Shared neural representations of orientation and location information during working memory
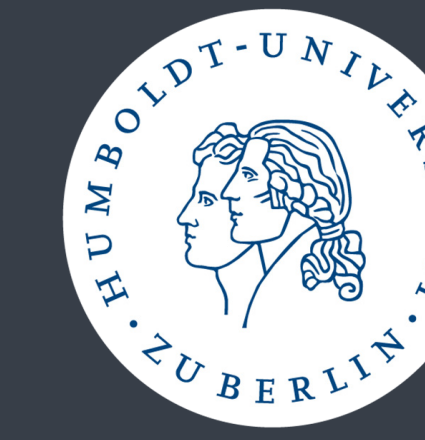
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Background

Visual items encoded during working memory can have **multiple representations** distributed across several regions, which likely differ in content[1].
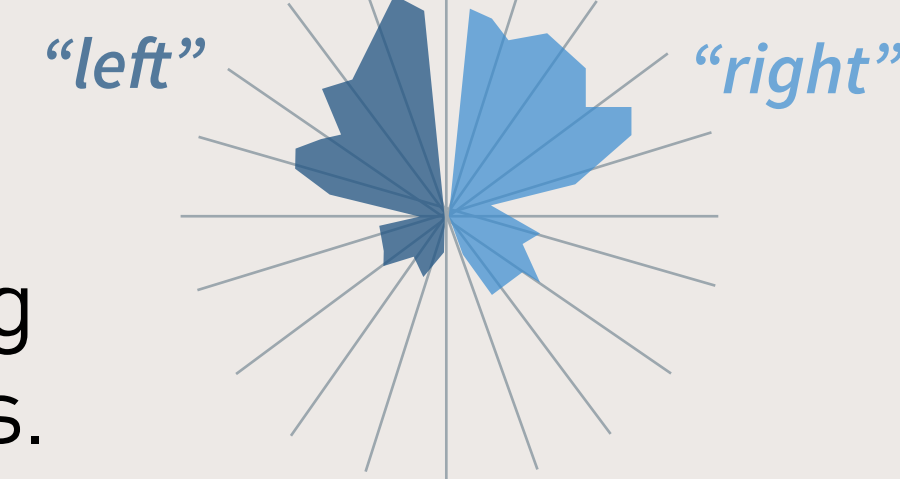
Orientation and location stimuli can be encoded in the same regions, indicating a **similarity between the two stimulus** types. They might be similar in their detailed representations, but also in the abstract ones[2].

