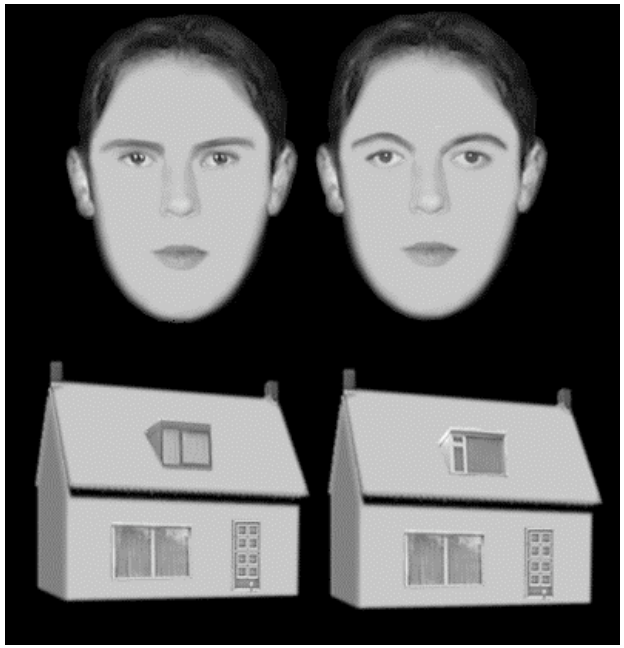
Hemispheric asymmetries for whole-based and parts-based face processing in the human fusiform gyrus.

Bruno Rossion
Laurence Dricot
Anne deVolder
Jean-Michel Bodart
Marc Crommelinck
Béatrice deGelder
Richard Zoontjes



Journal of Cognitive Neuroscience, 2000, 12, 793-802

Main findings and conclusions

* The right ‘fusiform face area’ (FFA) was found to be more activated when matching whole faces than matching face parts presented in whole face stimuli. The opposite pattern of reponse was found in the left FFA.

* These lateralized differences were be specific to faces since control objects (houses) processed either as wholes or parts did not induce any change of activity within these regions.

* This double dissociation between two modes of face processing brings new evidence regarding the lateralized localization of face individualization mechanisms in the human brain.

Introduction

Despite observations of bilateral face-specific activity in anterior/mid fusiform regions in PET and fMRI studies (1-5), a number of fMRI studies suggested that face-specific processing in normal subjects is confined to the right hemisphere, whereas left fusiform regions would belong to a general object recognition system (6-7).

HOWEVER...

Most fMRI studies used passive stimulation or 1-back recognition tasks, allowing the observer the choice of the perceptual strategy

AND...

Behavioral and Neuropsychological studies suggest that right and left hemisphere process faces differently

- **RH superiority to identify faces (8)**
- **No hemispheric advantage with inverted faces (9)**
- **LH superiority when feature-detection strategy induced by instructions (10)**
- **Cases of Prosopagnosia with Bilateral or Unilateral RH lesions (11-12)**

In a neutral context, faces relies heavily on configural or *global mechanisms* lateralized to the *right hemisphere* (13) while recognition by the *left side* of the brain is thought to occur by *piecemeal processing* of the components that make up the face rather than the whole image as a single coherent pattern (14)

AIMS OF THE STUDY:

1. Clarifying the functions of face-specific regions in face processing
2. Localization of the hemispheric differences in face processing observed behaviorally

