MULTFS MRI dataset

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Question of interest:

How does the brain represent different aspects of the same naturalistic stimuli across a variety of tasks that are inter-related?

MULTFS:

Multi-Tasks, Feature, Stimuli

Working memory dependent tasks

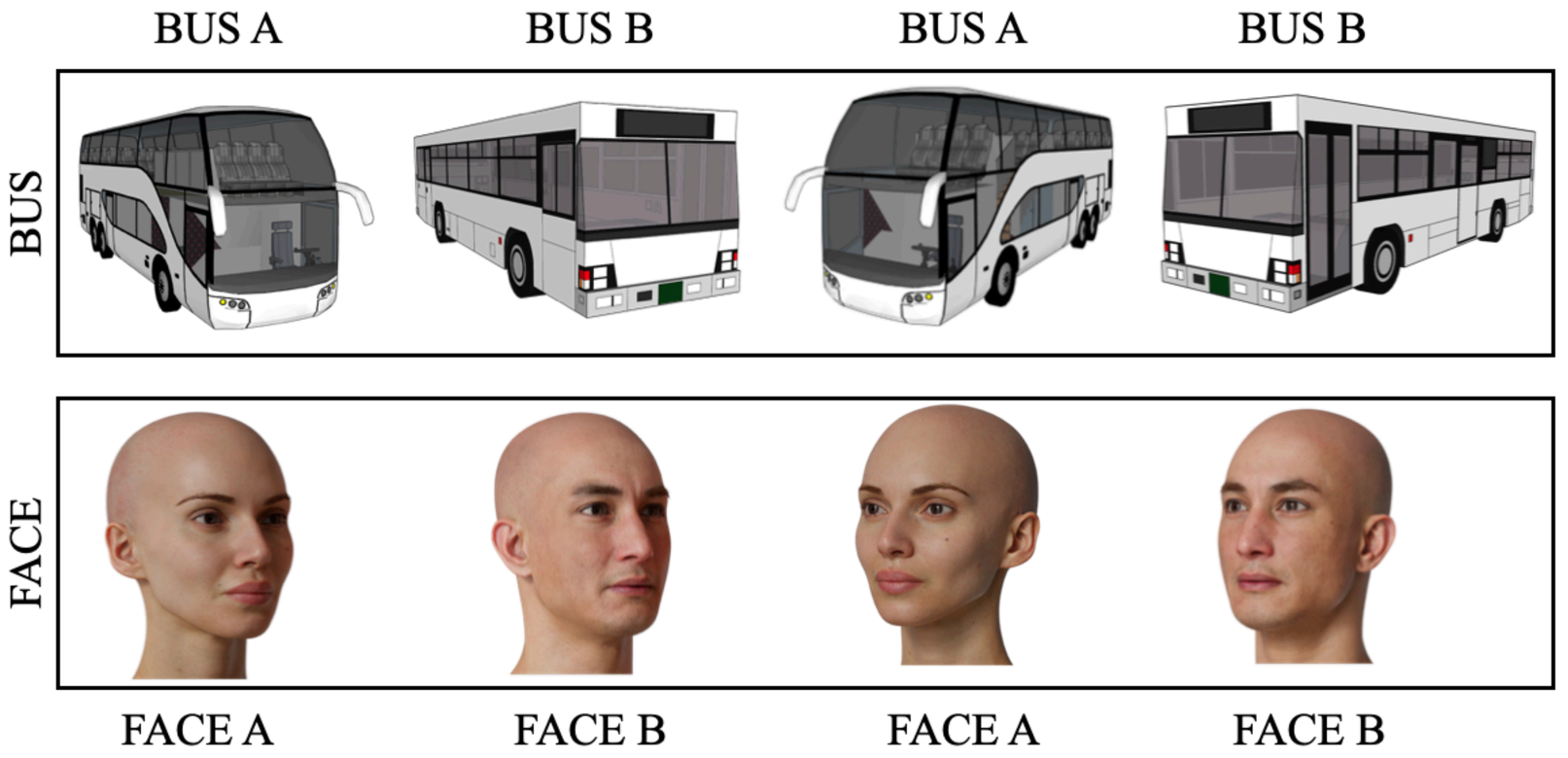
For this fMRI dataset, we collect data from:

N-BACK

Interleaved delay match to sample

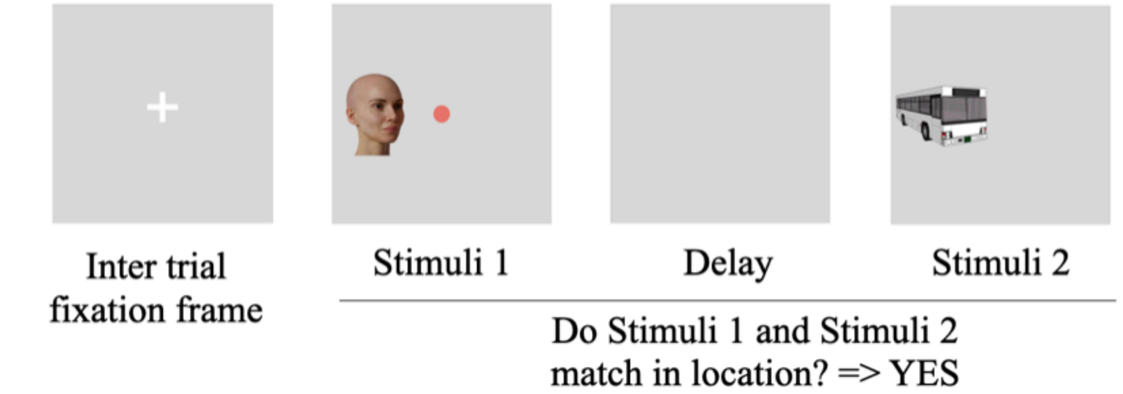
Contextual decision making

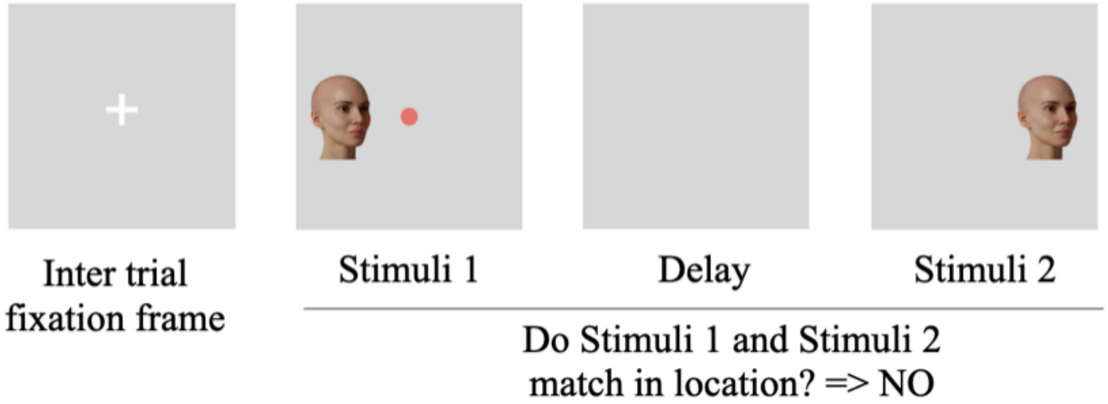
Stimuli



Baseline Task: Delay Match to Sample (DMS)