In previous behavioural work, we found that **verbal strategies[3] and words used for memorizing orientations and locations are similar**, suggesting similar abstract representations.
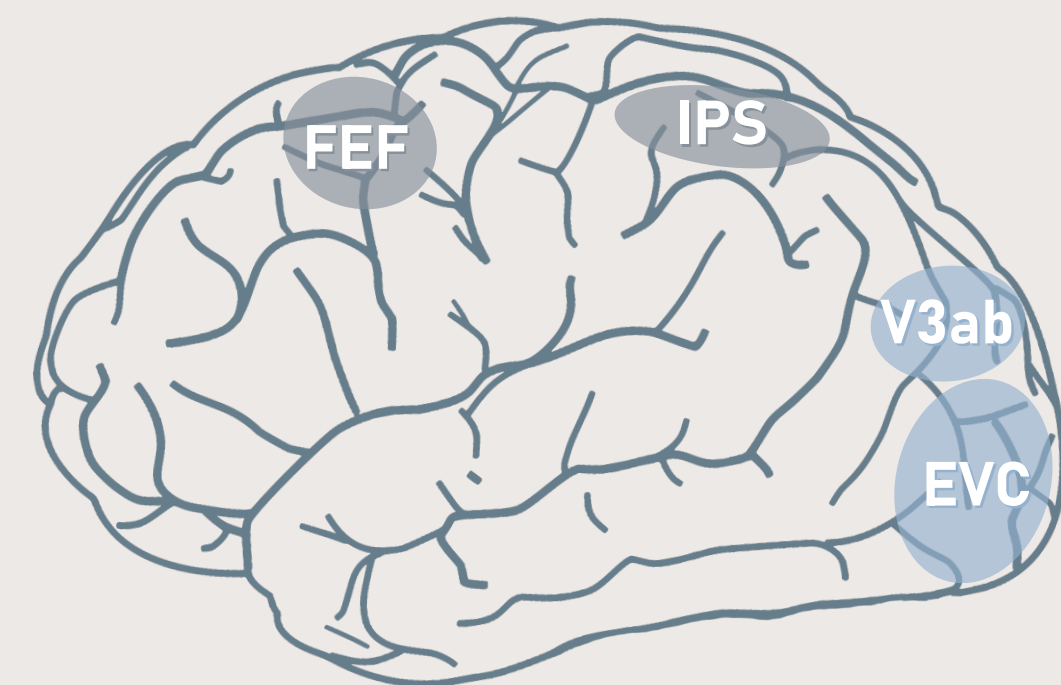
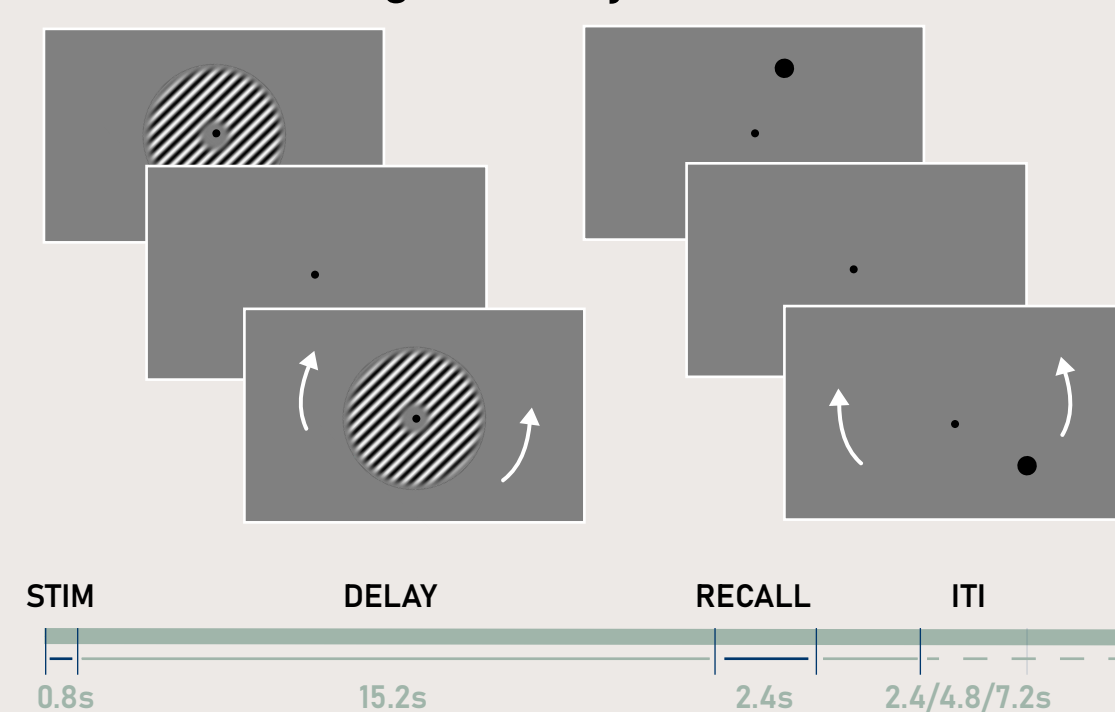word usage for orientation stimuli in behavioral naming task

"left"   "right"

How do orientation and location stimuli share neural representations?

