Access to high-level face information sharpens orientation-selective coding in V1

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Introduction

- Orientation-selectivity is a core property of the primary visual cortex (V1), a low-level visual region in the brain.
- The fusiform face area (FFA), a face-specialized region, is tuned to horizontal orientation cues, mirroring peak behavioral accuracy in recognizing upright faces.
- High- and low-level visual areas interact to build robust representations of the visual world, but the mechanisms behind this integration remain unclear.

Does high-level tuning for faces influence orientation selective coding in V1?

Key take-aways

- ✓ Face-specialized areas prefer cardinal orientations, that carry diagnostic face information. Upright faces get a further boost in the horizontal range, an advantage lost with face inversion.
- ✓ V1 orientation selectivity is influenced by high-level face information, with sharper orientation selectivity for faces than scrambled. V1 responses did not differ between upright and inverted faces.
- ✓ V1 face representations were more distinct in the horizontal range, despite univariate suppression, showing V1 orientation coding is sharpened for diagnostic face cues.

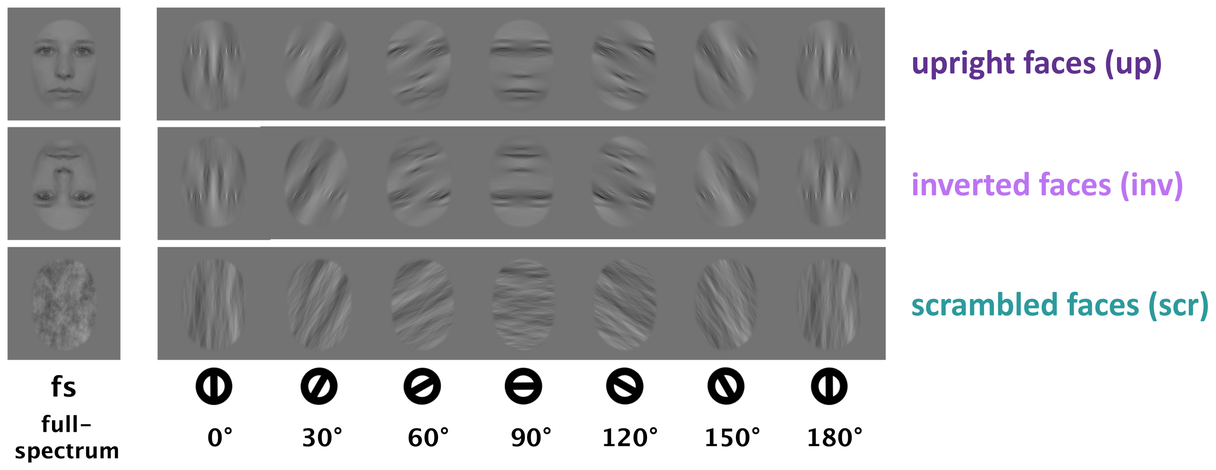
Methods

3T fMRI neuroimaging (orthogonal task; n = 20) with unfamiliar faces (**upright**, **inverted**, **scrambled**).

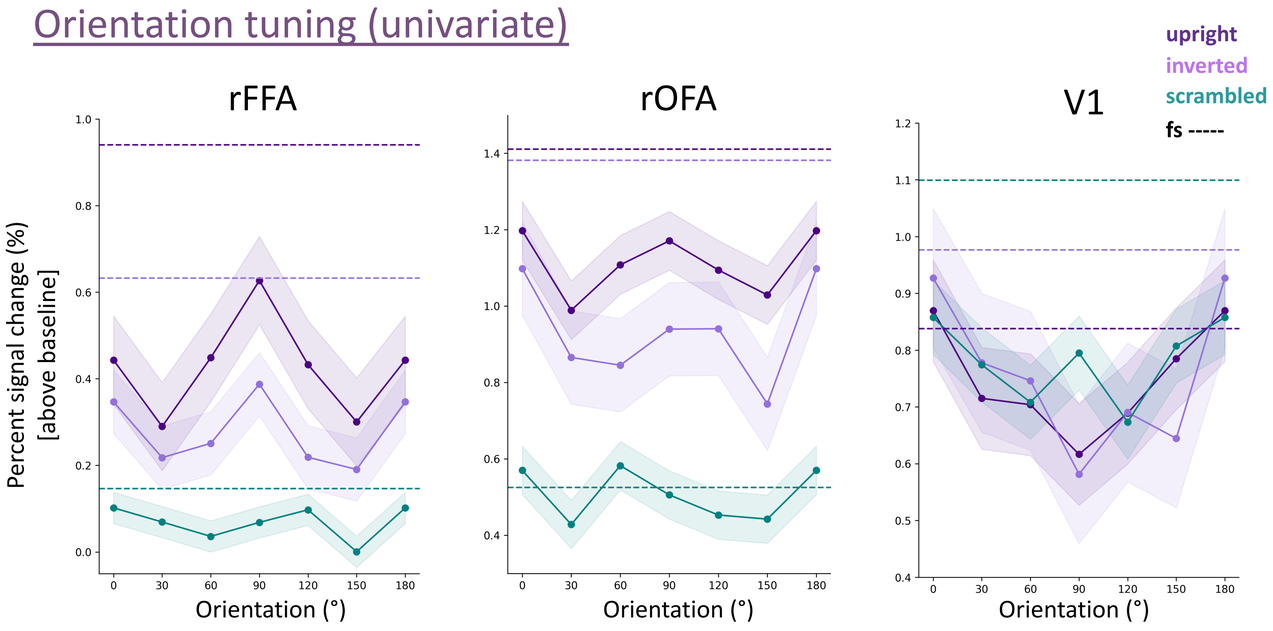
Psychophysics (identity matching task; n = 20) with faces of famous male celebrities (**upright**, **inverted**).