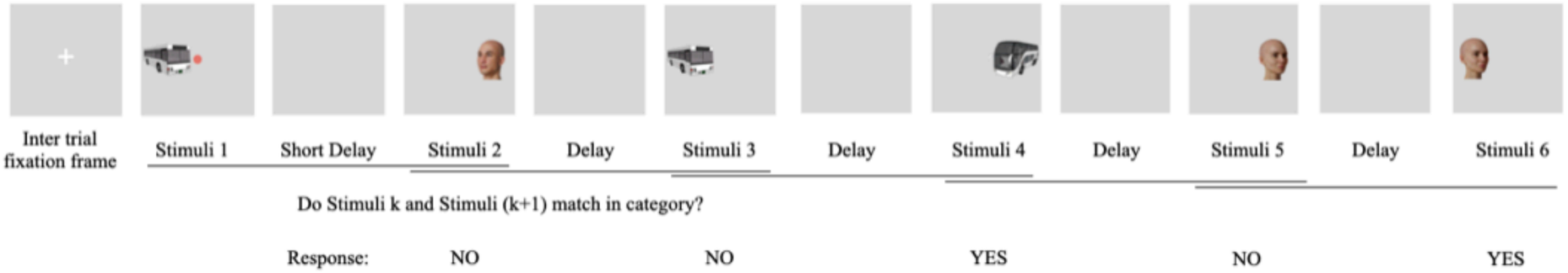
DMS location:



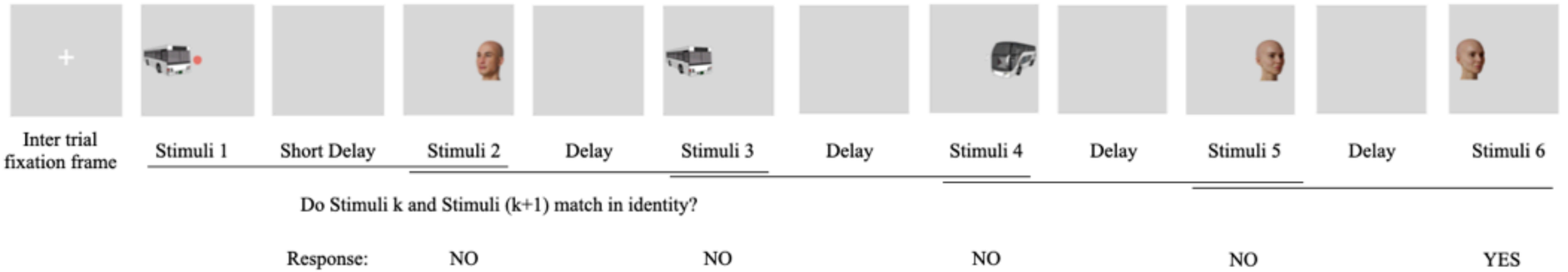


Task: 1-BACK

1back category



1back identity



Task: Contextual Decision making

ctxDM location category identity

Inter trial fixation frame | Stimuli 1 | Short Delay | Stimuli 2 | Delay | Stimuli 3

Do Stimuli 1 and Stimuli 2 match in location? => YES (don't respond)

YES => Do Stimuli 2 and Stimuli 3 match in category? => NO (respond!)

Task: Contextual Decision making

ctxDM category identity location

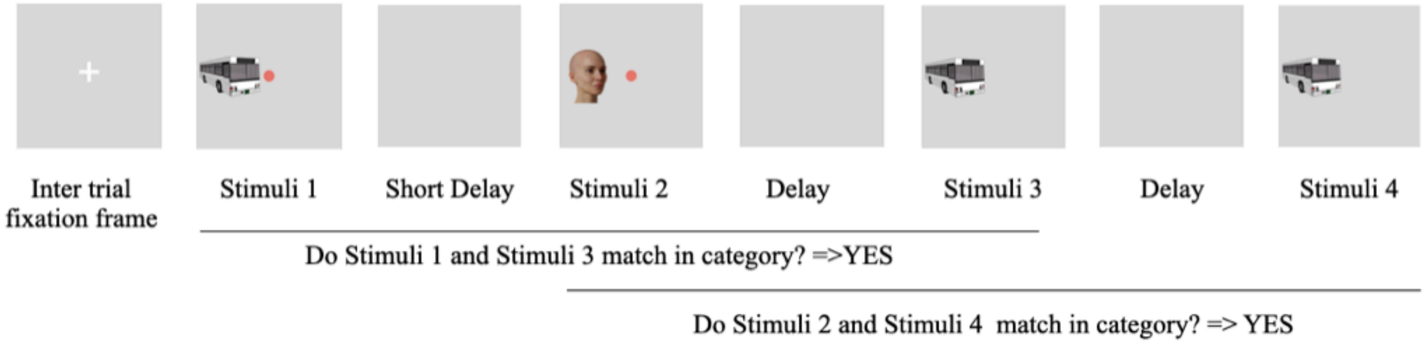
Inter trial fixation frame | Stimuli 1 | Short Delay | Stimuli 2 | Delay | Stimuli 3

Do Stimuli 1 and Stimuli 2 match in category? => NO (don't respond)

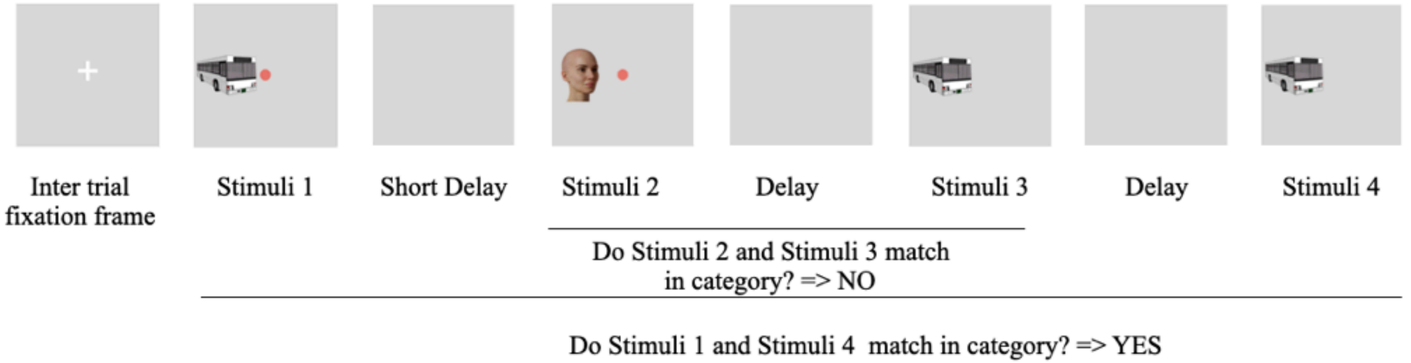
NO => Do Stimuli 2 and Stimuli 3 match in location? => YES (respond!)

