnitude of the N170 reduction for the peripheral face is independent of the amplitude of the N170 to the first face.

ERPs to First face:

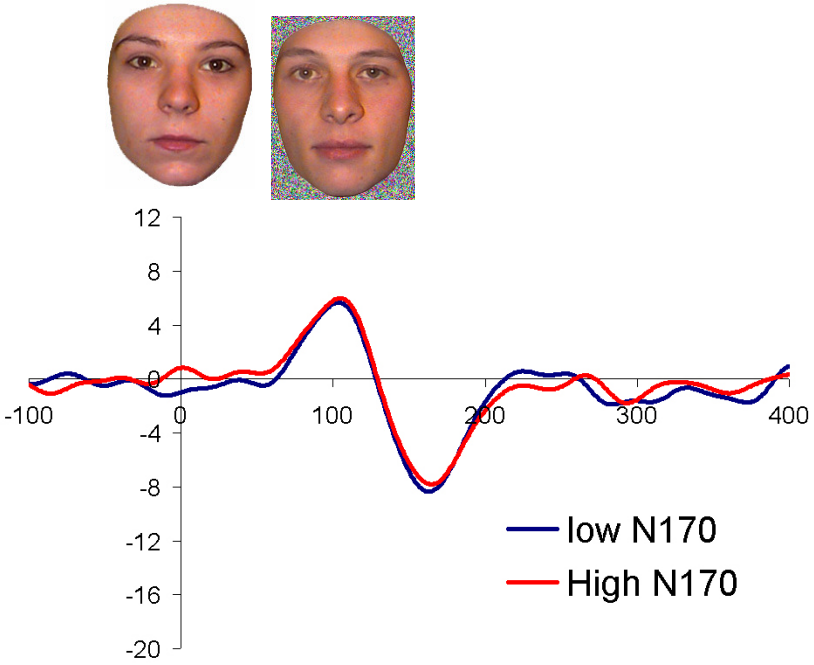
2 bins: N170 > mean N170 = high N170

N170 < mean N170 = low N170



ERPs to second face:

No difference between the 2 bins



Note: Analyses done for 3 subjects only

Can spatial attention explain the N170 reduction?

➔ Subject may pay more attention to the center of the screen (and thus less attention to the periphery) when a face compared to a scrambled-face is present at fixation

No !

➔ No differences in reaction times between the face and scrambled conditions. Studies on spatial attention generally find faster/slower target detection time for attended/unattended locations.

➔ We recently found that in this concurrent processing design, spatial attention and sensory competition have dissociable effect on ERP response to faces:
-The effects are dissociated in time
-Spatial attention and competition have orthogonal / additive effects on the N170

See Jacques, C. & Rossion, B. (in press). **Electrophysiological evidence for temporal dissociation between spatial attention and sensory competition during human face processing**. *Cerebral Cortex*.

Discussion