



Fusiform Face Area Activation During Image Recognition

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Transforming Analytical Learning in the Era of Big Data: A Summer Institute in Biostatistics

Introduction

Recently functional Magnetic Resonance Imaging (fMRI) has been widely used in neuroimaging. Researchers apply statistical analysis to fMRI data to obtain distinctive activated regions in brain when humans recognize faces and other man-made objects. Three theories have been proposed by different studies:

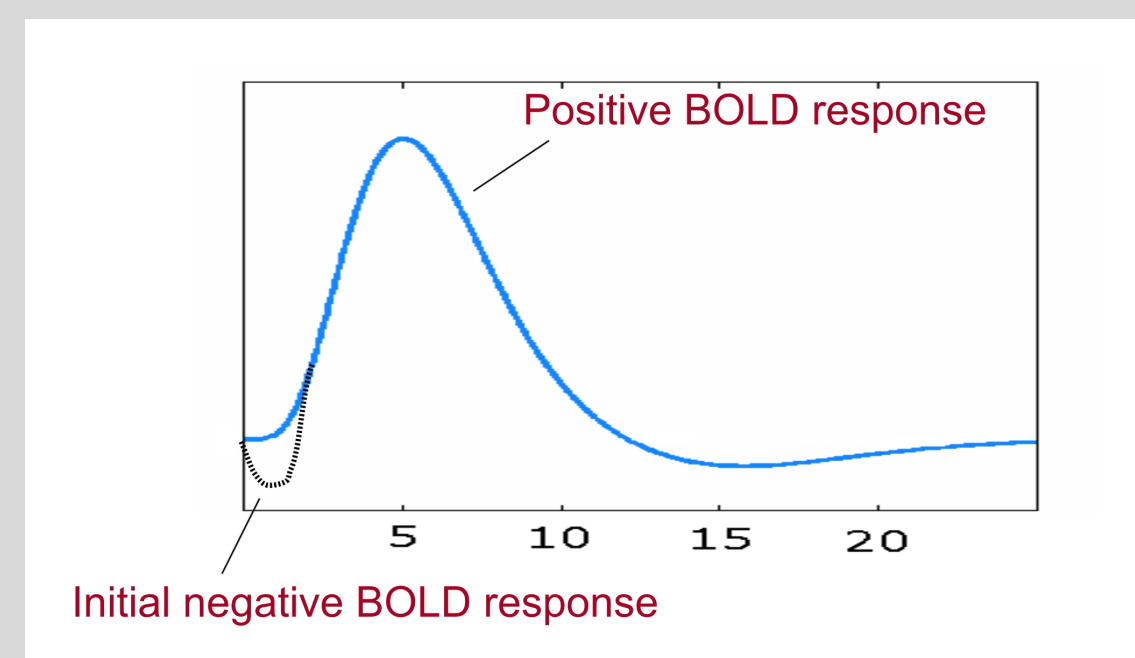
- Two specific regions in ventral temporal cortex are responsible in face/object recognition: fusiform face area (FFA) and the parahippocampal place area (PPA).
- The Ventral temporal cortex has different areas that help individuals' strengths in recognizing different objects.
- The activation regions of faces and other objects are overlapping and distributed.[1]

In this study, a face and three other objects have been viewed by subjects while being scanned by fMRI and contrasts between face and other objects have been analyzed. In this way, specific locations in ventral temporal cortex may be detected and we can figure out whether FFA or PPA has more activation when face is recognized compared with other objects.

Background

fMRI data is obtained through participants doing activities while inside an MRI machine.

- Data received arrives in k-space (complex valued data), and an inverse Fourier Transform returns it to a representation in Euclidean space.
- Each representation is a 3 dimensional model consisting of approximately 286,000 volume elements (voxels).
- The magnetic field flips hydrogen atoms, giving information of where blood flow is concentrated. Increased blood flow is associated with brain activity.
- This brain activity gives insight into which regions are being used during events and resting.