Methods

Data Acquisition
Visual working memory task

STIM | DELAY | RECALL | ITI
0.8s | 15.2s | 2.4s | 2.4/4.8/7.2s

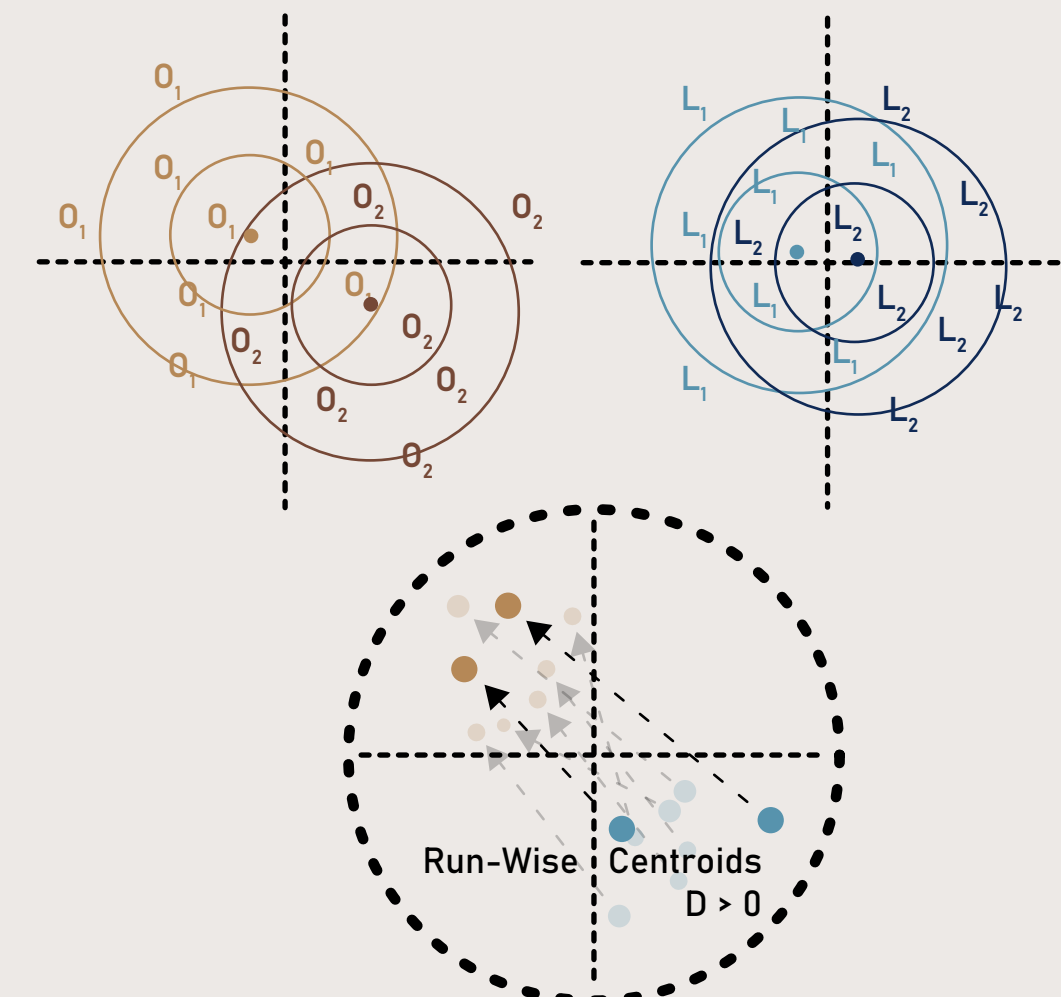n = 40 | 1h30 x 2 sessions
384 VWM task trials
168 Verbal task Trials
3T MRI | multiband sequence
TR = 0.8secs | voxel size = 2mm³

