MULTFS MRI dataset hackthon

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:

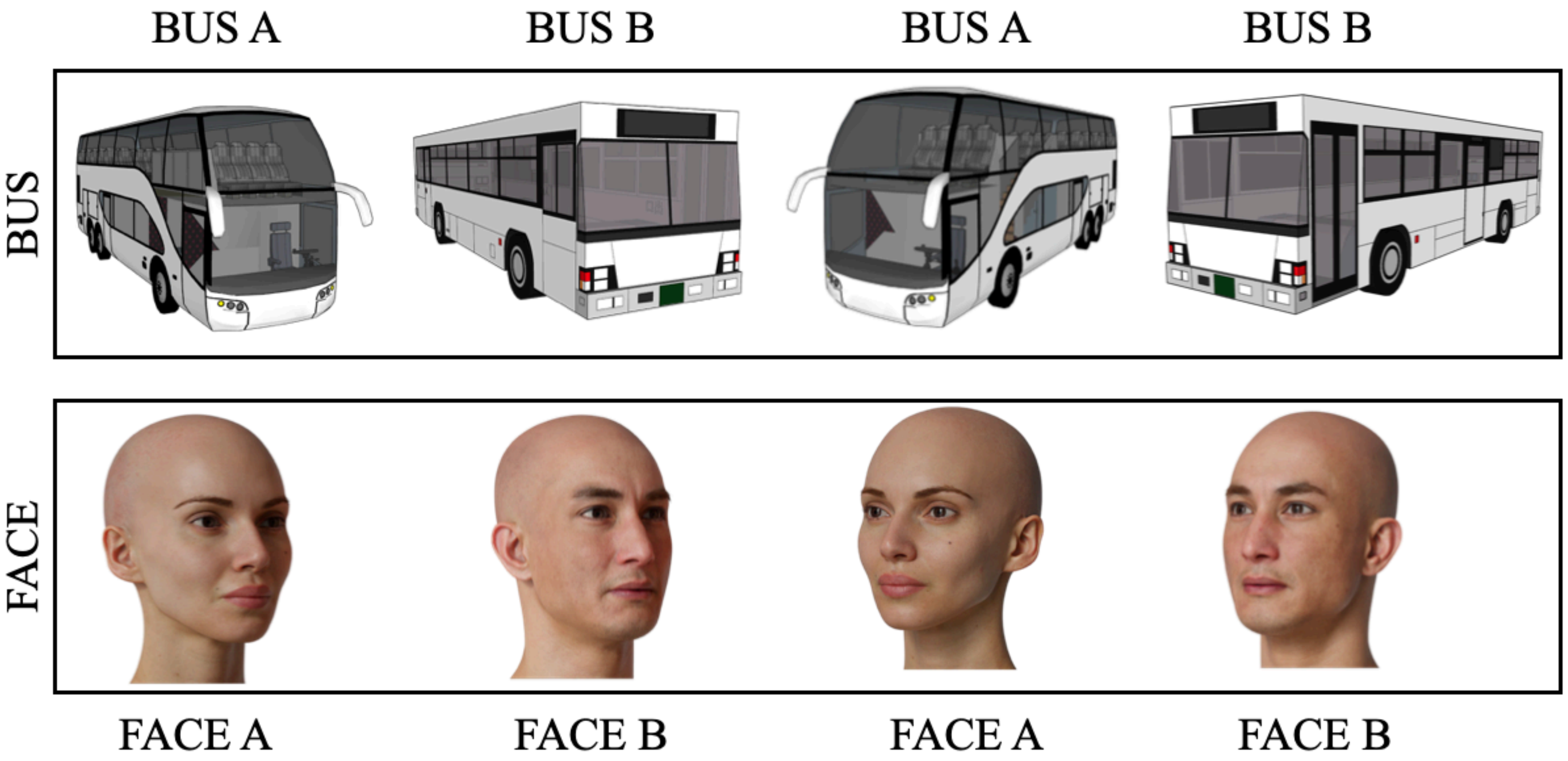
Multi-Tasks, Feature, Stimuli

Working memory dependent tasks

For this fMRI dataset, we collect data from:

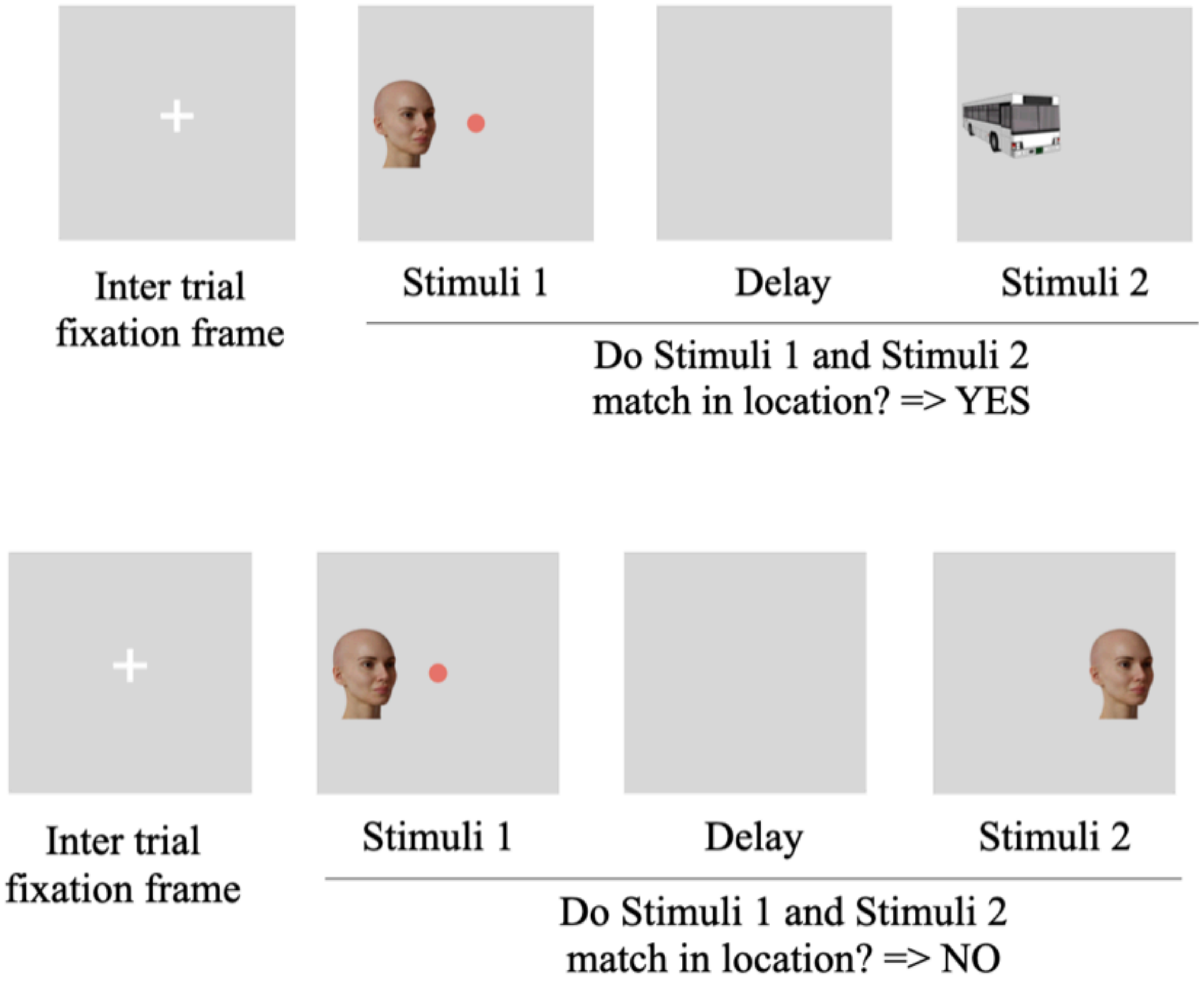
- N-BACK
- Interleaved delay match to sample
- Contextual decision making