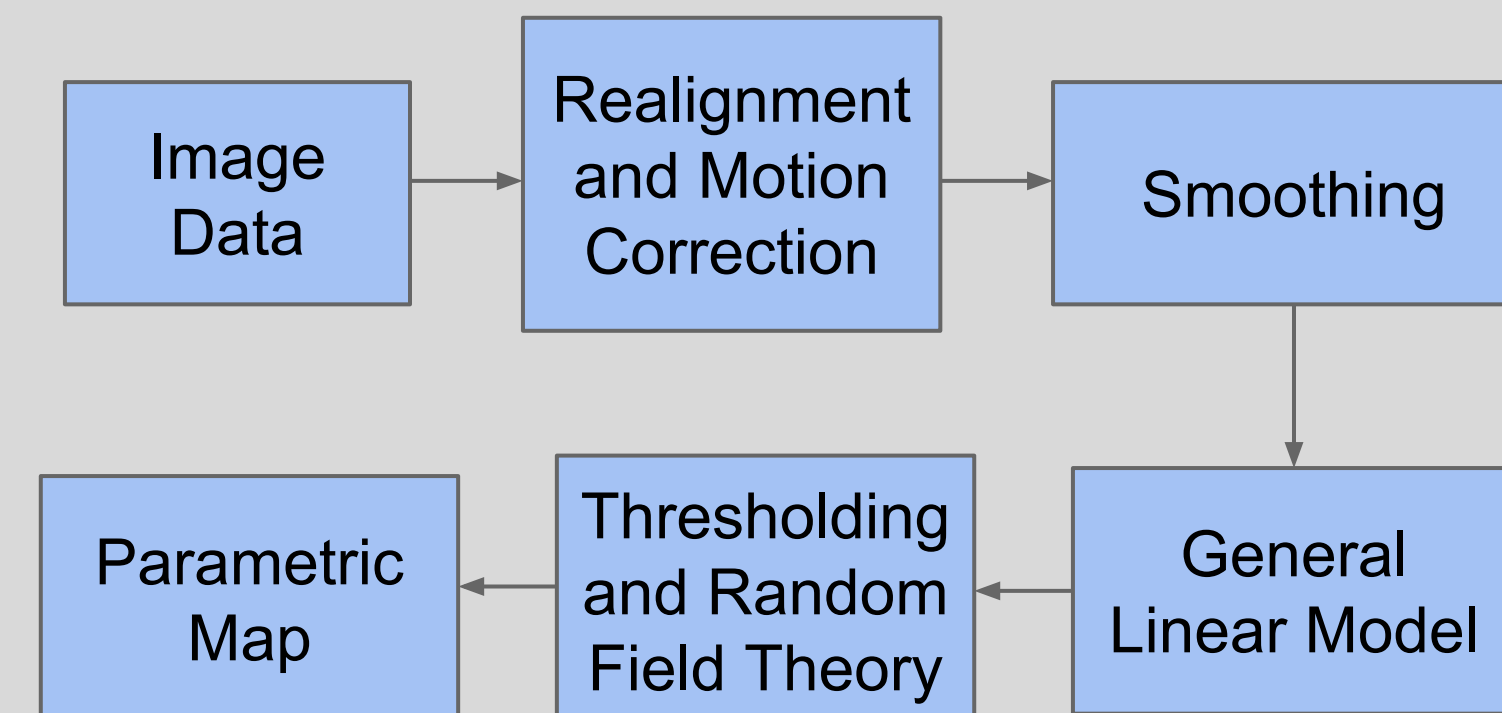


- The Blood Oxygenated Level Dependent (BOLD) signal is modeled using a general linear model (GLM), one at each voxel.
- Comparing parameter contrasts from these GLMs gives insight into which unique regions of the brain are relatively activated during events.