fMRI analysis

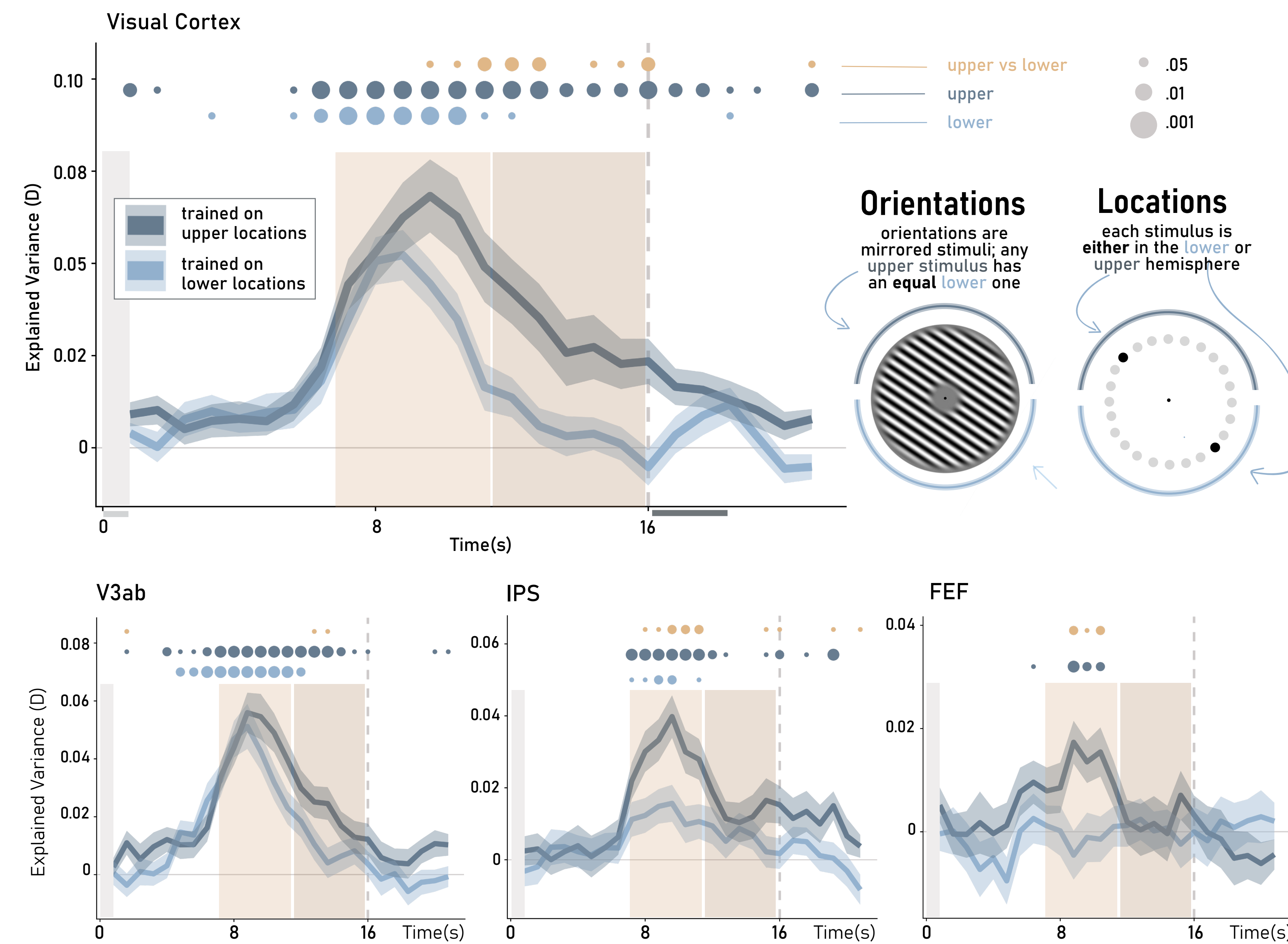› cvManova on location and orientation data

› cross-condition cvManova, trained on location data and tested on orientation data

Run-Wise   Centroids
D > 0

Results

Cross-Condition Classification
trained on Location, tested on Orientation data

Visual Cortex

trained on upper locations
trained on lower locations

upper vs lower   .05
upper   .01
lower   .001

Orientations
orientations are mirrored stimuli; any upper stimulus has an **equal** lower one

