Visual expertise with nonface objects leads to competition with the early perceptual processing of faces in the human occipitotemporal cortex

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See also:


Jacques & Rossion, 2006, Electrophysiological evidence for temporal dissociation between spatial attention and sensory competition during human face processing. Cerebral Cortex, in press
Main findings and conclusions

• The N170 component in response to FACES is substantially decreased in amplitude when subjects process nonface objects of expertise (Greebles) concurrently

• The effect of expertise is large, gradual over the course of training, and takes place mainly in the right hemisphere

Even if the face is a special kind of stimulus for the human brain, when one becomes an expert in discriminating members of a visually homogenous nonface category, this expertise may rely on shared perceptual processes with faces.
The question: When one becomes an expert in discriminating members of a visually homogenous nonface category, can this expertise rely on shared perceptual processes with faces?

No? — The processing of faces rely on domain-specific (modular) mechanisms

Yes? — The mechanisms used to recognize faces can be adapted to deal with other object categories. They are not attached to a domain, but more general, and plastic.

Here, we address this question using:

- Event-related potentials (ERPs)
- Faces and novel objects
- An expertise training study
- A paradigm with competing stimuli

*Introduction*
The question of the modularity of face processing mechanisms is a very old debate in the literature (e.g. Bodamer, 1947; Yin, 1969; Ellis & Young, 1989; Nachson, 1995)

Faces appear to rely on specific mechanisms for most of us:


* **Neurophysiological evidence**: cells in infero-temporal cortex responding only for faces (Gross et al., 1972; Perrett et al., 1982)

* **Neuropsychological evidence**: brain lesions can lead to face-specific impairments in rare cases, prosopagnosia (Bodamer, 1947; Sergent & Signoret, 1992)

* **Neuroimaging evidence**: occipito-temporal brain areas responding more to faces than objects, particularly in the right hemisphere (e.g. Sergent et al., 1992; Kanwisher et al., 1997)

  + **ERPs**: faces evoke a large component starting at 130 ms, much smaller for other object categories, the VPP/N170 complex (Jeffreys, 1989; Bentin et al., 1996)

*Introduction*
However, these observations do not contradict the view that certain mechanisms used for faces remain plastic even in adults, and can be recruited for other object categories following an extensive visual experience.

E.g.:

Evidence of increased costs of upside-down inversion in dog experts presented with dog pictures (Diamond & Carey, 1986)

Increased integration of parts (sensitivity to configuration) in novel objects (Greebles) following ~ 10 hours training (Gauthier & Tarr, 1997)

Increased activation in ‘face areas’ of the fusiform gyrus to pictures of birds and cars in bird and car experts (Gauthier et al., 2000)
A few comments …

- The effects of visual expertise do not have to be as large as for faces to invalidate the modularity hypothesis, but show the same pattern, increasing with visual expertise.

  Yet, admittedly, these effects could be stronger …

- Any kind of visual expertise with nonface objects will not necessarily increase the reliance on mechanisms used for faces.

- Behavioural and neuroimaging findings are indirect evidence that faces and objects of expertise may share common perceptual mechanisms.

→ With ERPs, we are looking for strong effects of visual expertise, taking place at the early stages of face categorization

  = on the N170 component

Introduction
Introducing

- Event-related potentials (ERPs) to faces

- A paradigm with competing stimuli

- Novel objects (Greebles) in an expertise training study
Method = averaging epochs of EEG time-locked to the onset of a face stimulus
Introduction
The **N170** is larger for faces compared to other objects categories (e.g. Bentin et al., 1996; Bötz, et al., 1995; Eimer, 2000; Rossion et al., 2000)

*Introduction*
N170
= Earliest and only consistent scalp electrophysiological response in humans that differentiates between faces and other object categories.

Introduction
Jacques & Rossion (2004):

**N170 response to multiple face stimuli**
‘Face to face’ condition

Onset of first stimulus: face vs scrambled face

Onset of second stimulus: face (left vs right)

ISI - response: left or right?