Stimuli



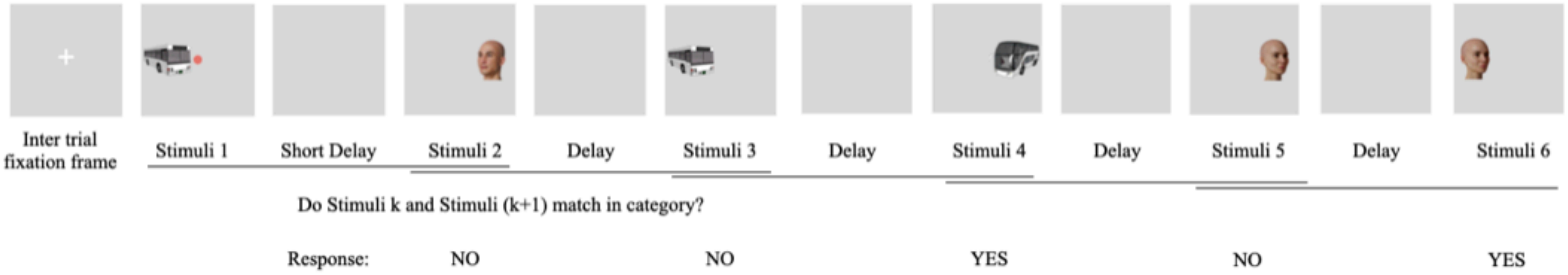
Baseline Task: Delay Match to Sample (DMS)

DMS location:

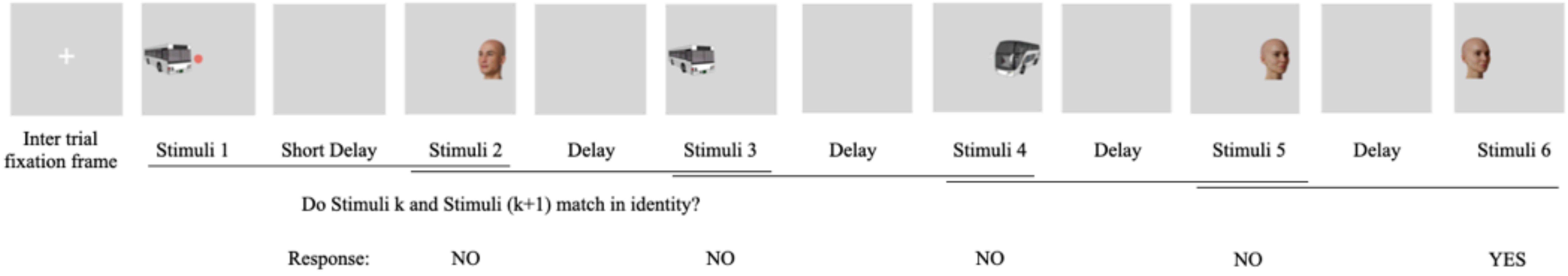


Task: 1-BACK

1back category

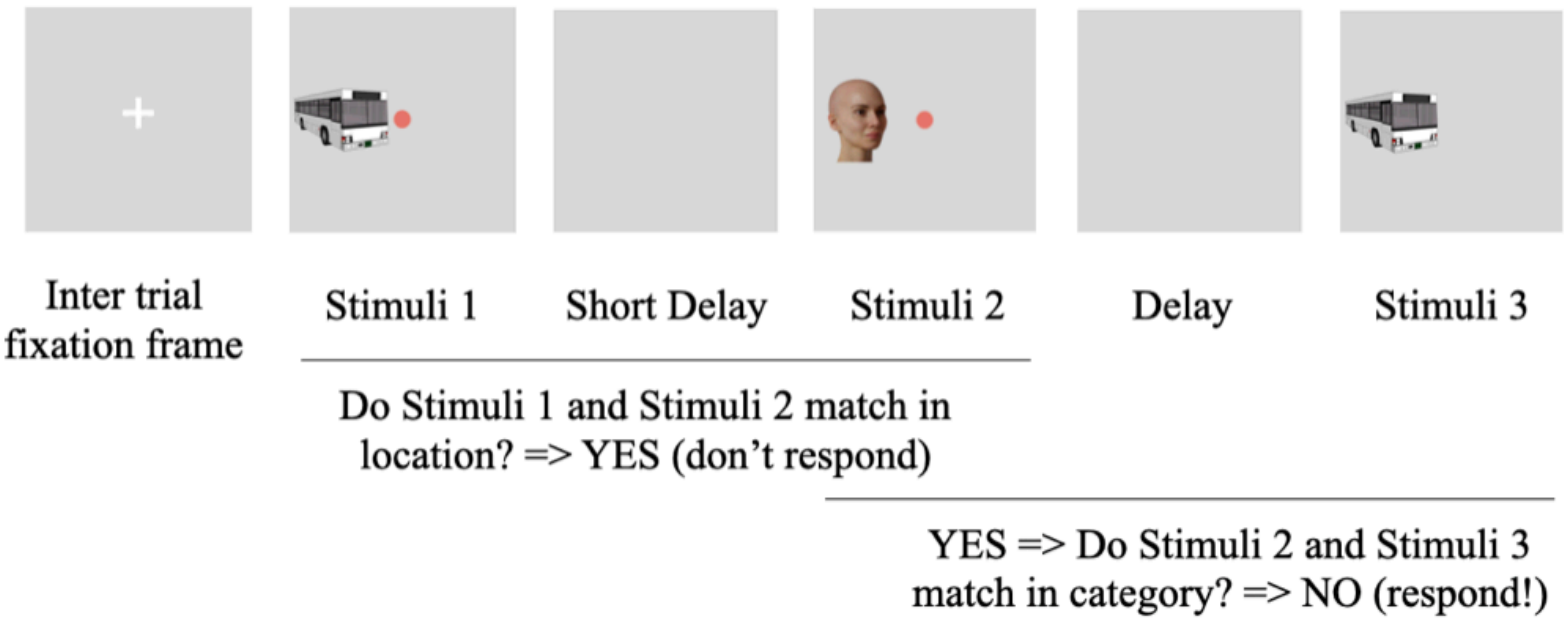


1back identity



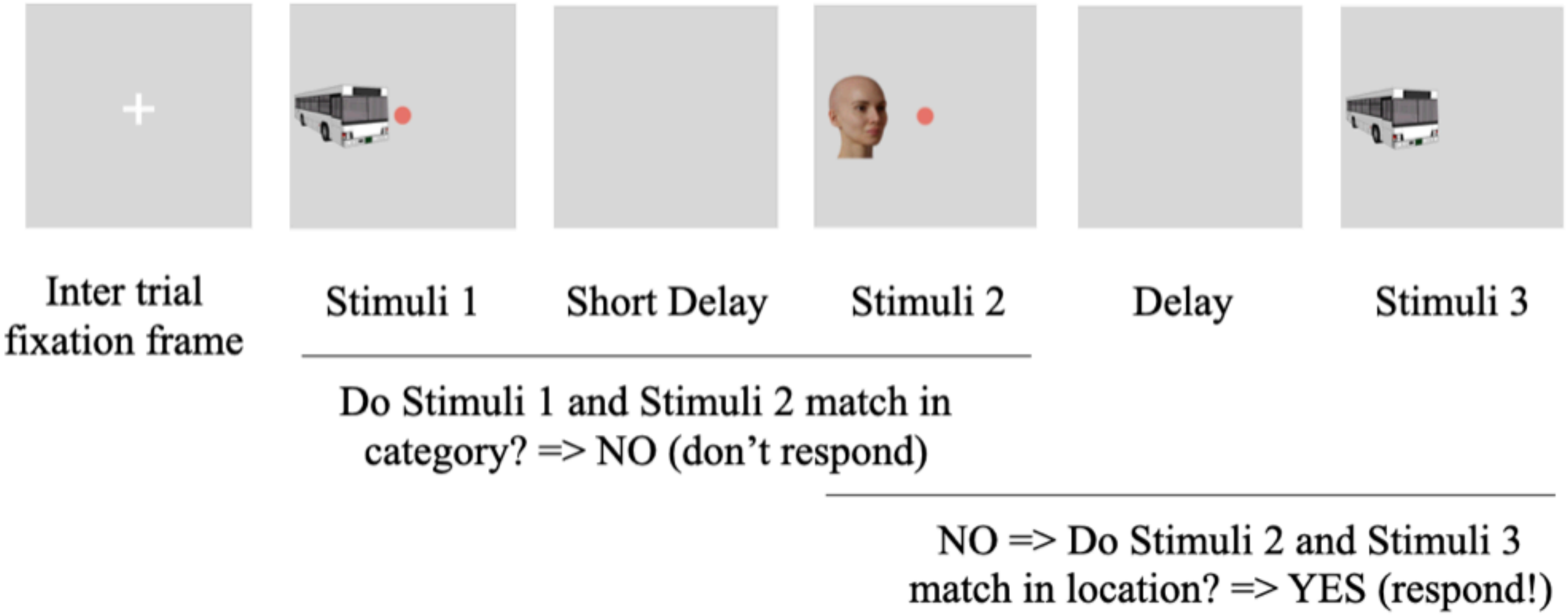
Task: Contextual Decision making

<u>ctxDM location category identity</u>



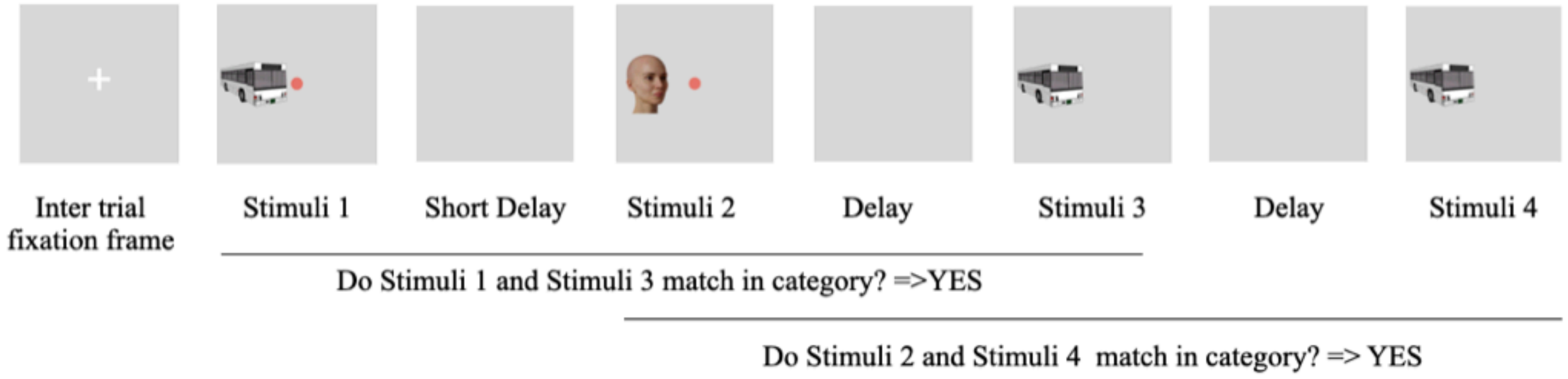
Task: Contextual Decision making

ctxDM category identity location

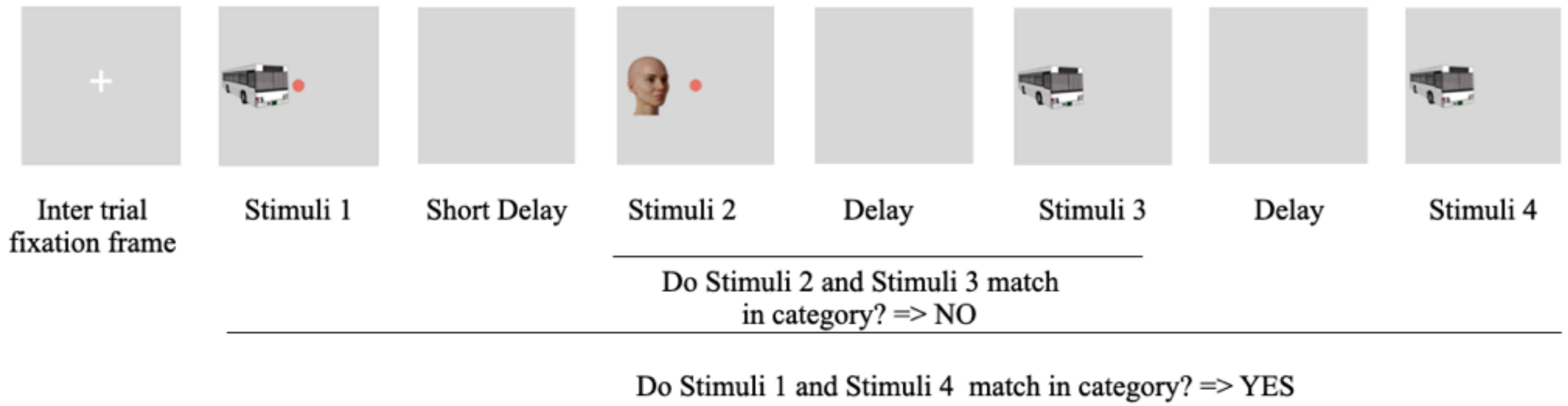