Task: interleaved Delay-Match to Sample

interDMS ABAB category



interDMS ABBA category



MULTFS MRI pilot data analysis

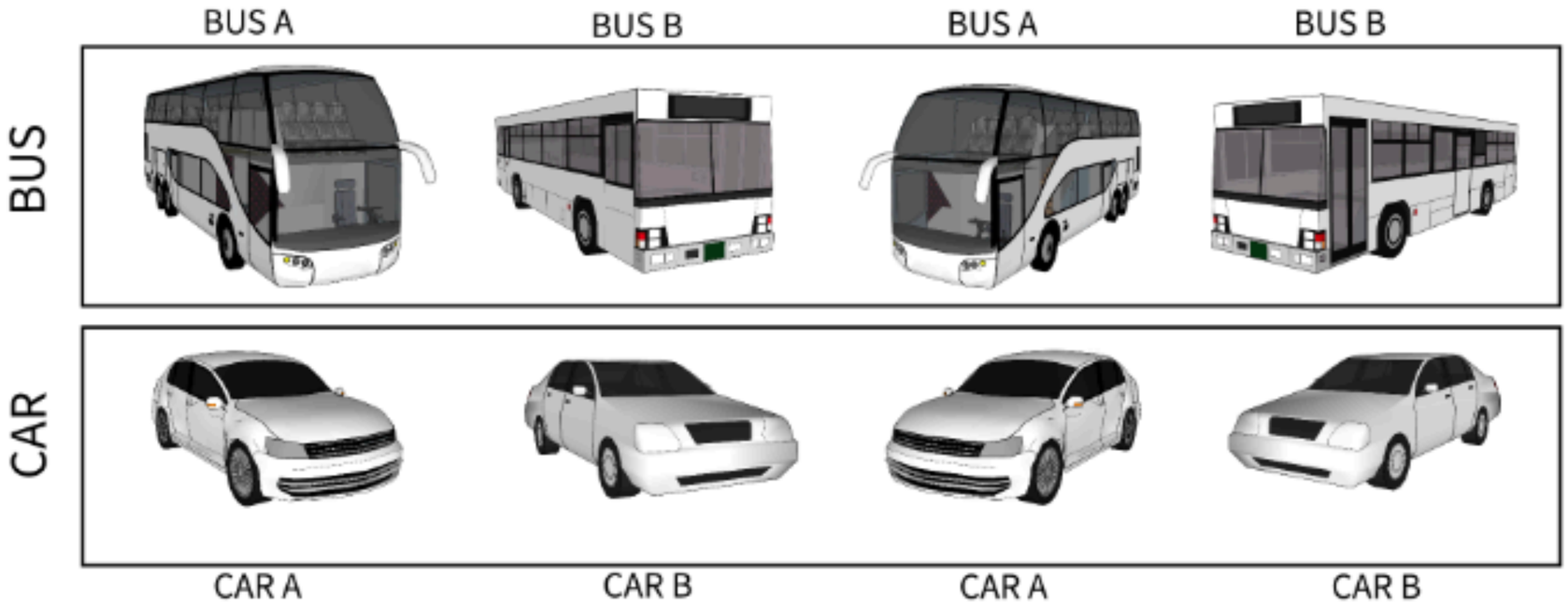
Tasks available:

dms location, 1back-catgory,
1back-location, ctxdm-LCO

Preliminary results

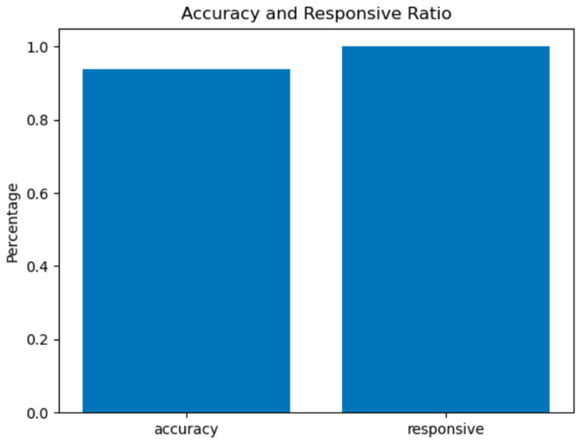
1. Behavioural performance
2. Imaging data analysis
    1. Methods
    2. Results

