Multi-voxel pattern analysis of face and object exemplar discrimination in occipital cortex.

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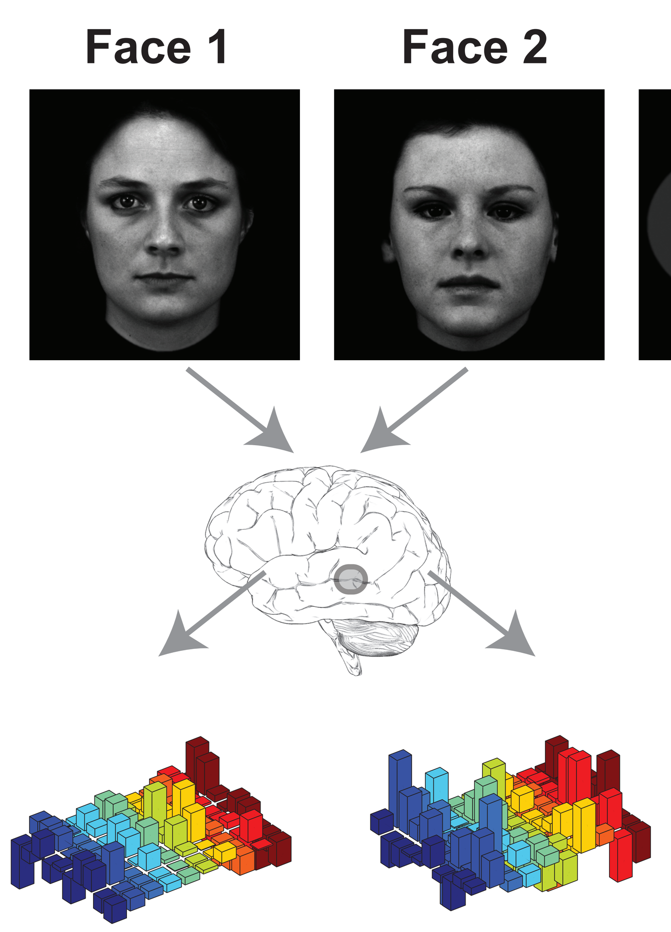
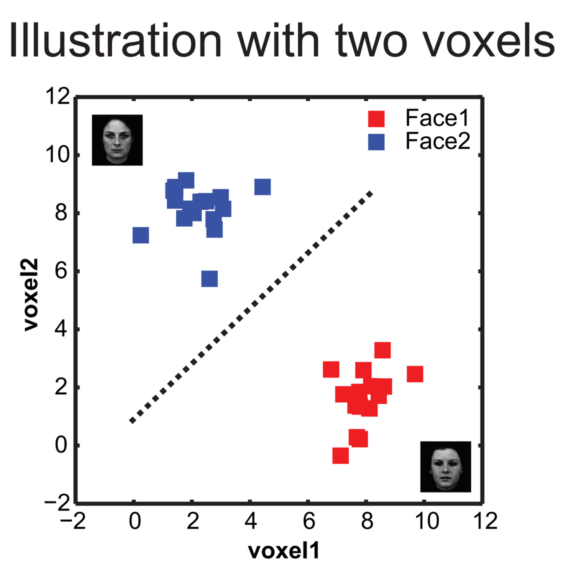
Background

Contrasting fMRI activity for different visual stimulus categories has revealed cortical areas that respond to specific classes of stimuli such as faces (e.g. FFA, OFA and STS) and generic objects (e.g. LOC). It is yet unclear what specific function is served in these areas with some hypotheses proposing OFA as an early stage, feeding into FFA for identity, and STS for identity-invariant expression processing for faces.To test this and explore further, we examined whether spatial patterns of fMRI activity in these regions of interest contained information sufficient to differentiate individual faces and objects.