Locations
each stimulus is **either** in the lower or upper hemisphere

V3ab   IPS   FEF

We assessed other possible location training sets around the circular space, amounting to a total of 12 comparisons.
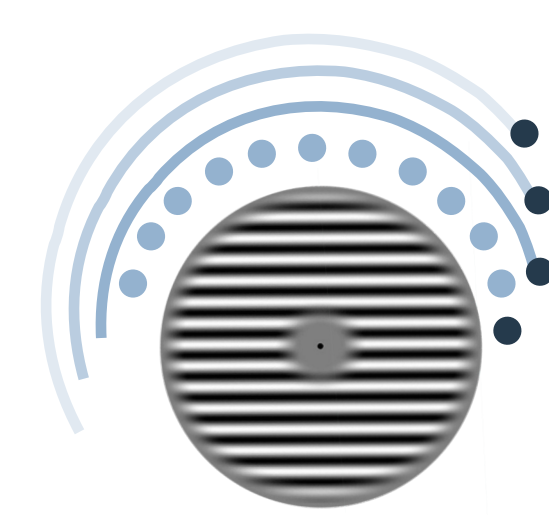
The upper location group starting at 0° still proved to be the best at explaining the orientation data.

Visual Cortex   V3ab   IPS   FEF

Early delay

Late delay

upper locations
lower locations
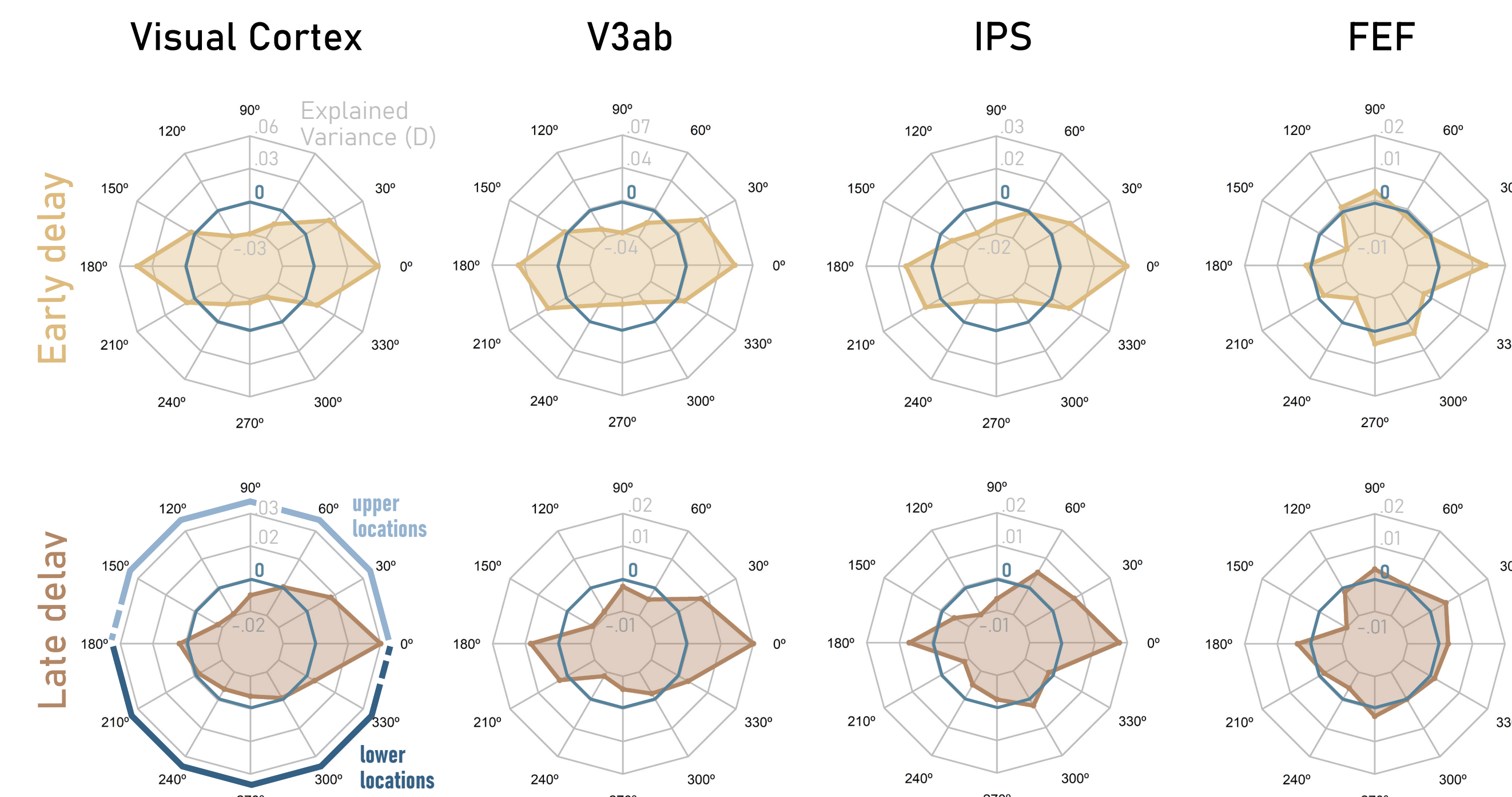
Conclusions