Stimuli

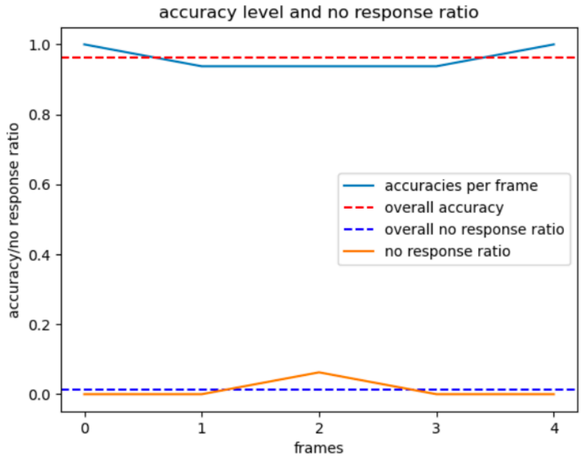


Behavioural Performance

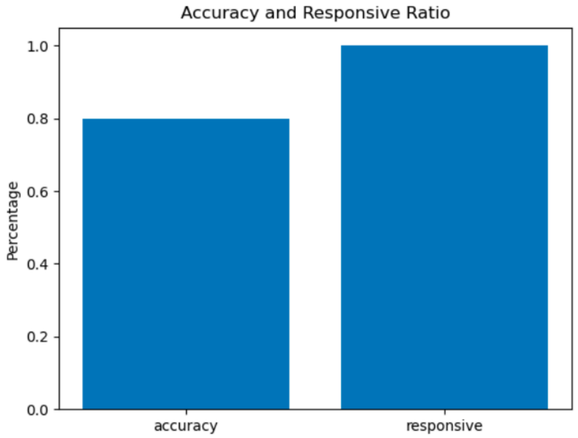
Dms location task



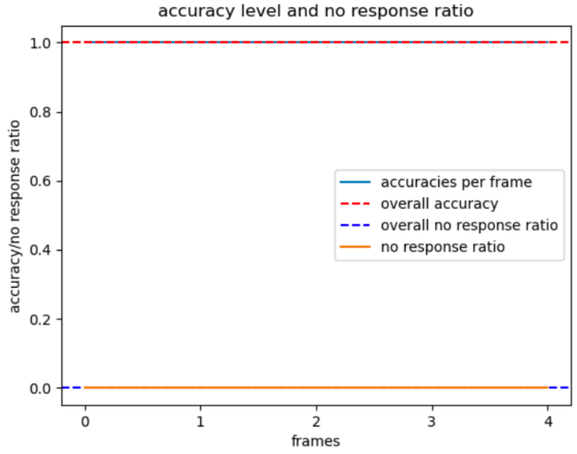
1back location task



Ctxdm LCO task



1back category task



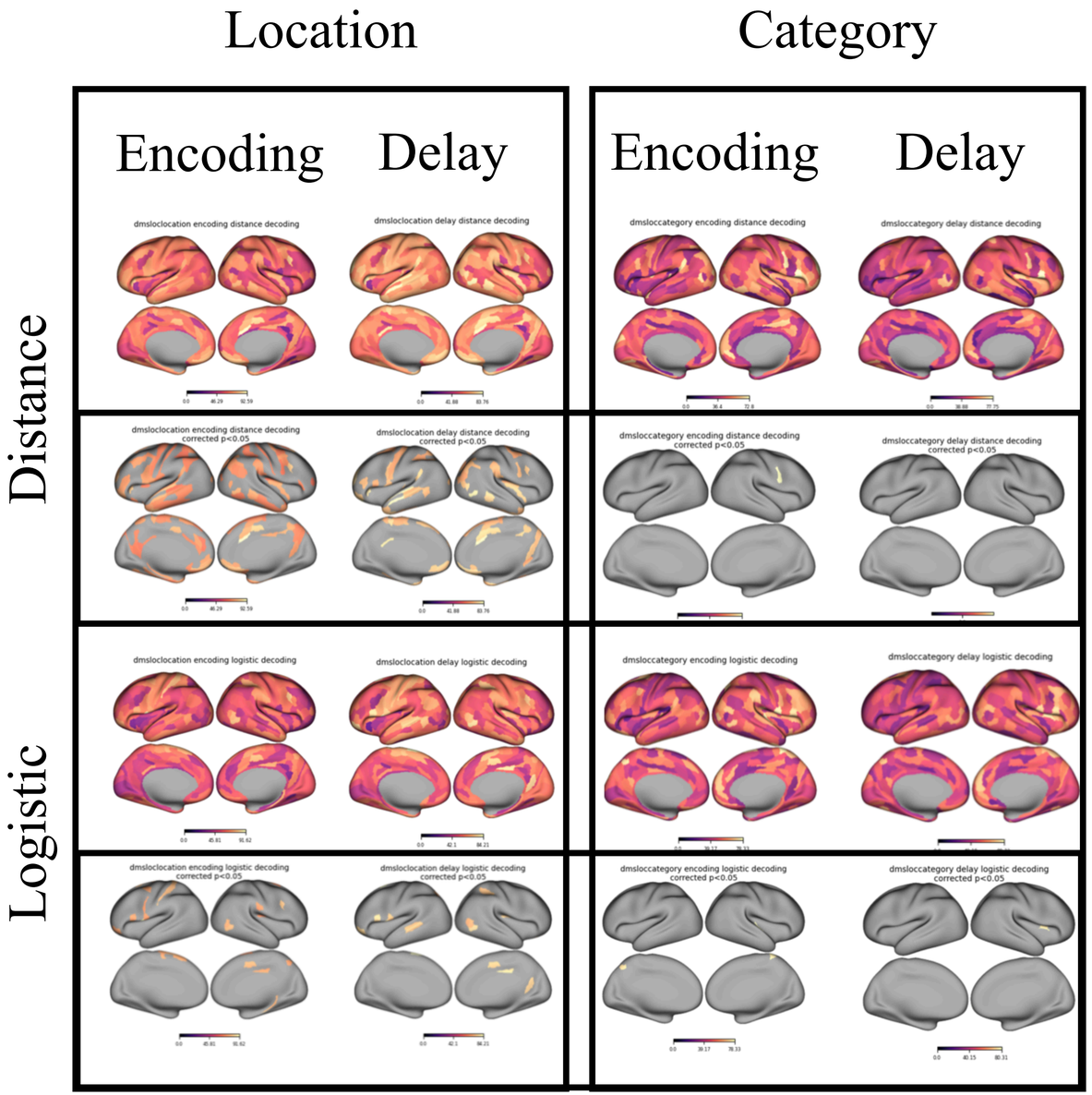
Imaging data analysis: Methods

Goal: To test whether feature information is decodable during stimulus presentation and delay period.

Methods:

- apply GLM to the imaging data and obtain betas for corresponding TRs of interest.
- Perform distance/logistic regression based decoding analysis.
- Select brain regions that encode features of interest with null permutation test