Questions

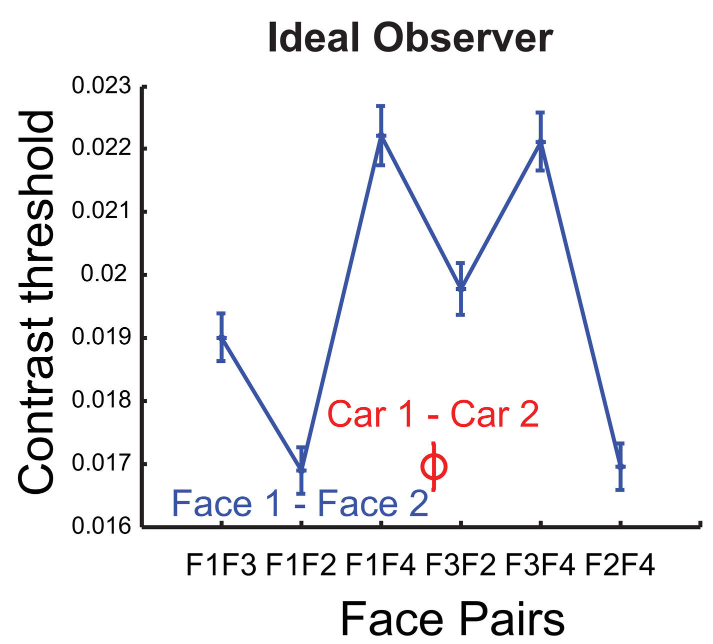
Can we predict from the pattern of fMRI activity across voxels which face (or car) the observer is viewing?
Which cortical regions support this information?
If FFA is involved in identity processing for faces only, then prediction accuracy should be high for faces, but low for cars.





Selection of stimuli

For the comparison of the accuracy measure between the face and the car tasks to be meaningful, we need to make sure the task difficulty for these are comparable. We first picked the two car exemplars, and then searched for a face pair with the same degree of confusability, or similarity, between the exemplars. We used ideal observer luminance contrast thresholds in a 2-alternative forced-choice task as an index of similarity.