Task: interleaved Delay-Match to Sample

interDMS ABAB category



interDMS ABBA category



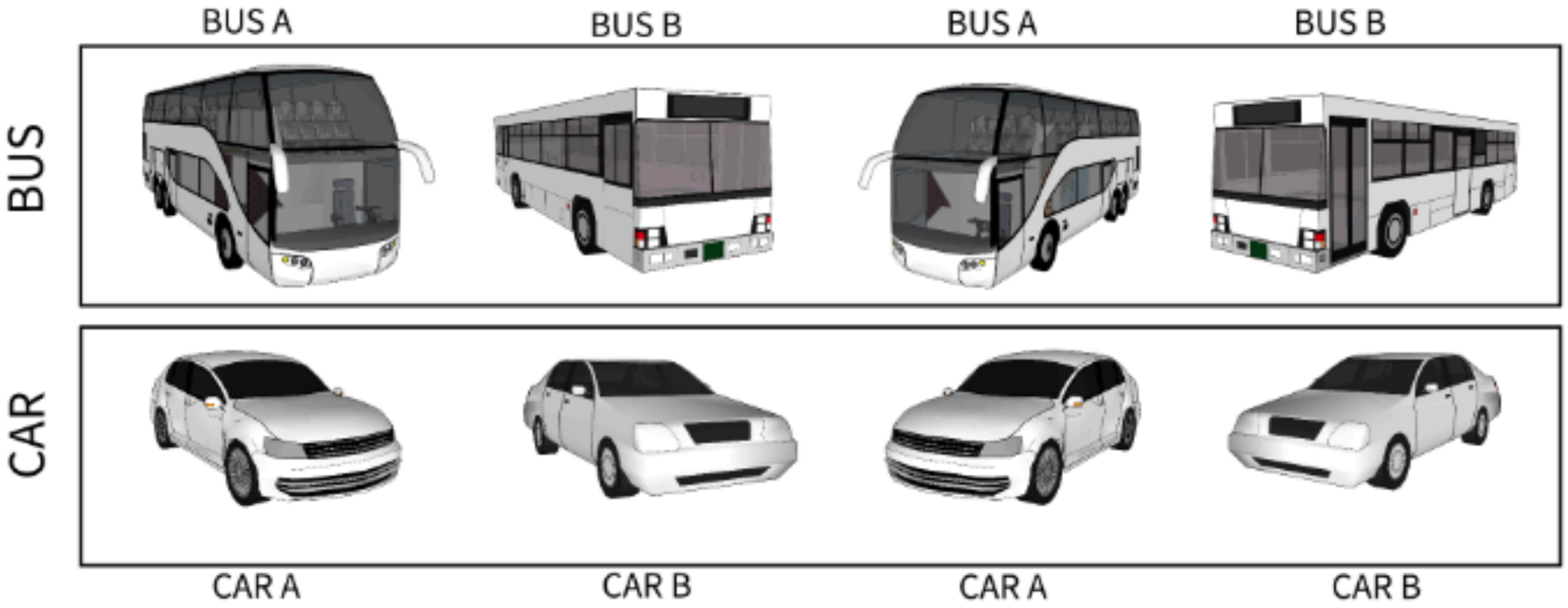
MULTFS MRI pilot data analysis

Tasks available:
dms location, 1back-catgory,
1back-location, ctxdm-LCO

Preliminary results

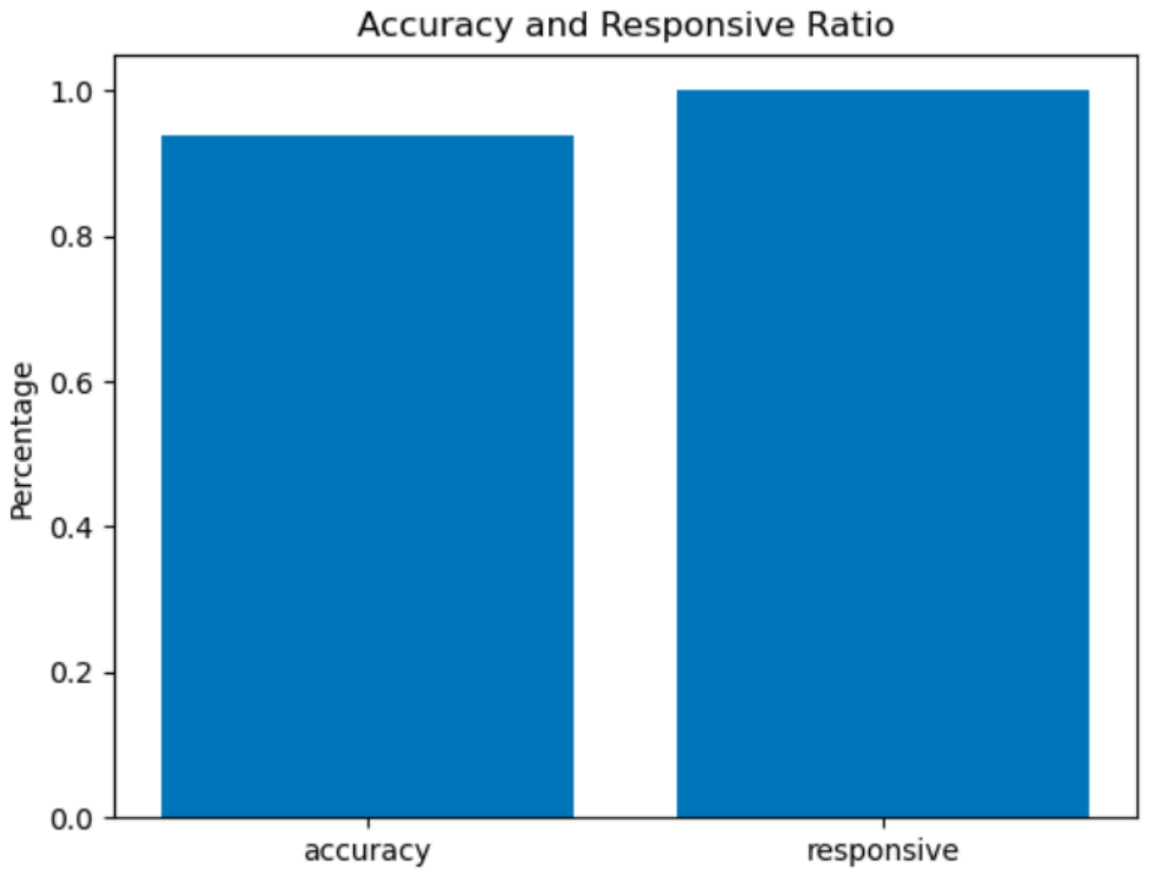
1. Behavioural performance
2. Imaging data analysis
    1. Methods
    2. Results