Stimuli: Orientation-filtered stimuli were created using a wrapped Gaussian filter (std = 15°) across 0°–180° in 30° steps. All stimuli were equalized to have the same luminance and contrast.

Analyses: Region-of-interest (ROI) analysis, Multivoxel pattern analysis (MVPA), Correlation analysis



Orientation tuning (univariate)

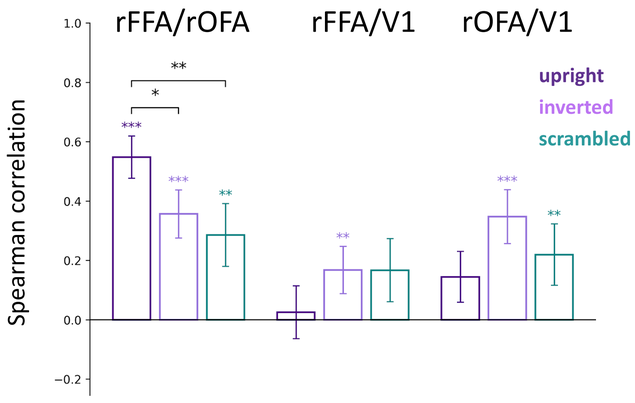


Face-specialized areas show cardinal tuning, responding higher at orientations that retain diagnostic face cues.

The horizontal advantage in rFFA for upright faces is abolished by inversion.

V1 tuning profile diverges for faces and scrambled images, in the horizontal range only.

Correlation between ROI orientation tuning profiles

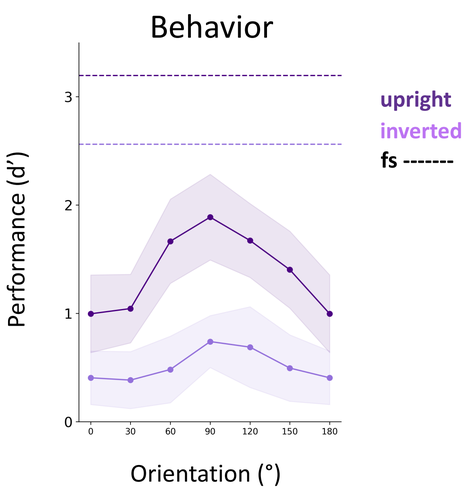


For each subject, correlations (left) show similarity between ROI tuning profiles.

Orientation tuning profiles of rFFA/rOFA align more closely for upright faces, indicating high-level processing for faces that follow natural statistics.

Inversion reduces high-level rFFA/rOFA processing, likely engaging low-level, feature-based rOFA/V1 processing instead.