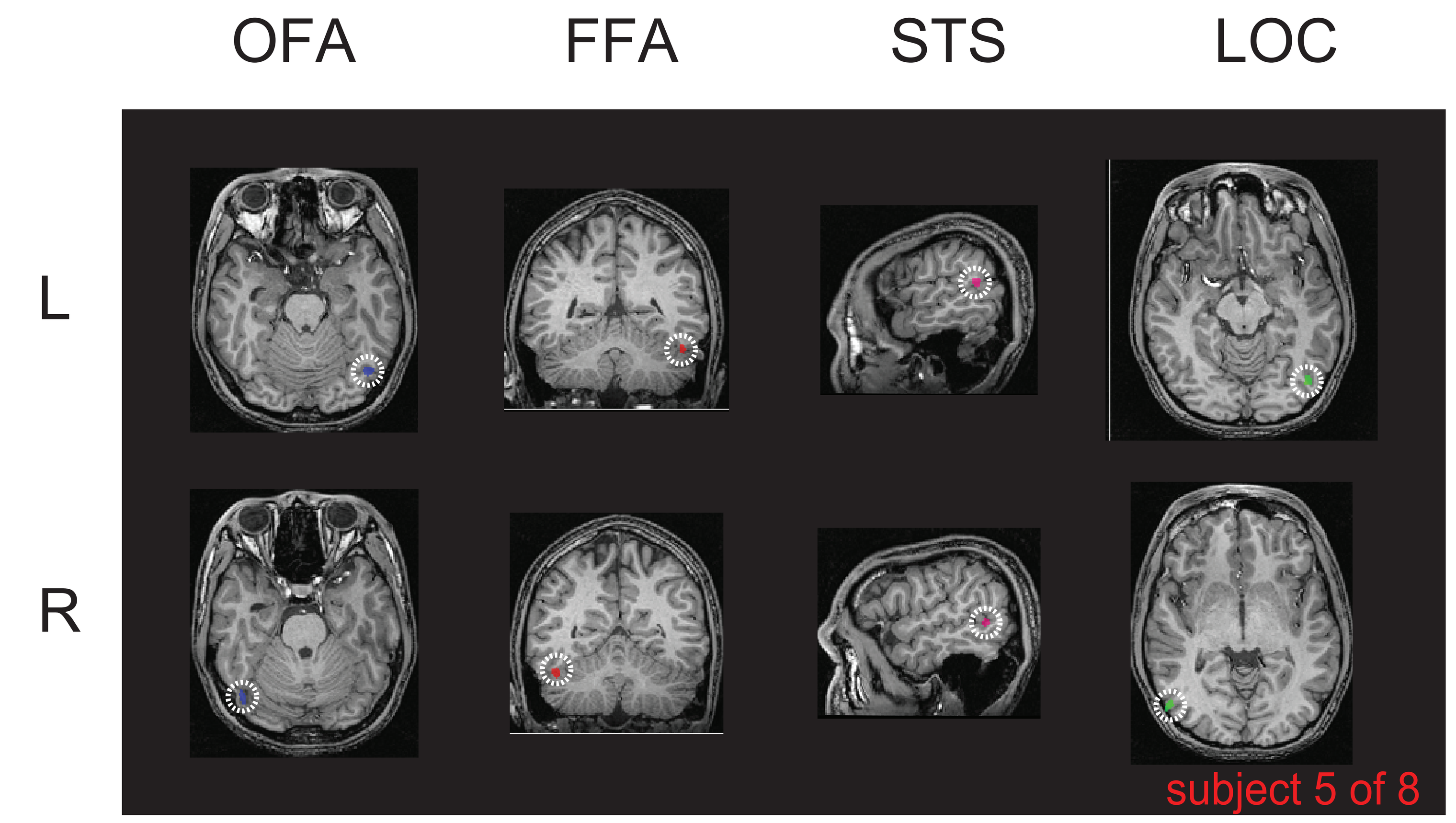
fMRI

3T Phillips scanner, TR = 2 s, TE = 30 ms
Anatomical resolution: 1 x 1 x 1 mm
fMRI resolution: 1.875 x 1.875 x 3 mm
Each subject's functional scan coregistered to respective anatomical scan and analzed individually.

Localizer

Stimuli: video clips of faces, objects and phase-scrambled objects
Ten blocks of each stimulus category separated with fixation blocks.
Each block consisted of six video clips, five novel, one repeated.
Eight subjects participated, and performed a 1-back task.
GLM contrast for FFA, OFA, STS: Faces > Objects, LOC: Objects > Phase-scrambled objects.
Only top 200 of significant voxels (5% FDR) were included for each ROI.