Stimuli

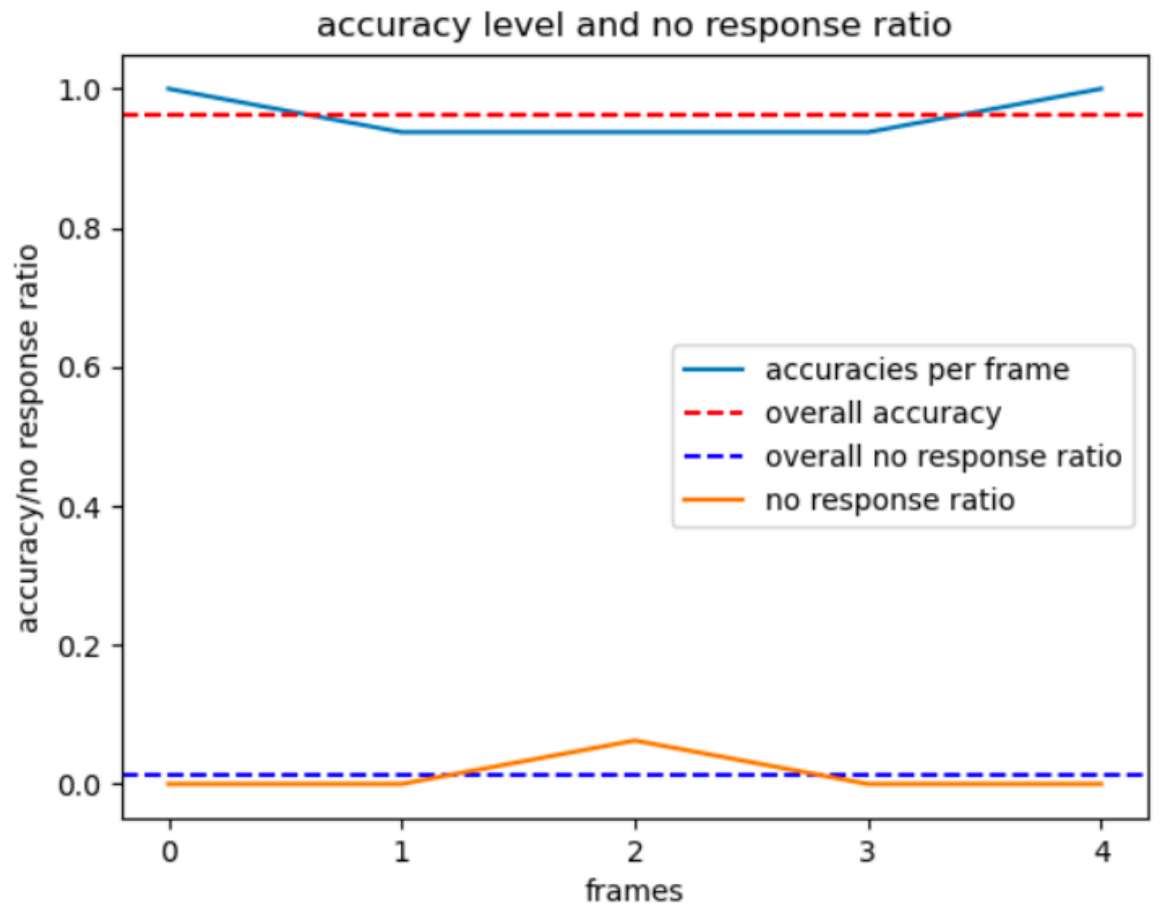


Behavioural Performance

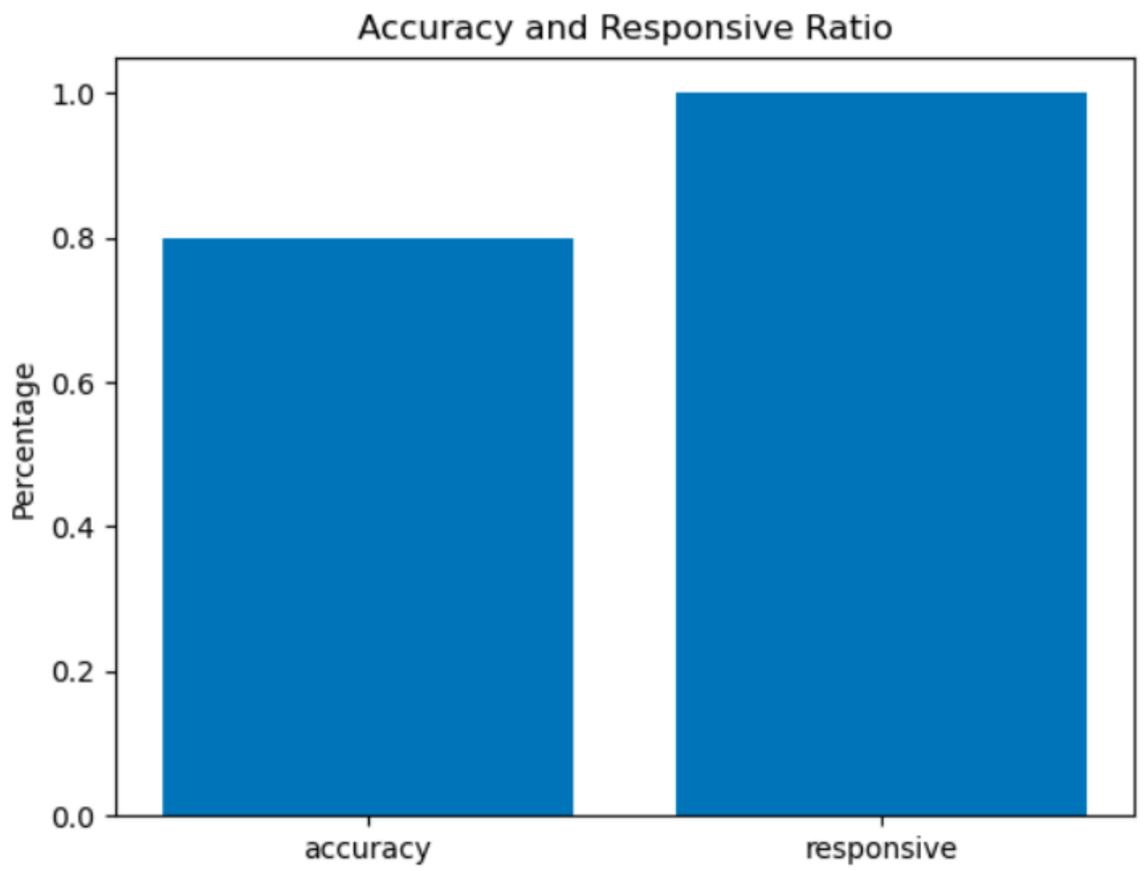
Dms location task



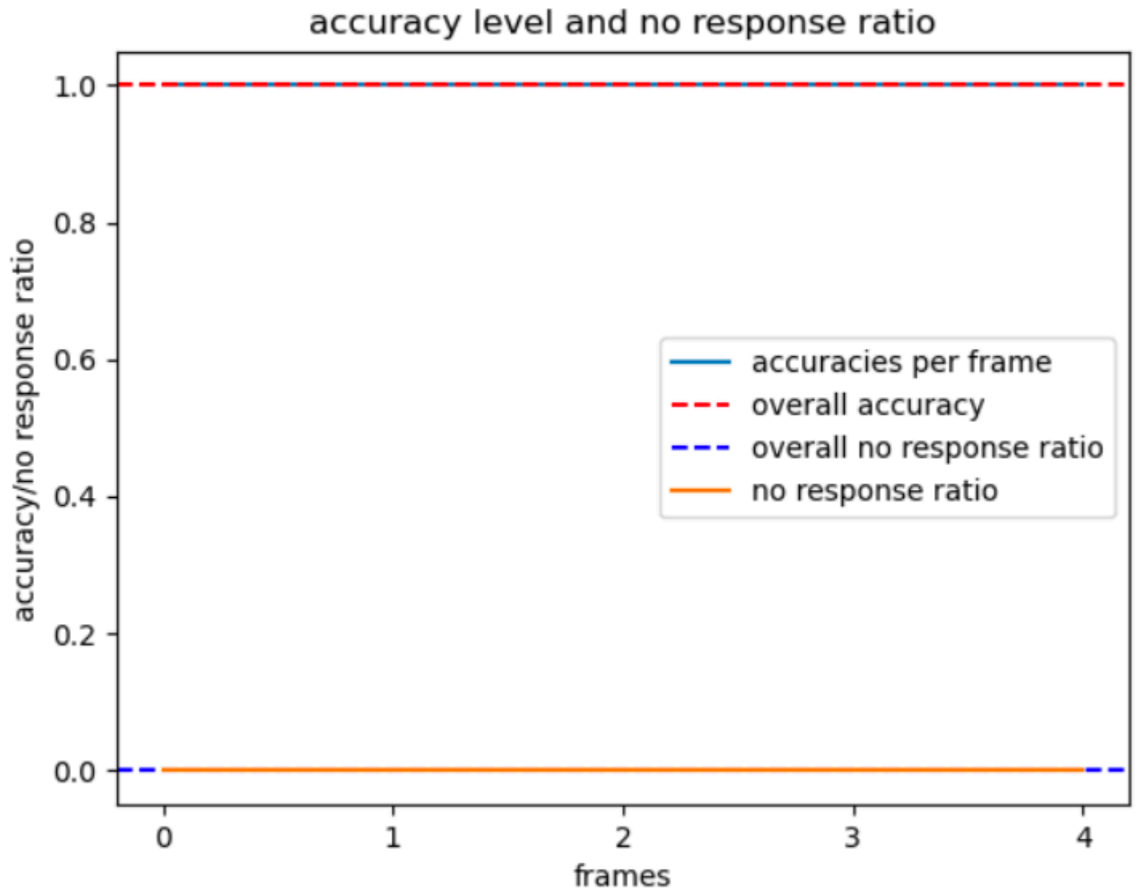
1back location task



Ctxdm LCO task



1back category task



