A network of occipito-temporal face-sensitive areas besides the right middle fusiform gyrus is necessary for normal face processing

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*Brain*, 2003, 126, 2381-2395.
Main findings and conclusions

* Prosopagnosia can follow a right hemispheric lesion sparing the ‘fusiform face area’ (FFA)

* The integrity of face-preferential coding in the right inferior occipital cortex (‘occipital face area’, OFA) is necessary for normal face perception, and a lesion of this region may be the main cause of prosopagnosia.

* Activation of the ‘FFA’ may not be due to inputs from the ‘OFA’ in normal subjects, as in a feedforward face processing model

* We suggest that both the ‘FFA’ and ‘OFA’ in the right hemisphere and their reentrant integration are necessary for normal face processing

Note: these observations have been replicated in another case of prosopagnosia, DF, by Steeves et al. (2006, *Neuropsychologia*).
Neuroimaging studies have disclosed three visual areas where a larger response to faces than other object categories is consistently observed in single subjects, with a right hemispheric dominance:

- **Inferior Occipital Gyrus** (‘Occipital face area, OFA’)
- **Middle Fusiform Gyrus** (‘Fusiform face area, FFA’)
- **The Superior Temporal Sulcus (STS)**

*Introduction*
Two of these areas are located in the ventral visual stream.

'Fusiform face area' (FFA)

'Occipital face area' (OFA)

Introduction
Two critical questions

* Are these areas (all) necessary for normal face perception?

* How do they interact with each other during face processing?
To answer these questions, we performed an fMRI study of the prosopagnosic patient PS, who is unable to recognize faces following a brain damage in 1992
PS has normal visual functions and object recognition

- Low-level: small left paracentral scotoma, acuity: 8/10 both eyes

- Reading OK

- 100% object recognition (Colorized Snodgrass and Vanderwart set by Rossion & Pourtois, 2004)

- No deficit at subordinate object recognition, even when RTs are considered
2AFC: Matching at basic and individual level

(data from Schiltz et al., 2006, *Cerebral Cortex*)

First stimulus 2000 ms; pair until response

*Case description*
2AFC: Matching at basic level

A. Correct RTs for Between-category discrimination

Case description
2AFC: Matching at individual level

B. Correct RTs for Within-category discrimination

Case description
Anatomical scan: PS’s lesions spare the right ‘FFA’

Results
PS’s lesions concern the right ‘OFA’

**Results**
Introduction

'Occipital face area' (OFA)
Conclusion 1:

The right ‘OFA’ is necessary for normal face processing
Can we activate the right middle fusiform gyrus (FFA) for faces despite the face impairment and lesion to the right inferior occipital cortex (OFA)?
Introduction

‘Fusiform face area’ (FFA)

‘Occipital face area’ (OFA)
Right middle fusiform activation in patient PS

Faces - Objects, block design fMRI

Results
The localization of PS’ right FFA is similar to that of controls (note the degree of variability between subjects)
The level of activation of PS’ right FFA is in the normal range

<table>
<thead>
<tr>
<th>Subjects</th>
<th>Talairach coordinates (X, Y, Z)</th>
<th>Z-mean</th>
<th>Size (cm³)</th>
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<tr>
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<td>42 -44 -14</td>
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<td>S1</td>
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<td>47 -54 -13</td>
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<td>PS(1)</td>
<td>42 -59 -18</td>
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<td>PS(2)</td>
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</table>
The right OFA is not necessary for face-sensitive activation at the level of the FFA. This contradicts a view according to which the ‘OFA’ would be the front end of the system (e.g. Haxby et al., 2000).

Conclusions
What have we learned?

1. The integrity of the right inferior occipital cortex (OFA) is necessary for normal face processing

   But …

2. The integrity of the right inferior occipital cortex (OFA) is NOT necessary for face-preferential responses in the fusiform gyrus (FFA)
Recently: Another prosopagnosic patient (DF) with bilateral ‘OFA’ damage and ‘FFA’ activation

Steeves et al., 2006, *Neuropsychologia*
What is happening in normal subjects?

Parallel processing in both regions, activated independently for faces?

**OFA**
- Inferior occipital gyri
  - Early perception of facial features

**FFA**
- Lateral fusiform gyrus
  - Invariant aspects of faces – perception of unique identity

**Superior temporal sulcus**
- Changeable aspects of faces – perception of eye gaze, expression and lip movement

**Intraparietal sulcus**
- Spatially directed attention

**Auditory cortex**
- Prelexical speech perception

**Amygdala, insula, limbic system**
- Emotion

**Anterior temporal**
- Personal identity, name and biographical information

**Core system:** visual analysis

**Extended system:** further processing in concert with other neural systems

Conclusions
Or …

Activation through the anterior face-sensitive region?

1. Core system: visual analysis
   - ‘OFA’
   - Inferior occipital gyri
     Early perceptual facial features
   - Superior temporal sulcus
     Changeable aspects of faces – perception of eye gaze, expression and lip movement

2. Extended system: further processing in concert with other neural systems
   - ‘FFA’
   - Lateral fusiform gyrus
     Invariant aspects of faces – perception of unique identity

Conclusions

Intraparietal sulcus
Spatially directed attention

Auditory cortex
Prelexical speech perception

Amygdala, insula, limbic system
Emotion

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Personal identity, name and biographical information