Methods

**** 8 right-handed male subjects (22-25 years old)***

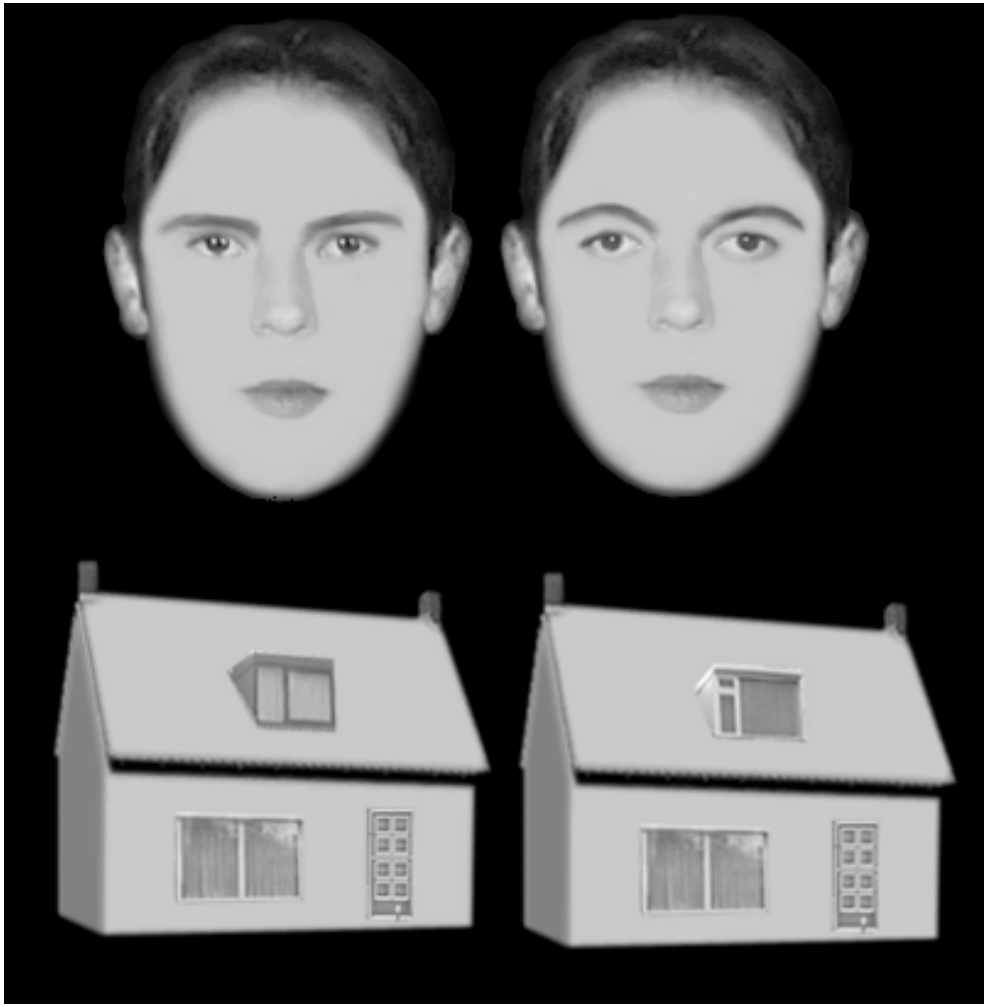
**** 4 kinds of stimuli: photographs of control faces, control objects; photograph like faces and photograph-like gray-scale houses (Fig.1)***

**** Delayed matching task on pairs of stimuli during 12 scans***

**** Scans 1, 2,11,12: Localizer task: matching faces or matching objects***

**** Scans 3 --> 10: Experimental scans: 2 x 2 design***

- *1. Faces-Global: Match of the Whole face*
- *2. Faces-local: Match of either the eyes or the mouth*
- *3. Houses-Global: Match of the Whole house*
- *4. Houses-Local: Match of either the superior or the inferior window*



Examples of stimuli used in the experiment. The 2 faces presented above differ only by the eyes; the 2 houses differ only by the superior window.

Methods

**** Data acquisition: behavioral (accuracy rates and RTs), rCBF (3D PET scanner) and 3-D MRI (T1)***

**** PET data analysis: SPM 96 (15)***

1. Main contrast

- *FACES - OBJECTS*
  - *> 3 regions (p< 0.001):*
    - *Right inferior occipital cortex: rOFA*
    - *right middle/anterior fusiform gyrus :(r)FFA*
    - *left middle/anterior fusiform gyrus: (l)FFA*

2. 2-by-2 comparaisons within face-specific regions (p<0.05)