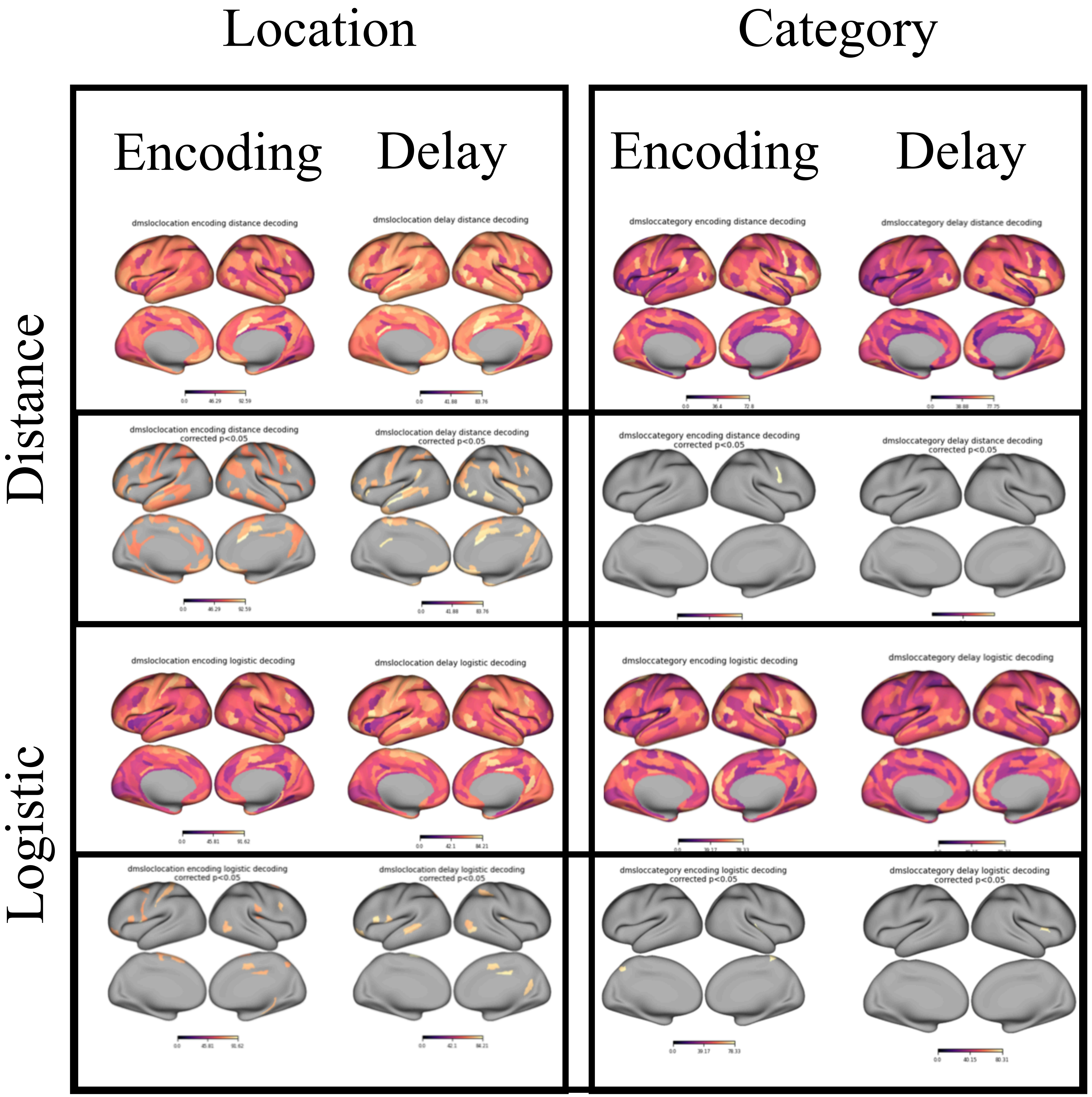
Imaging data analysis: Methods

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

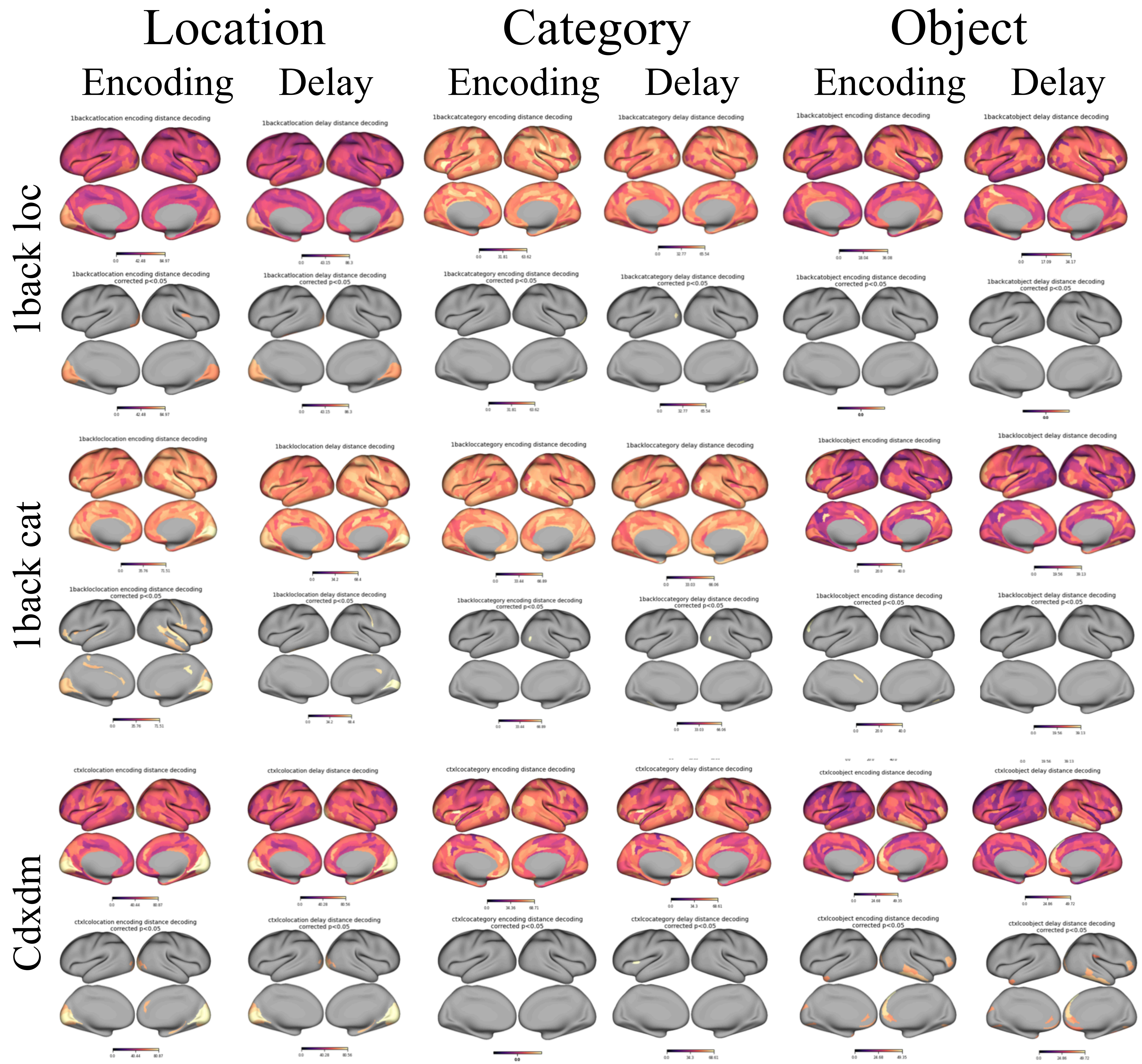


Decoding for the DMSLOC task:

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.