Imaging data analysis: Results

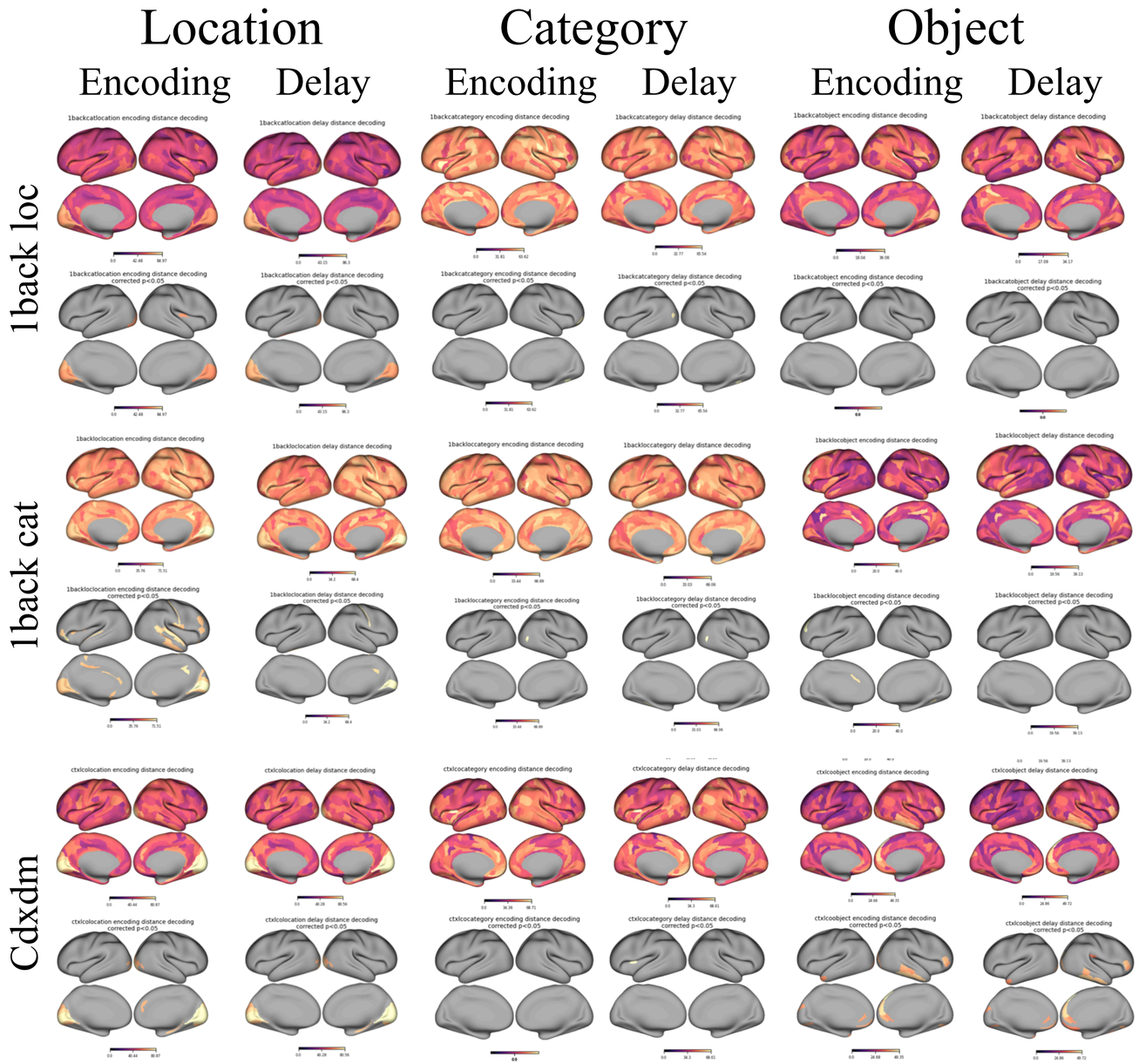


Decoding for the DMSLOC task:

1. We observed that location information was more readily decodable than category information, with distance-based decoding yielding an accuracy rate as high as 92.59% during the encoding period.

2.While logistic regression provided slightly higher decoding accuracy, fewer brain regions met the statistical significance threshold.

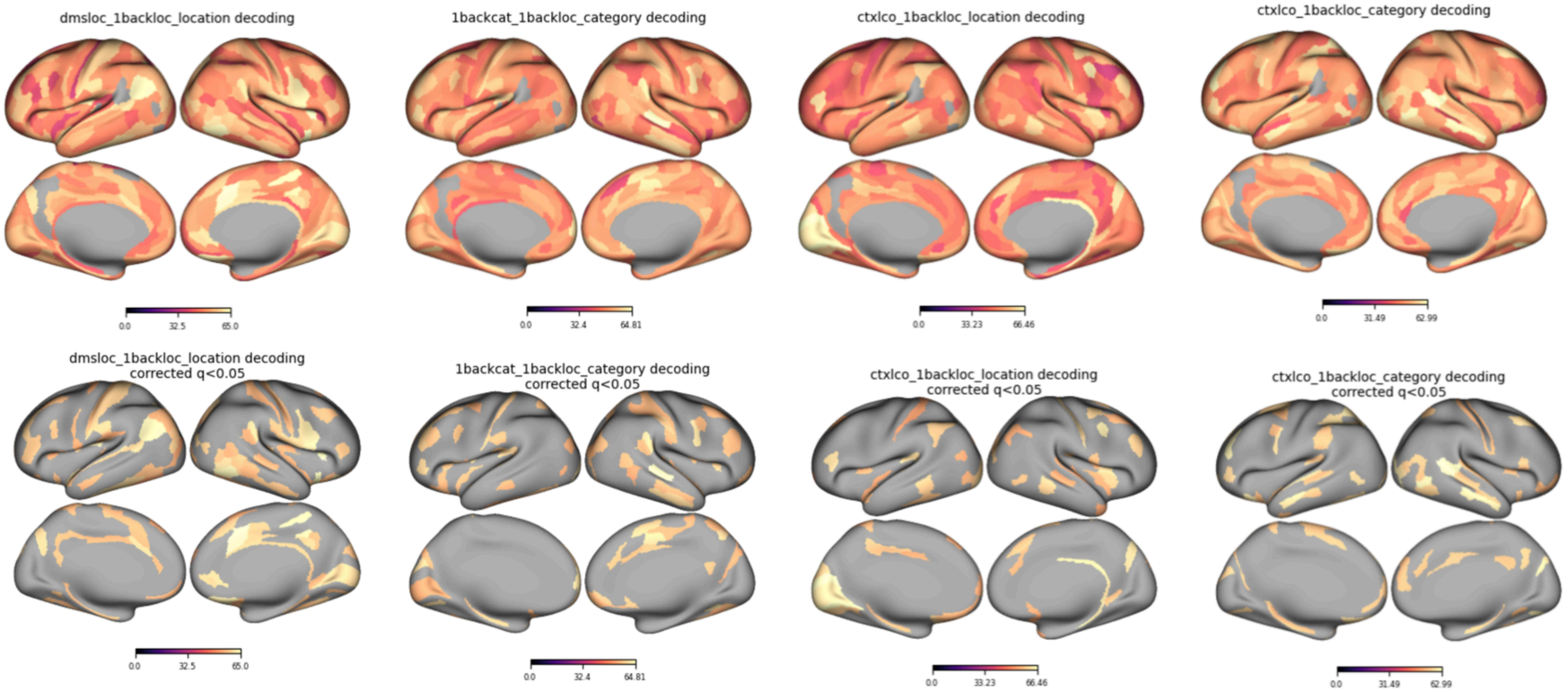
Imaging data analysis: Results



Notes: distance based decoding for 1backloc, 1backcat and ctxlco task.

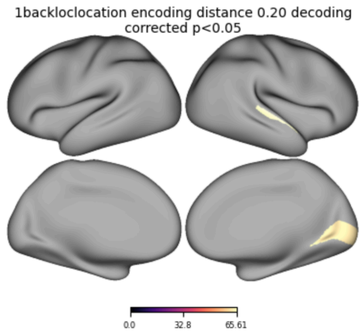
1. The brain regions that met the statistical significance threshold were mainly located in the primary visual area.
2. We observed that location was the most easily decodable feature, while object information could only be decoded from the ctxlco task.

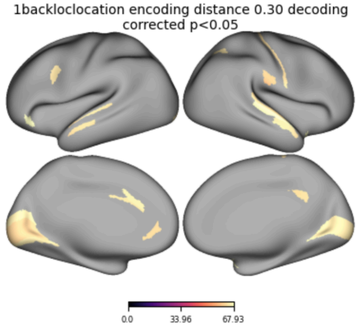
Imaging data analysis: Results

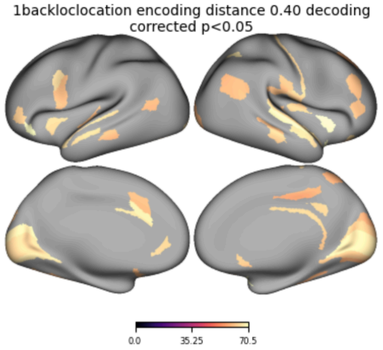


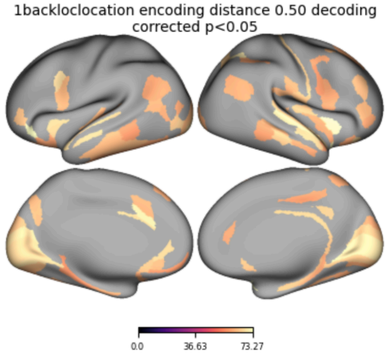
Notes: Cross Context Decoding analysis
Train on different task tested on 1backloc w.r.t indicated feature of interest
Although the overall decoding accuracy on the test dataset was lower than that of classifiers trained on the same dataset, we observed that the classifiers trained on different tasks showed more significant brain regions. This suggests that there was some degree of generalization across tasks.