Correlation with behavioral tuning

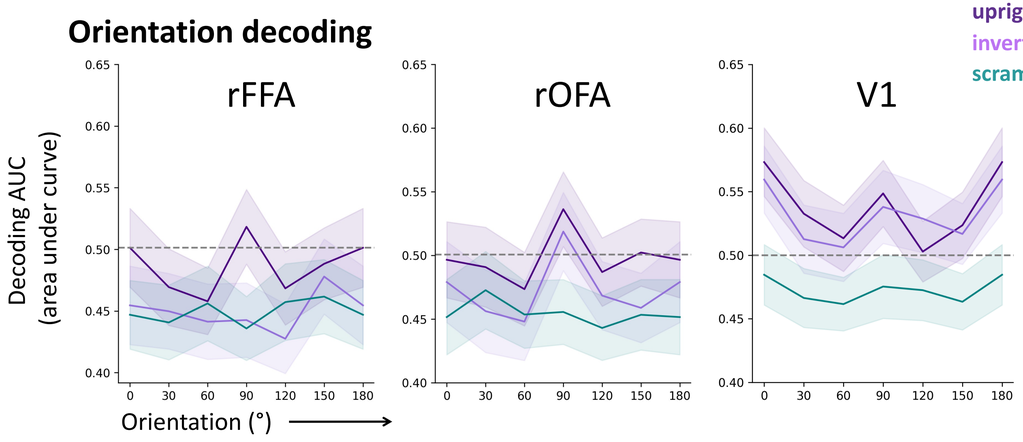


Per subject, identity recognition behavior was correlated with univariate and multivariate orientation tuning profiles to assess if brain responses predict identity recognition performance.

Only rOFA generalization predicted behavioral tuning across subjects, highlighting its role in extracting diagnostic features for upright face recognition.

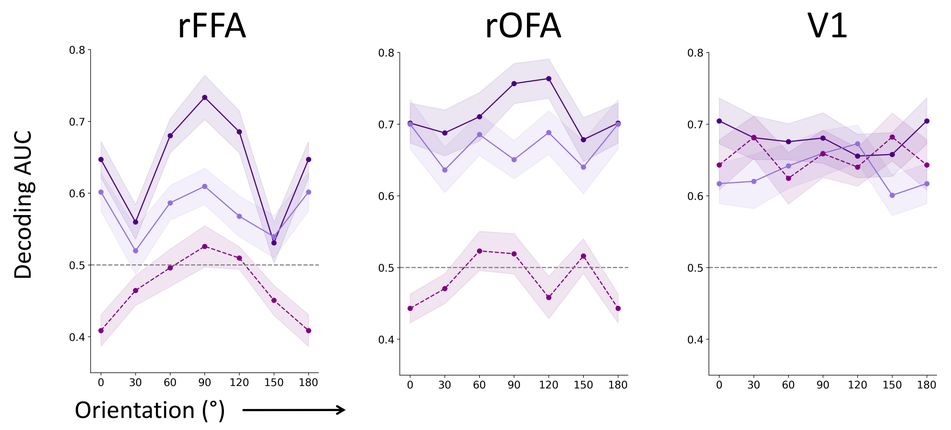
Orientation tuning (MVPA)

Orientation decoding



Face orientation information is more distinct in the cardinal range in V1.
scrambled = at chance

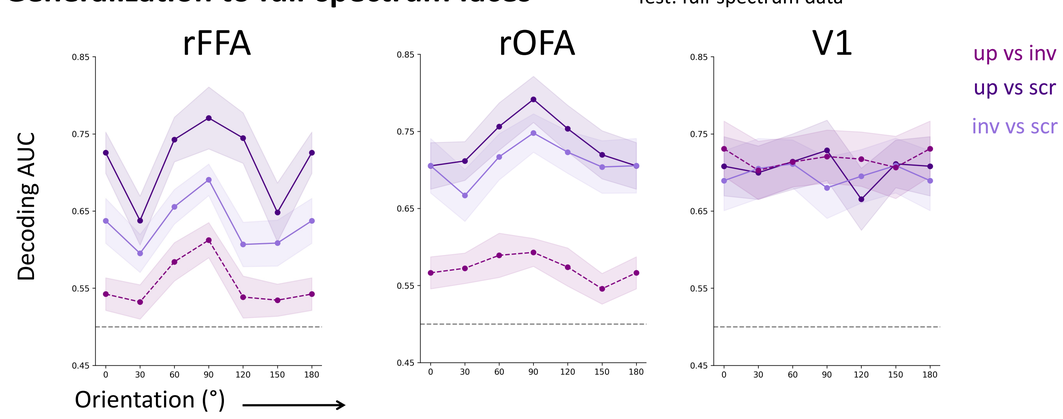
Stimulus type decoding



Upright faces shows better decoding in the horizontal range in face areas.
Inversion abolishes this face-specialized horizontal advantage.

Generalization to full-spectrum faces

Train: orientation filtered data
Test: full-spectrum data



Both upright and inverted faces generalize well in face areas, especially in the horizontal range, highlighting the stability of face cues in this range.