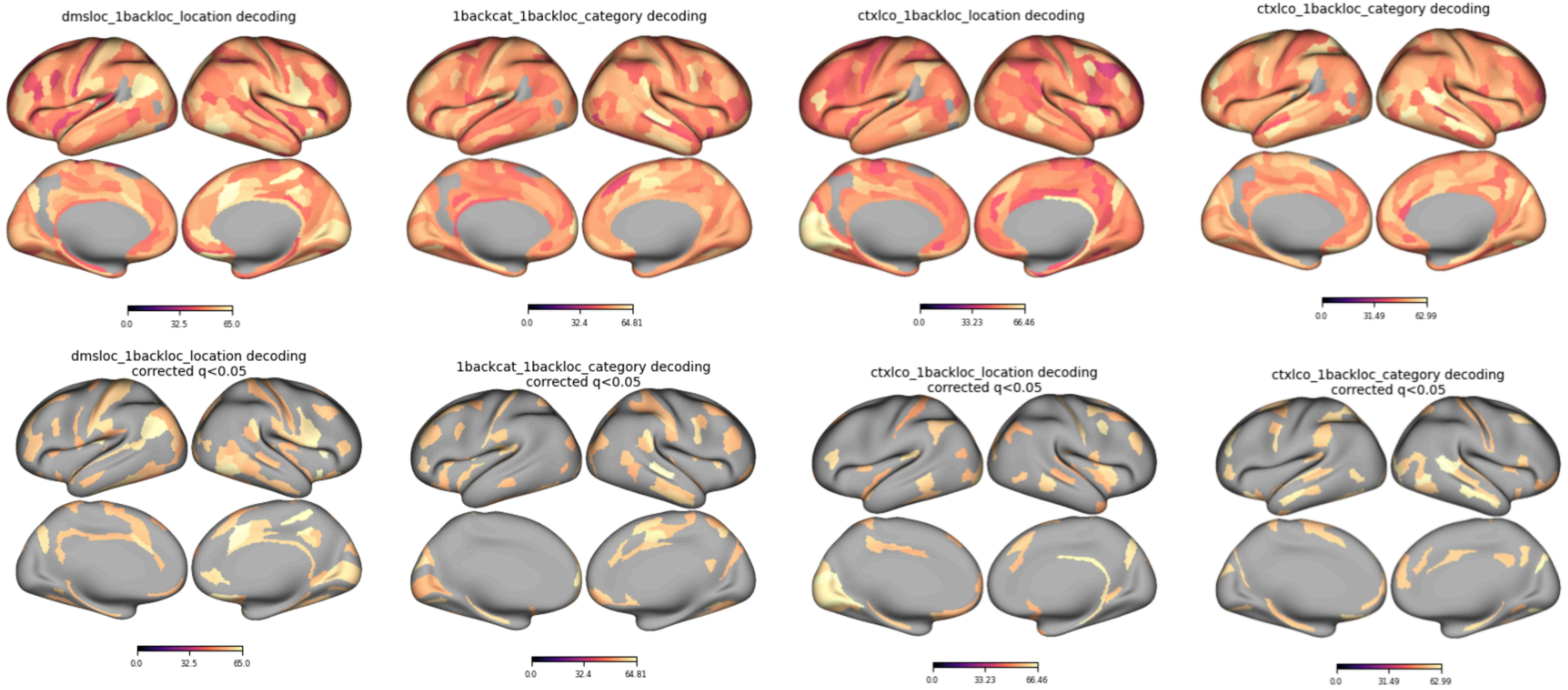
Imaging data analysis: Results



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

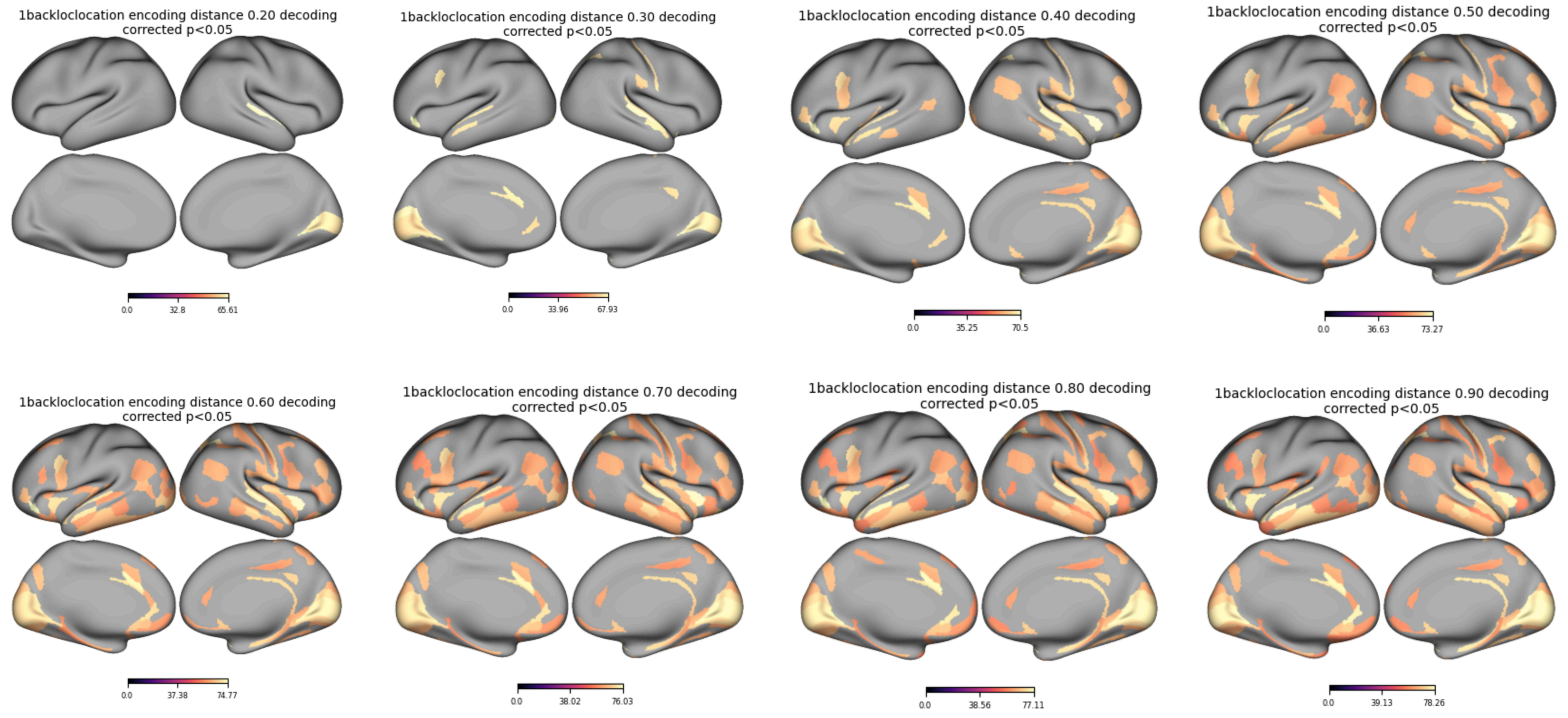
1. The brain regions that met the statistical significance threshold were mainly located in the primary visual area.
2. We observed that location was the most easily decodable feature, while object information could only be decoded from the ctxlco task.