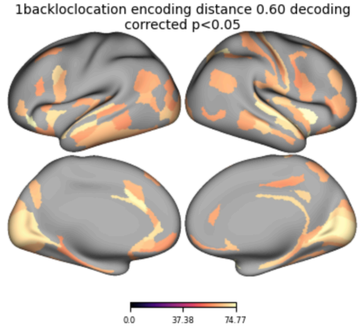
Imaging data analysis: Results

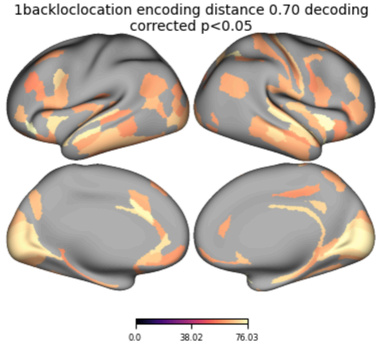


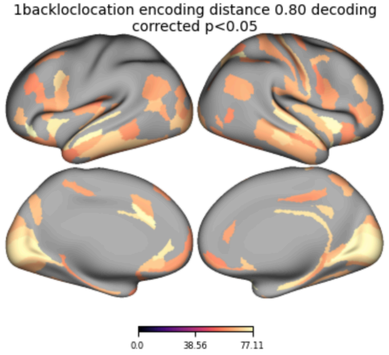


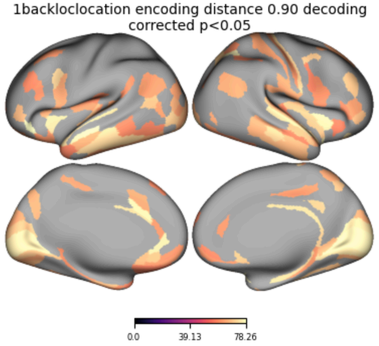


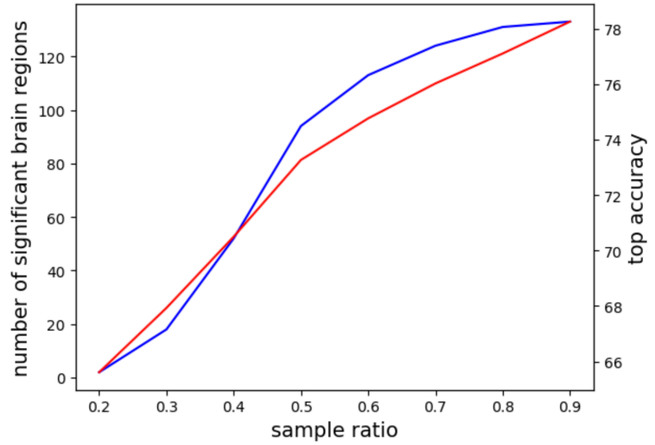




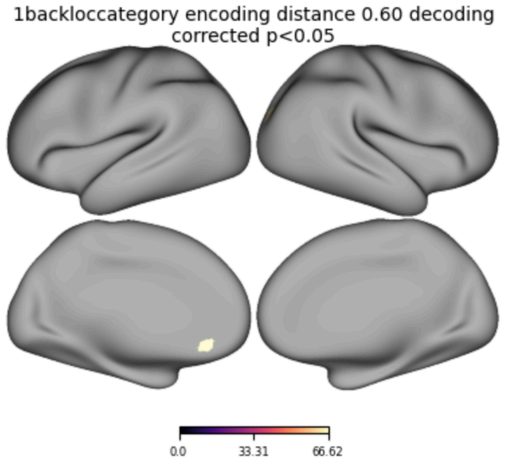


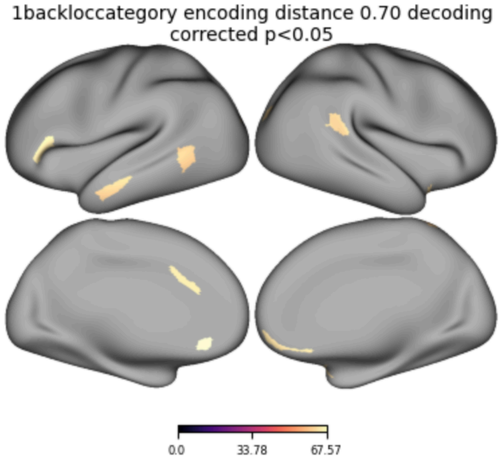


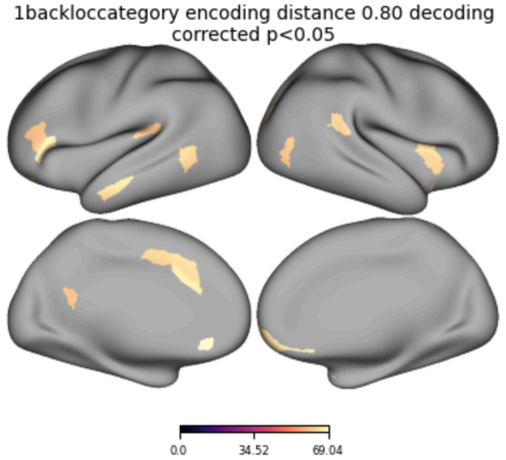


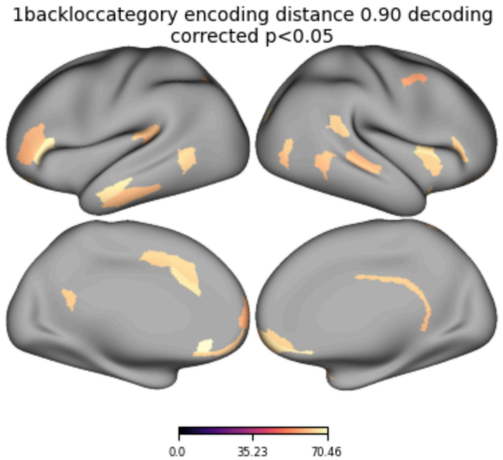


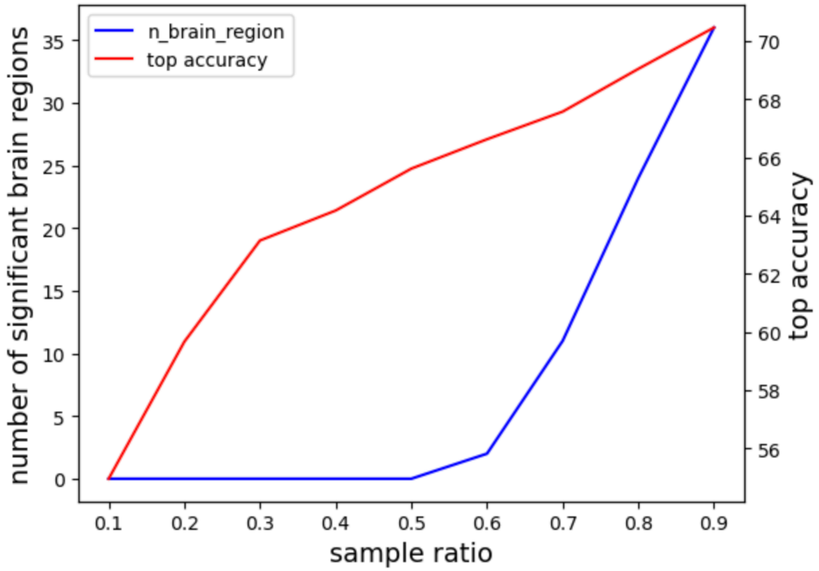
Imaging data analysis: Results











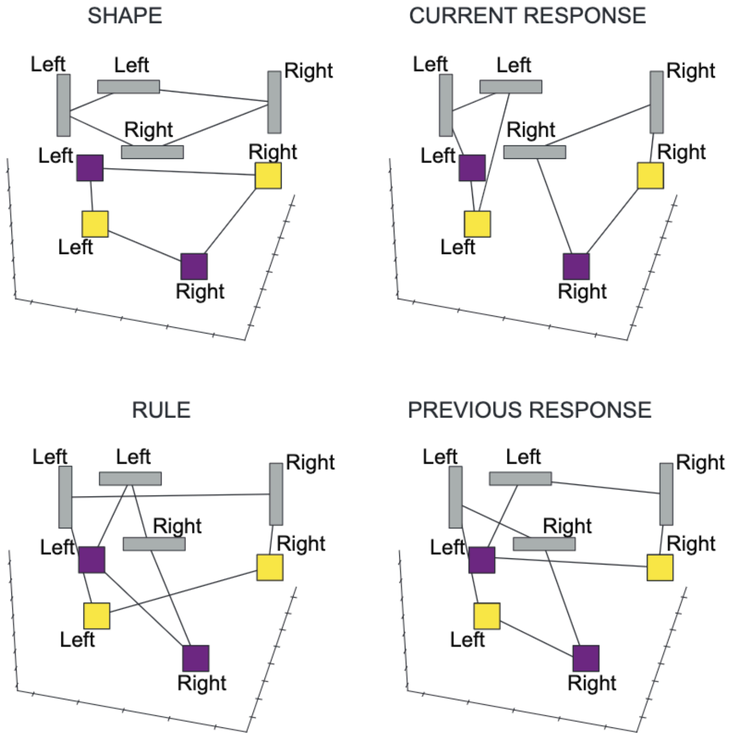
UPDATED tasks

1. Longer stimulus presentation and delay period (to include at least 1TR + 2TR, detailed calculation see next page)