Methods and Analysis

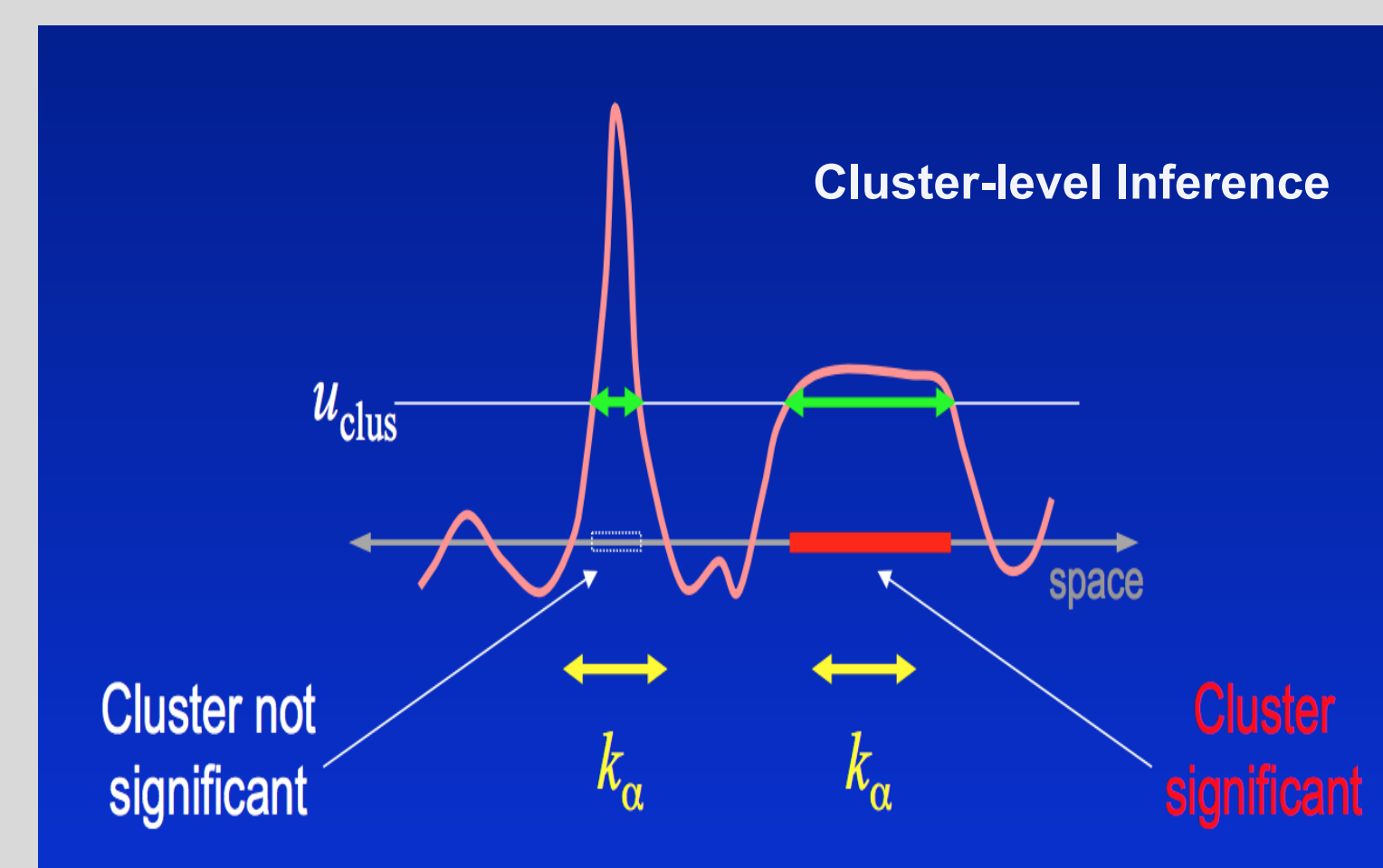
Data and Preprocessing:

- Data was obtained from a public repository from Haxby et Al. 2005. A subset of the data was analyzed from the raw data files which were processed using FSL.
- There are many factors that create noise: the head movement, heartbeat, respiration during the experiment, inhomogeneous magnetic field, etc.
- Before data was analyzed, preprocessing steps are conducted to reduce the noise so that better inferences will be made. They include: motion correction, slice timing correction, temporal smoothing, spatial smoothing and intensity normalization.



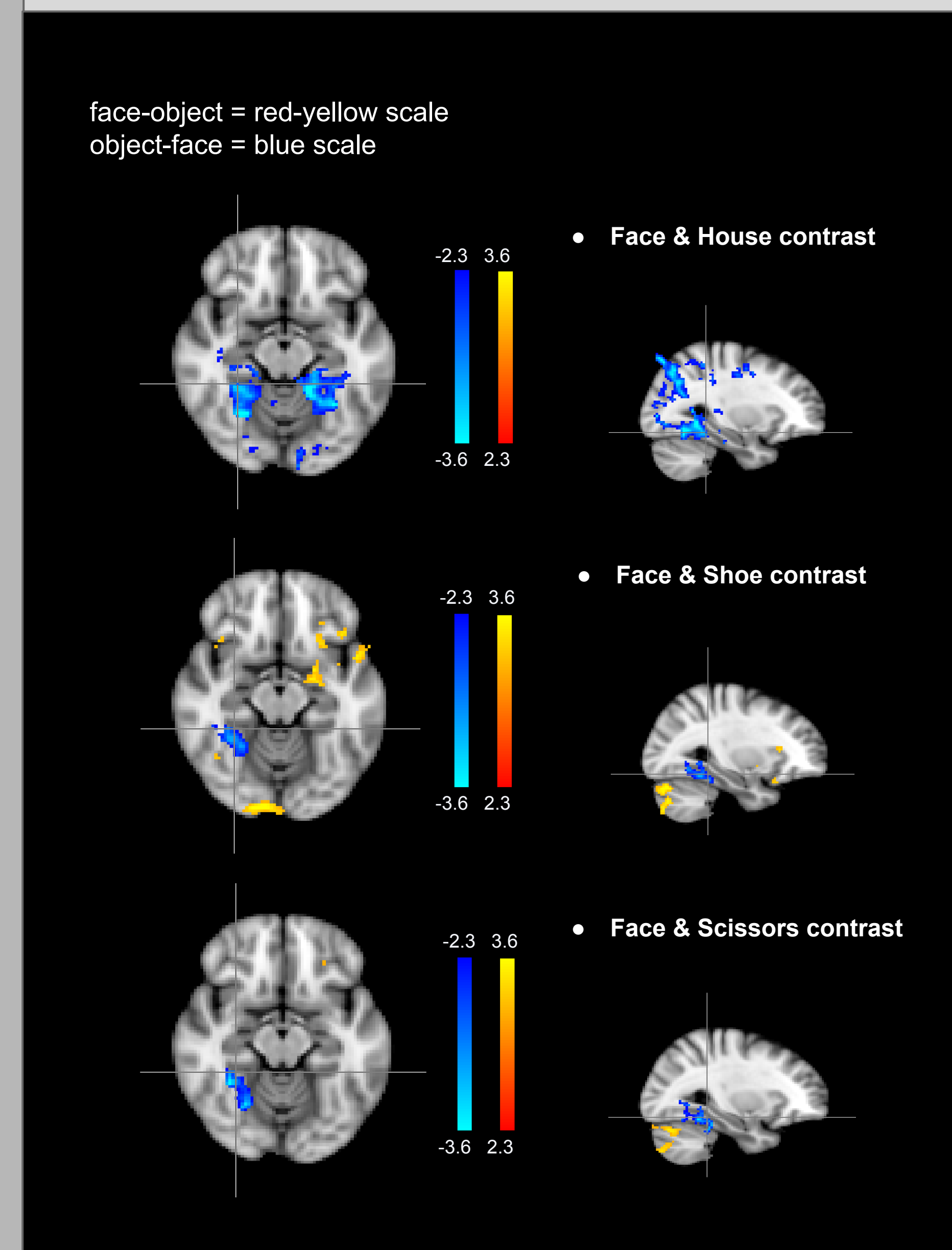
Analysis Steps:

- A fixed-effects analysis (GLM) was conducted on each of the 6 subjects over each of 12 replicated fMRI runs. (Subject 5 only had 11 replications).
- A second-level, mixed-effects analysis (GLM) was then conducted on the group of 6 subjects.
- We analyzed six contrasts in the mixed-effects analysis. Each contrast was between looking at faces vs. another object: face-shoe, shoe-face; face-scissors, scissors-face; and face-house, house-face.
- Cluster-level analyses using Random Field Theory was applied to select those clusters that
 - are larger than some thresholding volume
 - and all voxel intensities within a cluster are above a threshold (set as 2.3 by default)



Results

The pictures shown below depict the standardized contrast images of the areas of brain activation when looking at a face and a house, a face and a shoe, and a face and scissors.



Face & House Contrast						
House-Face Cluster Information						
cluster index	voxel number	p-value	max Z test-statistic	z-max x(mm)	z-max y(mm)	z-max z(mm)
1	11761	1.4e-45	4.62	-16	-44	-10
2	509	0.000336	3.59	-12	-52	-44

Face & Shoe Contrast						
Face-Shoe Cluster Information						
cluster index	voxel number	p-value	max Z test-statistic	z-max x(mm)	z-max y(mm)	z-max z(mm)
1	706	5.57e-05	3.84	44	-60	-20
2	475	0.00185	3.49	44	-66	-2

Face & Scissors Contrast						
Face-Scissors Cluster Information						
cluster index	voxel number	p-value	max Z test-statistic	z-max x(mm)	z-max y(mm)	z-max z(mm)
1	733	0.000151	3.37	14	-78	28
2	835	4.29e-05	3.65	34	-48	-14

- There are more significant activations in PPA when objects are presented versus faces.
- The FFA does not seem to be more activated when looking at faces versus these 3 objects.

Discussion

Possible reasons that our result do not fully agree with the literature:

- The sample size is small (6 subjects) and thus the power is low.
- Sample selection not a random sample:
 - Unbalanced gender distribution: 5 women and 1 man
 - No information about how subjects were recruited
- Based on the assumption that subjects are representative of the population, mixed effect was used to account for inter-subject variability. However, the assumption would not hold if the sample was selected with bias.

Conclusion

- There was significant activation in the parahippocampal place area (PPA) when an object was viewed, which aligns with the findings in the literature.
- No significant difference in BOLD signal was found between face and other objects in the fusiform face area (FFA), which contradicts the findings in the literature.

Works Cited

[1] Haxby, J. V., Gobbini, M. I., Furey, M. L., Ishai, A., Schouten, J. L., & Pietrini, P.(2001). Distributed and overlapping representations of faces and objects in ventral temporal cortex. *Science*, 293(5539), 2425-2430.

The data set was uploaded by the authors of the paper onto <http://www.openfmri.org/dataset/ds000105>.

FSL: <http://fsl.fmrib.ox.ac.uk/>