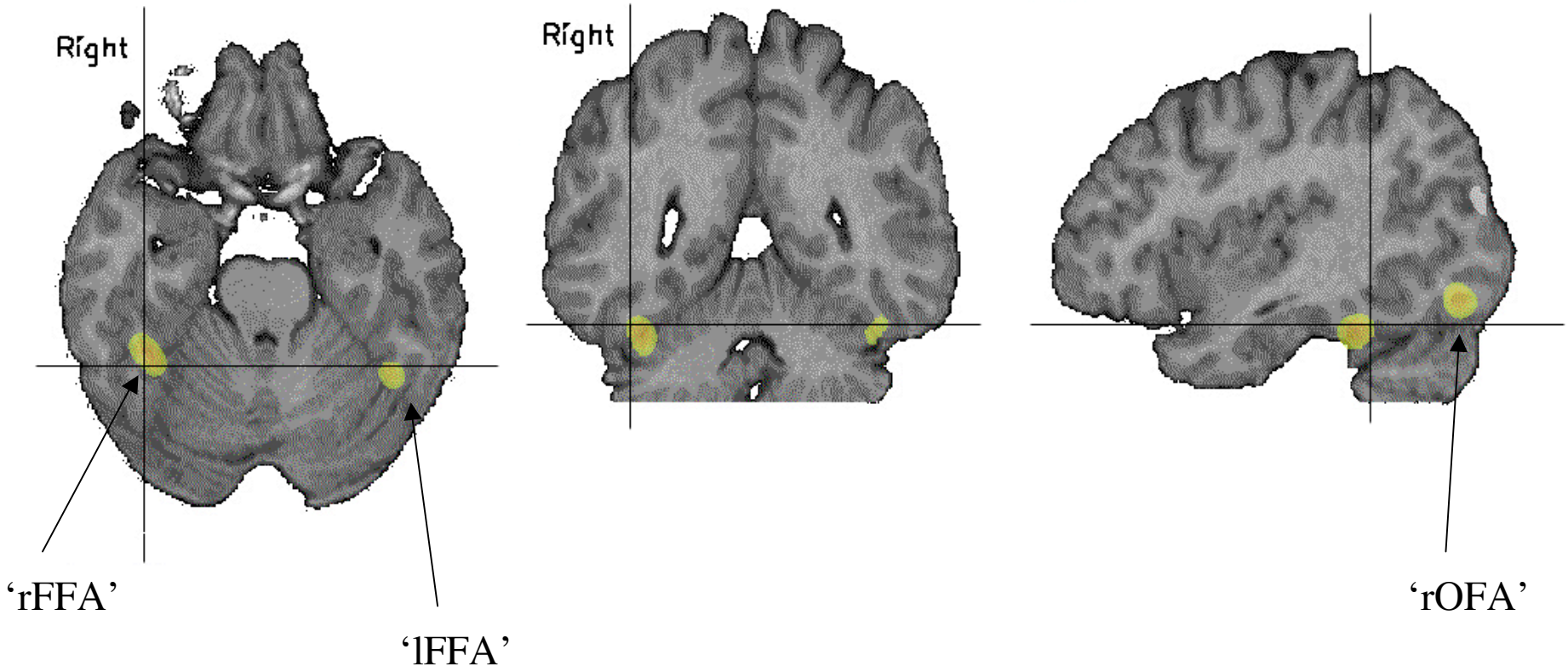
- *(-) ("Faces global " - "Faces Local")*
- *(-) ("Houses global" - "Houses local")*

Behavioral results

	Reaction time (ms)		Accuracy (%correct)	
	mean	sd	mean	sd
Face processing (W)	938	182	90	5
Face processing (P)	1028	199	88	7.5
House processing (W)	1033	187	91	11
House processing (P)	926	199	95	4.5
Baseline Faces	825	195	96	4.4
Baseline Objects	773	200	96	3.5

RTs: ANOVA 2 x 2 : significant interaction between process and stimulus ($p<0.01$)