2. To guarantee decodable category/object information, replace car with faces
3. Make sure for each run, MRI trigger stimulus onset.

List of Research questions

1. Does the brain utilize an abstract low dimensional representation for different object properties?
2. Is this abstract representation generalizable across different tasks? If so, to what level it can generalize?

Method: Cross Condition Decoding analysis



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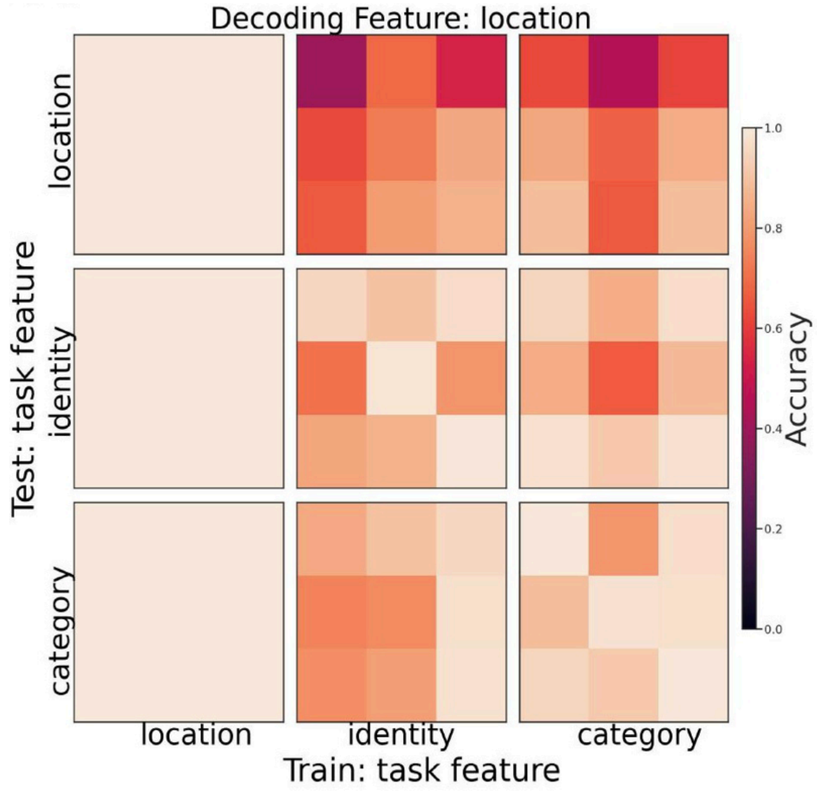
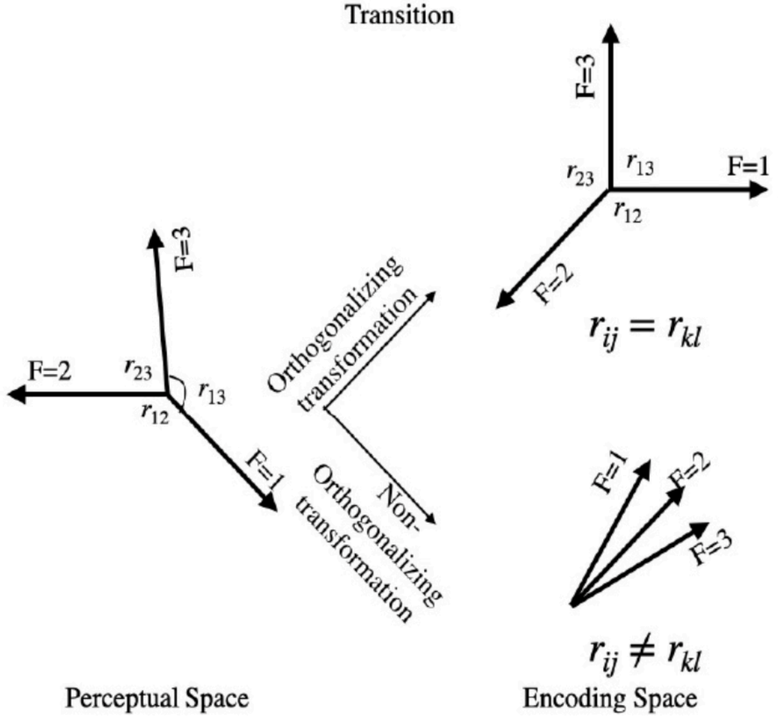
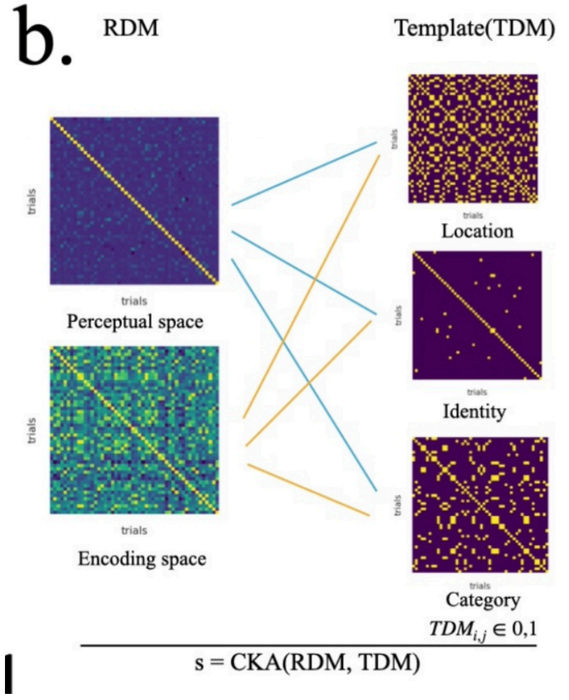