Regions of interest

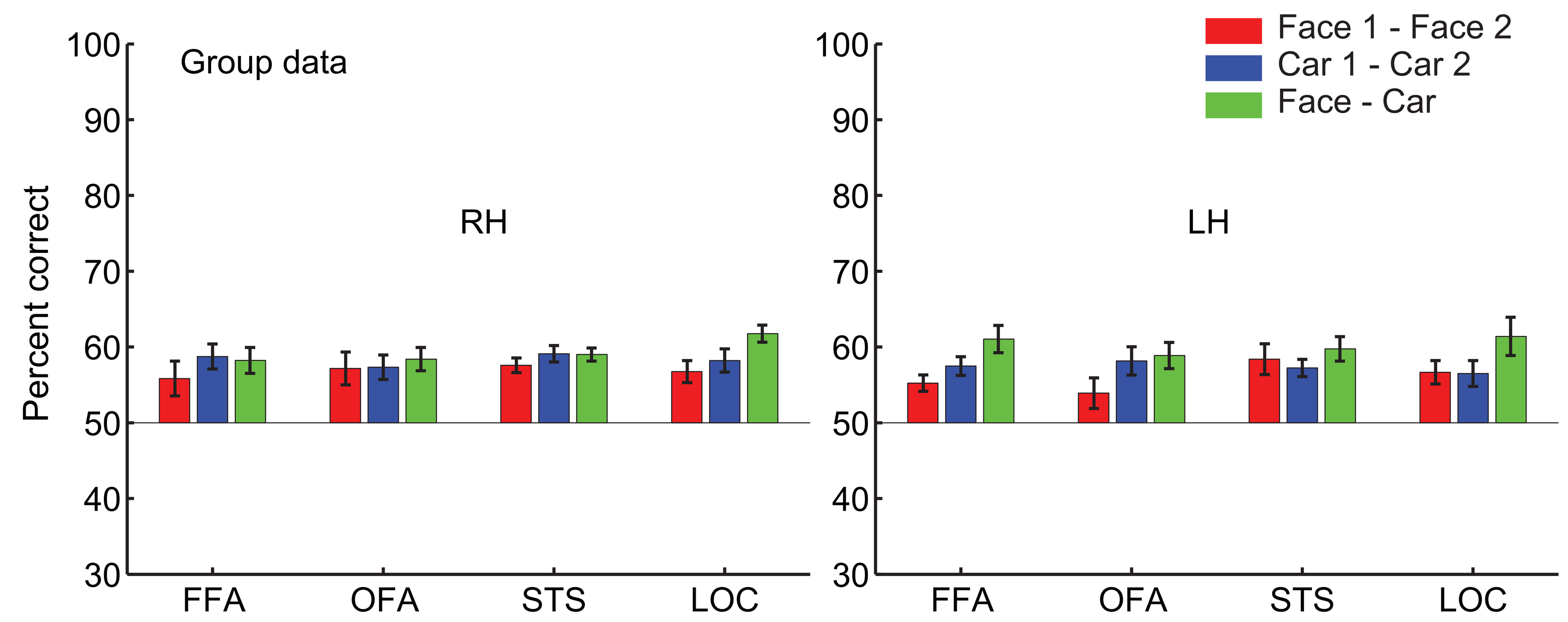


MVPA

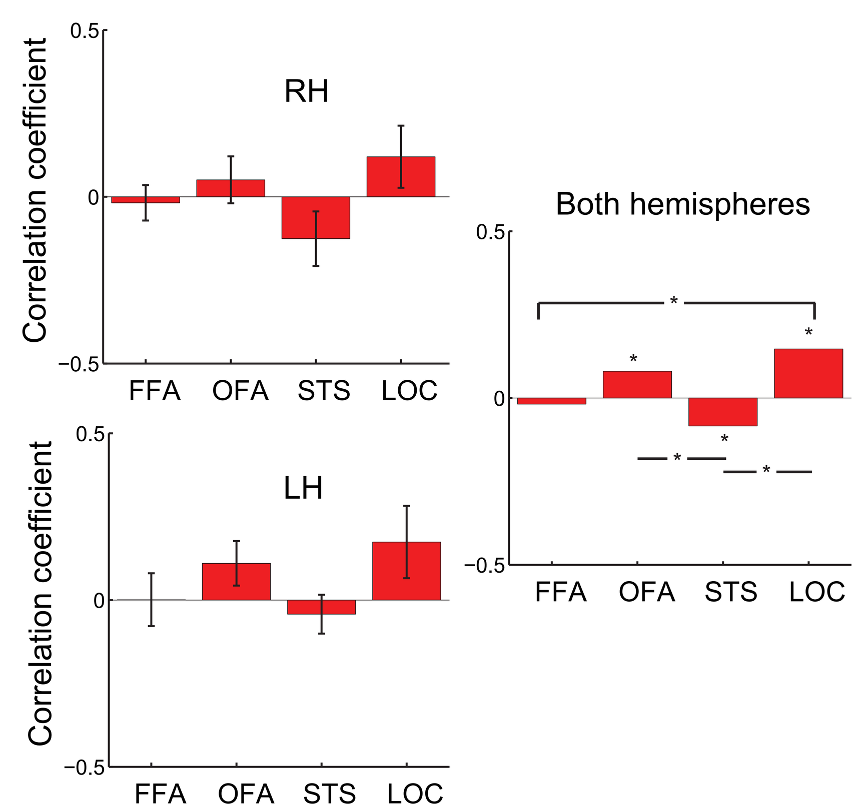
Stimuli: two faces and two cars (i.e., 4 classes: face 1, face 2, car 1, car 2) displayed at random sizes (approx. 4.5 - 9°) for 0.5s followed by 1.5s blank screen (TR = 2s).
Each scan contained 16 stimulus blocks, four of each class, ordered randomly. Stimulus blocks consisted of 6 reps of the same image, and were separated by fixation blocks.
Task: Detection of slight decrease in contrast (1 image/block).
Total 24 trials/class, half (12) randomly selected as training, and the remaining half used as test. This train-test procedure was repeated four times, and test accuracy was averaged.
Accuracy averaged across three independent scans for each subject and ROI.
Classification was based on a linear boundary between two classes obtained via training a support vector machine implemented in Brain Voyager MVPA Toolbox.

Results

Classification accuracy was significantly better than chance (50%) for the between (face/car) task, and both within-category tasks (face1/face2, car1/car2) in all eight regions of interest. Between-category classification accuracy was better than within in left and right LOC and left FFA, but did not differ in any other regions.



Do successful classification of faces and cars depend on different sub-regions of a given cortical area e.g., right FFA?
To test this, we computed correlations between the magnitude of the voxel weights in the face and car tasks.



A repeated measures ANOVA with hemisphere (L, R) and area (FFA, OFA, STS, LOC) as factors show a significant main effect of area. There was no main effect of hemisphere, nor a significant interaction, reflecting similar correlation structure in the two hemispheres. Collapsing the two hemishperes reveal significant correlations for STS (<0), LOC (>0), and OFA (>0).

Conclusions

All areas in the core face network as well as LOC contain information necessary to individuate faces and cars.
Although the easier of the two tasks, between-category discrimination was comparable to within in most areas, with LOC showing better between-category discrimination consistent with its hypothesized role in object processing.
Voxel weight magnitude correlations suggest that early processes common to both tasks may use overlapping neural populations giving rise to the positive correlations in OFA and LOC, which are not seen in FFA or STS, in which more specialized processes may recruit relatively distinct neural sub-populations.

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