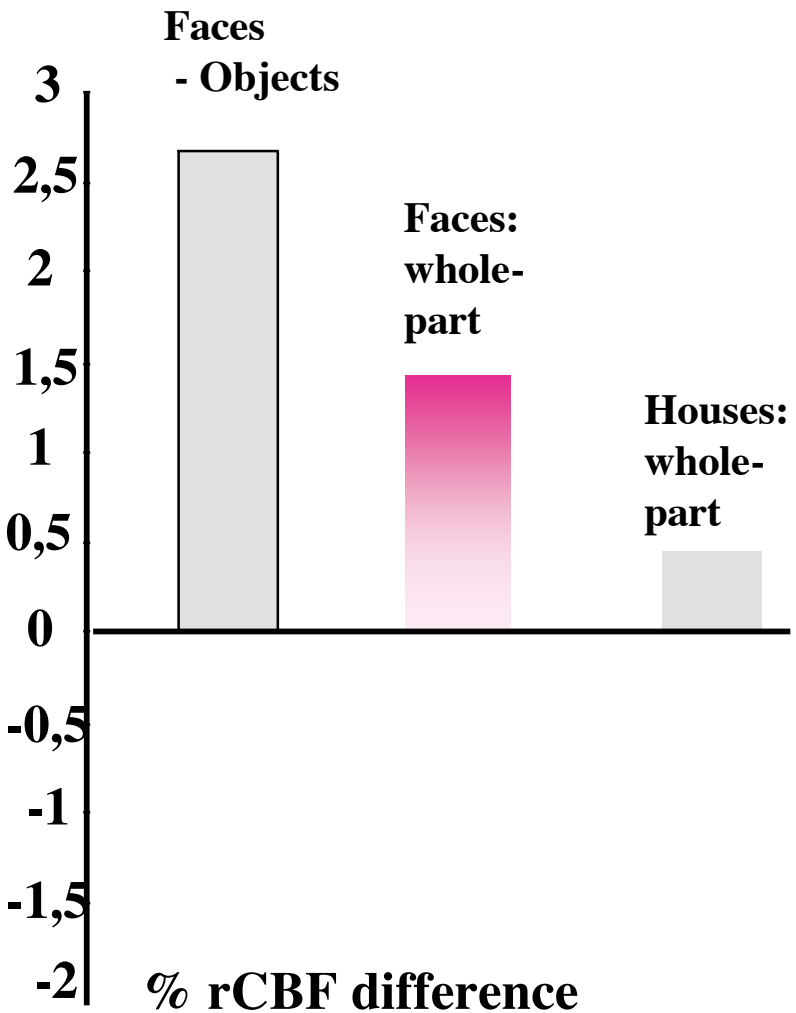
Whole faces are easier to process than parts in faces
but the reverse is observed for objects (houses)



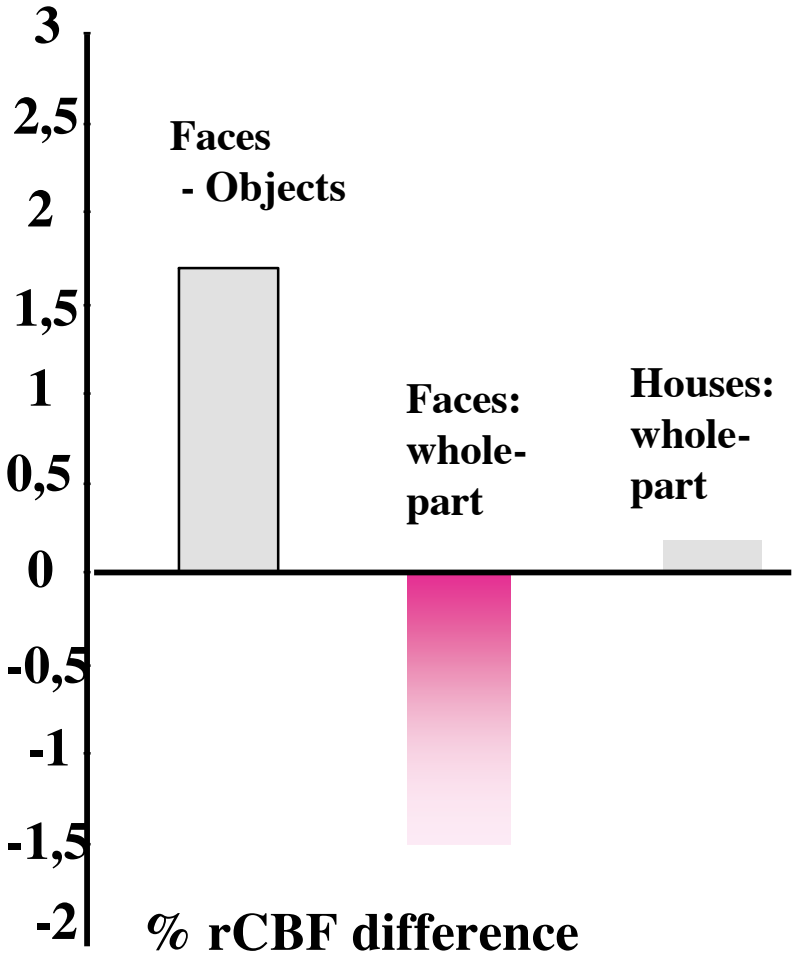
Group analysis with positron emission tomography (PET): regions showing a preference for faces over other objects