List of Research questions

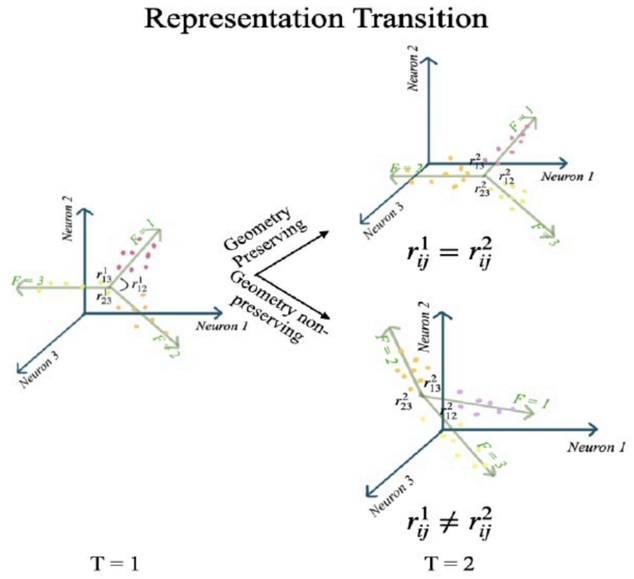
Hypothesis:
Compared to the visual regions, PFC orthogonalizes the axes along which distinct object properties are represented, enabling enhanced separation of object properties. Moreover, the task-relevant object properties are represented along more orthogonalized axes relative to task-irrelevant one

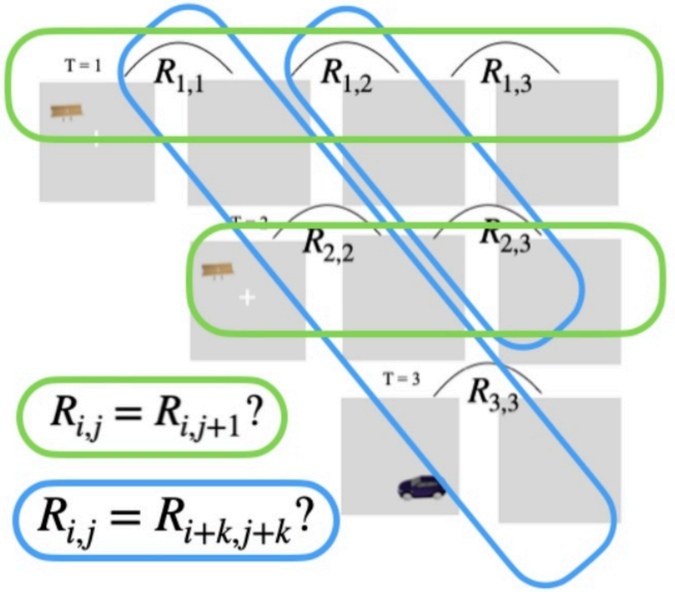




List of Research questions

Hypothesis: [dynamics of the representation geometry]
Across time, the brain preserves the geometric structure of the latent subspace representing various object properties. The rotational dynamics governing the transformation of WM encodings into memories was shared across stimuli, yet the transformations governing the retention of an encoding in the face of incoming stimuli were distinct across time.





trials count: 1back

9 trial per block 5.4 minutes
Each file contains 1 block
16 files in total: 88 min

We consider permute over all pairs of stimuli:
For category and object task: 16 pairs of stimuli in total
For location task: 64 pairs of stimuli in total

Each 1back task trial has 6 frames, which gives us 5 pairs of stimuli.
We also need to consider the consecutiveness of pairs of stimuli, since the second stimulus corresponding to the previous delay period is the first stimulus of the current delay period, by simulation, we need ***at least 24 trials*** for the 1backcat and 1backloc task, and ***80 trials for the 1backloc task*** to guarantee at least 5 repetitions for each pairs of stimuli. => 18+18+109=145 =>80min

Total trials: 24 + 24 + 72 = 120 trials
Each trial: 6*1.5 (stimulus presentation)+6*4(delay) = 33 sec
Total time: 120*33 = 3960 sec = 67 min

trials count: interDMS

16 trials per block, around 6 min
30 block files => 180 min

We consider permute pairs of stimuli over the first two frames and randomly choose the stimuli for the 3rd and 4th frames. Similar as before, we have 16 pairs of stimuli for the cat and obj task, 64 pairs of stimuli for the loc task. We have two patterns in total: ABBA, ABAB.

Total trials: 16 (pairs of stimuli) * 2 (patterns) * n_rep * 2 (features) + 64 (pairs of stimuli) * 2 (patterns) * n_rep = 192 n_rep
Each trial: 1(1st delay) + 3 * 4 (the rest delay and response time) + 4 *1.5 (stimulus presentation) = 19 sec
Total time: 192n_rep * 19 = 60.8 * n_rep min

trials count: ctxDM

20 trials per block, 5.5 minutes
32 files, 1 file for 1 block
=> 176 min

We consider permute pairs of stimuli over the first two frames and randomly choose the stimuli for the 3rd frame in a response balanced way. We have two task rules in total: LCO, COL. Since both rules involve the location feature, we need to consider 64 pairs of stimuli for both of them.

Total trials: 2 (rules) * 64 (pairs of stimuli) * n_rep = 128 * n_rep
Each trial: 1(1st delay) + 3*1.5 (stimulus presentation) + 2*4 (other delay and response time) = 13.5 sec
Total time: 128n_rep * 13.5 = 28.8 * n_rep min

Based on block file info, we need
7.4 hr scanning time
If not considering waste of time

In total, we need (67 + 89.6 * n_rep) min.
If consider 15% extra time,
n_rep = 5: 8.58 hr (actual recording time) * 1.15 = 9.87hr