500 - 700 ms

1200 - 1600 ms

300 ms

500 - 700 ms

ERPs


Introduction
**control condition (scrambled face)**

- **Onset of first stimulus:** face vs scrambled face
  - 500 - 700 ms

- **Onset of second stimulus:** face (left vs right)
  - 3.1 deg
  - ISI - response: left or right?
  - 300 ms

- **ERPs**
  - 1200 - 1600 ms
  - 300 ms
  - 500 - 700 ms

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*Introduction*

Massive reduction of amplitude of the N170
Interpretation

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)

→ ERP paradigm to address the competition between faces and objects of expertise

Introduction
Methods

Onset 600 ms  Onset 0 ms
Timeline of Task Events

Methods
Hypothesis: the N170 response to faces during the Greeble presentation will DECREASE with expertise training.
EEG recordings (64 channels) in 5 subjects

1. **Before** expertise training

2. **In between** training (session 4)

3. **Following** expertise training (session 8)
Developing visual expertise with non-face objects

The ‘Greebles’  \cite{Gauthier&Tarr,1997}
Results

ERP response to Greeble cue (novices) and Greeble cue (experts). The red line represents Novices, while the black line represents Experts.

Key:
- Red line: Greeble cue (novices)
- Black line: Greeble cue (experts)

The graph shows the ERP response in microvolts (µV) over time in milliseconds (ms) up to 500 ms. The N170 component is highlighted in the graph.
Massive reduction of the N170 in response to faces following expertise training with a nonface object category!
To sort out general effects from real effects of training ...

\[ \text{Control stimuli (untrained)} \]

\[ = 3 \text{ (expertise level)} \times 2 \text{ (stimulus) design} \]
ERP response to

Control object cue - Before
Control object cue - After

Results
Right hemisphere - right visual field

ERP response to

Results
Massive reduction of the N170 in response to faces following expertise training with a nonface object category.

Specific to the N170 (earlier P1 effects reflects main differences between recording sessions)

Specific to the objects trained (Greebles). Difference before and after for the same subjects and same stimuli.

Results
N170 amplitude to 2 hemispheres and 2 visual fields confounded

Interaction stimulus x training stage: p=0.02

Results
Right hemisphere - right visual field

ERP response to

Results
Right hemisphere - right visual field

ERP response to

Control cue - Greeble cue

Results
150-180 ms - N170 to Left Visual field

BEFORE

AFTER

Results
150-180 ms - N170 to Control MINUS Greebles Right Visual field

Before

Effects are stronger in the right hemisphere, even for ipsilateral presentations of the face

Results
Conclusions

N170 in response to faces is decreased following training, during concurrent processing with objects of expertise.

When one becomes an expert in discriminating members of a visually homogenous nonface category, this expertise may rely on shared perceptual processes with faces.

<< Modularity view of face processing
Alternative explanations/criticisms?

1. Can this effect reflect a simple increase of attention rather the recruitment of shared mechanisms?

   e.g. experts would pay more attention to the Greebles in the center, leading to reduced N170 to the lateralized face

Highly unlikely:

- Who would pay more attention? Experts or novices?
- The task is irrelevant, performance at ceiling, and no RT difference between conditions
- The effect is not sustained, but take place in a very narrow time window (130 -180 ms)
No evidence for an attention as an alternative explanation

+ Effects of attention (when manipulated) in this paradigm are independent from effects of spatial attention:

Jacques & Rossion, 2006, Electrophysiological evidence for temporal dissociation between spatial attention and sensory competition during human face processing. Cerebral Cortex, in press
Alternative explanations/criticisms?

2. The N170 component measured is not really face-specific

   e.g. should have been identified by an independent ‘face localizer’

Irrelevant because:

- The N170 is measured in response to FACES

- The effect takes place where it is larger for faces: right occipito-temporal sites (T6 or PO8 and surrounding sites).

- Even if the N170 suppression for faces reflect a competition from different populations of cells coding for faces and objects of expertise, the competition suggest that these populations carry similar processes in the same areas.

Discussion