Results

Right ‘FFA’



Left ‘FFA’



Results

Conclusions

BOTH HEMISPHERE ARE ENGAGED IN PREFERENTIAL FACE PROCESSING

rFFA: Whole faces > Face Parts (rCBF increase:1.56%)

Whole Houses = House Parts

lFFA: Face Parts > Whole faces (rCBF increase:1.51%)

Whole Houses = House Parts

Double dissociation between the kind of process performed on faces and the specific increase of rCBF to faces. The right anterior fusiform ('rFFA') appears to be more sensitive to the processing of the whole face while the left hemisphere is specifically more engaged in face processing than object processing when an analytical strategy is used.

Activity within the posteriorly lcoated 'rOFA' is largely unsensitive to wholes or parts face processing as manipulated by task instructions

The mechanisms specifically dedicated to face processing take place in neural regions located in the human fusiform gyrus of *both* hemispheres, depending on the strategy used to process faces

In addition, the present study shows

(a) an extension of previous neuroimaging observations (16) of hemispheric asymmetries for global and local processing to anterior regions of the ventral visual pathway

(b) evidence that modulations induced by manipulating the level at which a simulus is processed can be selective to the particular category best represented by neurons in the region whose activity is modified

(c) an anatomical localization of hemispheric asymmetries observed in previous behavioral and neuropsychological face processing studies that is entirely compatible with a right/left advantage for whole/parts processing of faces

In a neutral context, behavioral studies indicate that the attentional system for faces is usually set to the global level (17)

--> depending on the methods sensitivity and the experimental design, the present observations may explain why face-selective activations are usually observed either in the right fusiform gyrus alone or in bilateral regions with a right hemisphere advantage, but never in the left fusiform gyrus alone

--> The top-down modulations induced by task instructions within fusiform regions may be due to a selective amplification of face-selective and face feature-selective neuronal responses within these areas

REFERENCES

1. Haxby, J.V. et al. (1994). *J Neurosci*, 14, 6336-6353.
2. Puce, A. et al. (1995) *J Neurophysiol*, 74, 1192-1199.
3. Gauthier, I. et al. (in press) *Nature Neurosci.*
4. Halgren, E. et al. (1998) *Human Brain Map*, 7, 29-37.
5. Dubois et al. (in press) *Neuroimage*.
6. Kanwisher et al. (1997) *J Neurosci,* 17, 4302-4311.
7. McCarthy et al. (1997) *J Cog Neurosci*, 9, 605-610.
8. Farah, M.J. (1990). *Visual Agnosia,* Cambridge: MIT Press.
9. Leehey et al. (1978) *Cortex*, 14, 414-425.
10. Hillger, N. &Koenig, O. (1991). *J Cog Neurosci*, 3, 42-58.
11. Landis, T. et al. (1988). *Brain*, 11, 1287-1297.
12. Ettlin, T.M. (1992). *Cortex*, 28, 129-134.
13. Rhodes, G. (1993). *Brain Cog*, 22, 19-41.
14. Tovee, M.J. (1998). *Curr Biol*, 8, R17-R20.
15. Friston, K.J.et al. (1995). *Human Brain Map*, 2, 189-210.
16. Fink, G. et al. (1996). *Nature*, 382, 626-628.
17. Tanaka, J. & Farah, M.J. (1993). *Quart J Exp Psych*, 46A, 225-245.