We provide evidence that orientation and location stimuli **share neural representations**.

Orientation stimuli during working memory are **better explained by the responses to location stimuli on the upper half of the visual field**. This finding is consistent with the previous verbal behavioral results.

In anterior areas (IPS and FEF), this preference for upper locations is accentuated compared to EVC and V3ab. This is in agreement with the hypothesis that these areas are believed to store more abstract memory representations.

Future Outlook

This preliminary searchlight analysis shows decoding of individual spatial words in the auditory and visual cortices, and possibly language areas during a **verbal task** we conducted in the MRI scanner.
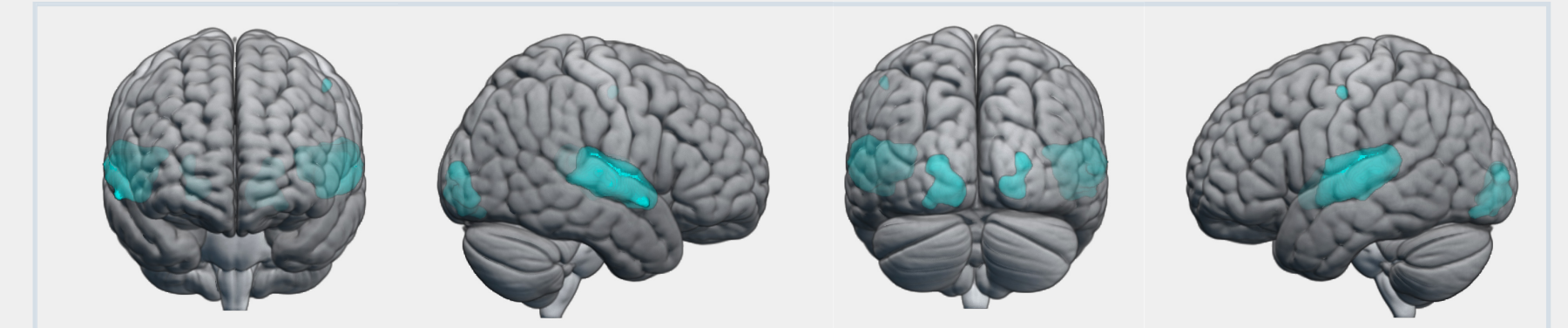
Neural activity from this verbal task might relate to the results of the memory task and give us more insight into the role of abstraction in working memory.

1. Christophel et al., Trends in Cognitive Sciences, 2017
2. Kwak & Curtis, Neuron, 2022
3. Souza et al., Journal of Memory and Language, 2021