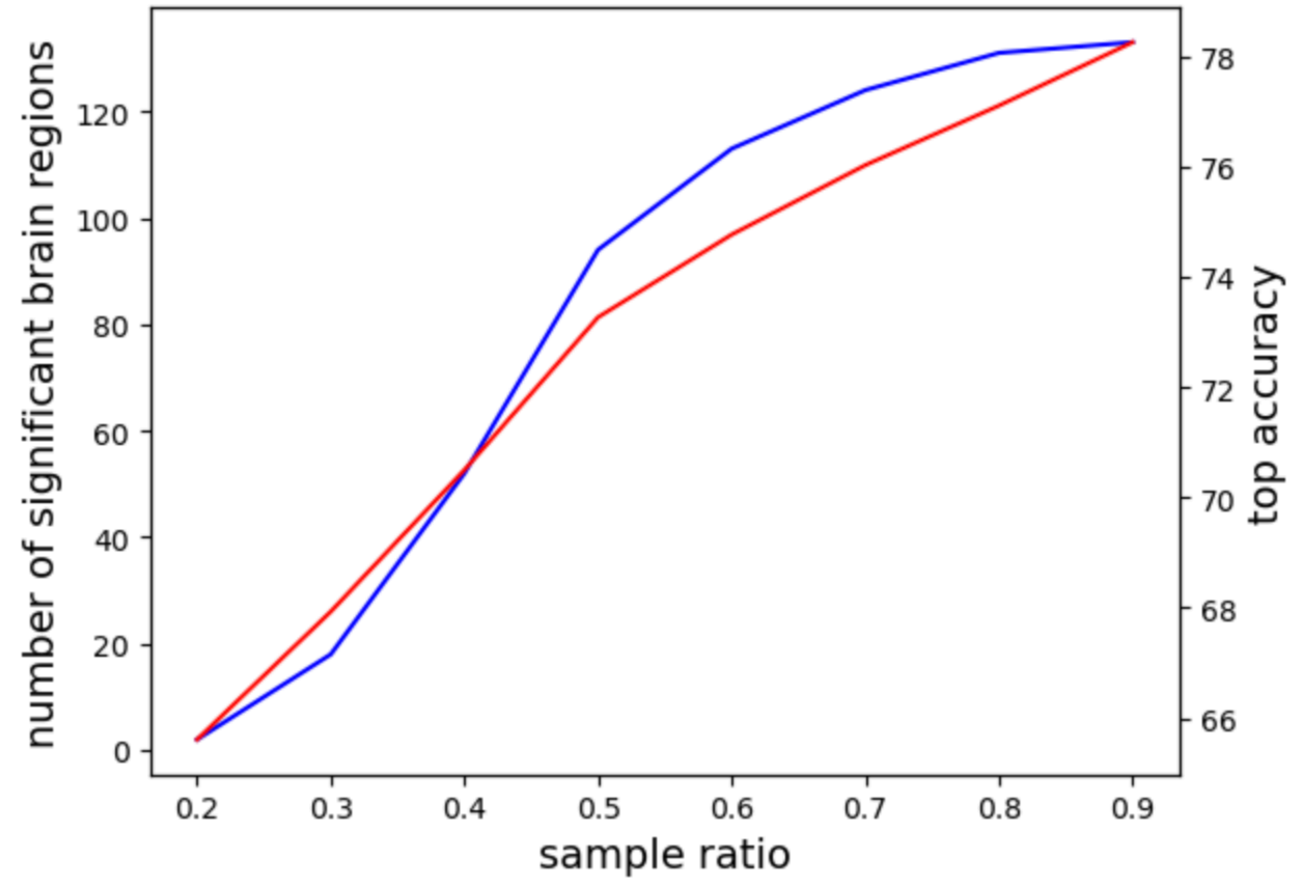
Imaging data analysis: Results



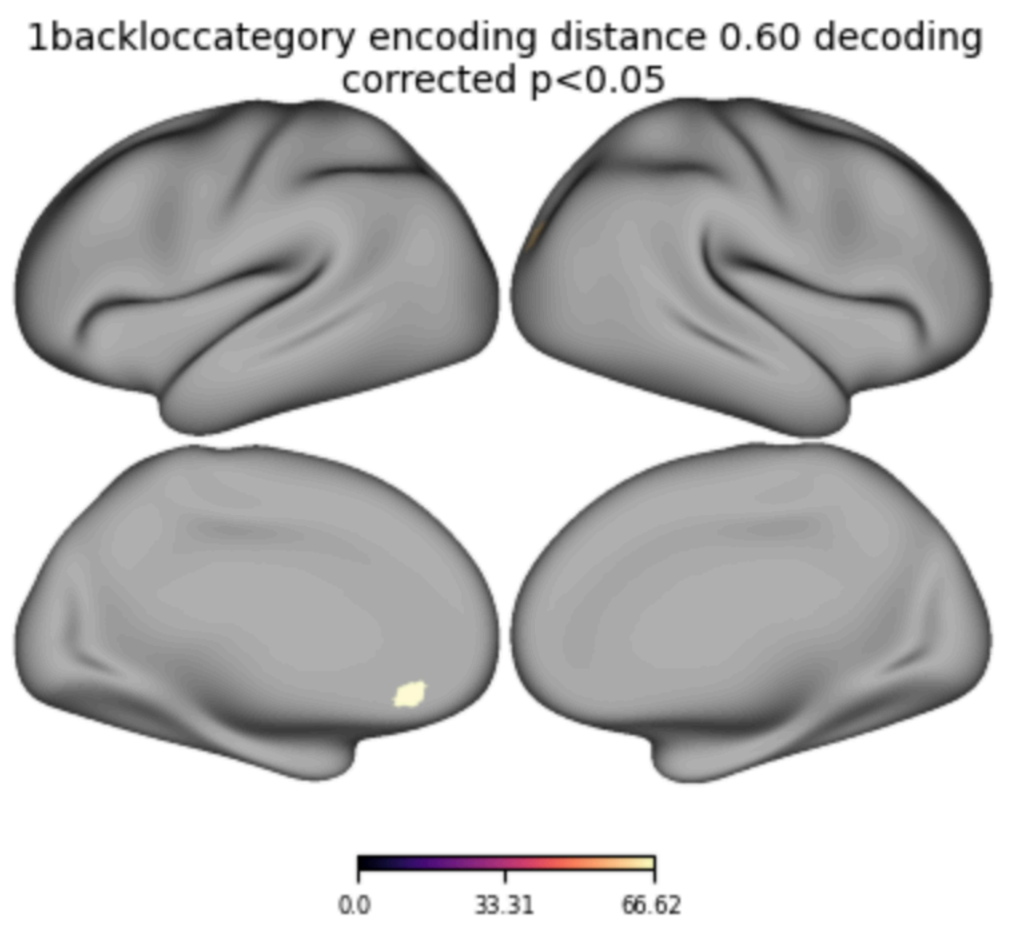
Notes: Cross Context Decoding analysis
Train on different task tested on 1backloc w.r.t indicated feature of interest
Although the overall decoding accuracy on the test dataset was lower than that of classifiers trained on the same dataset, we observed that the classifiers trained on different tasks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

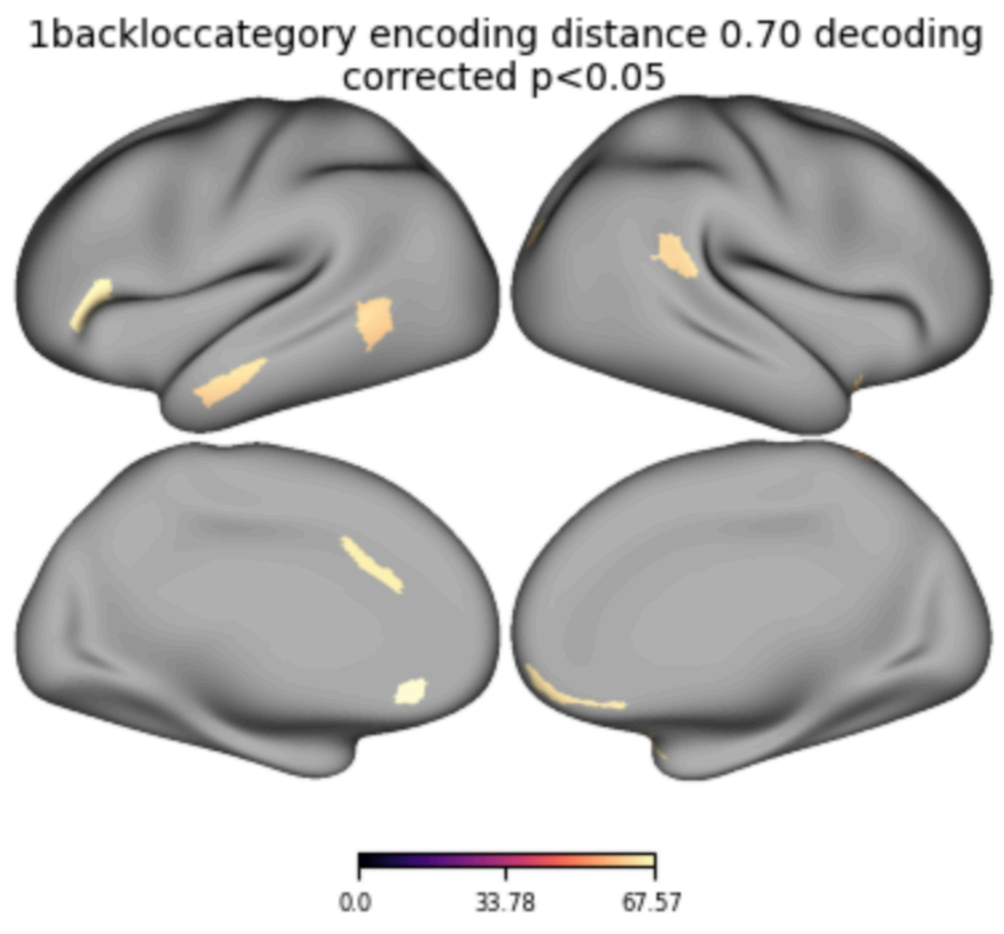
Imaging data analysis: Results

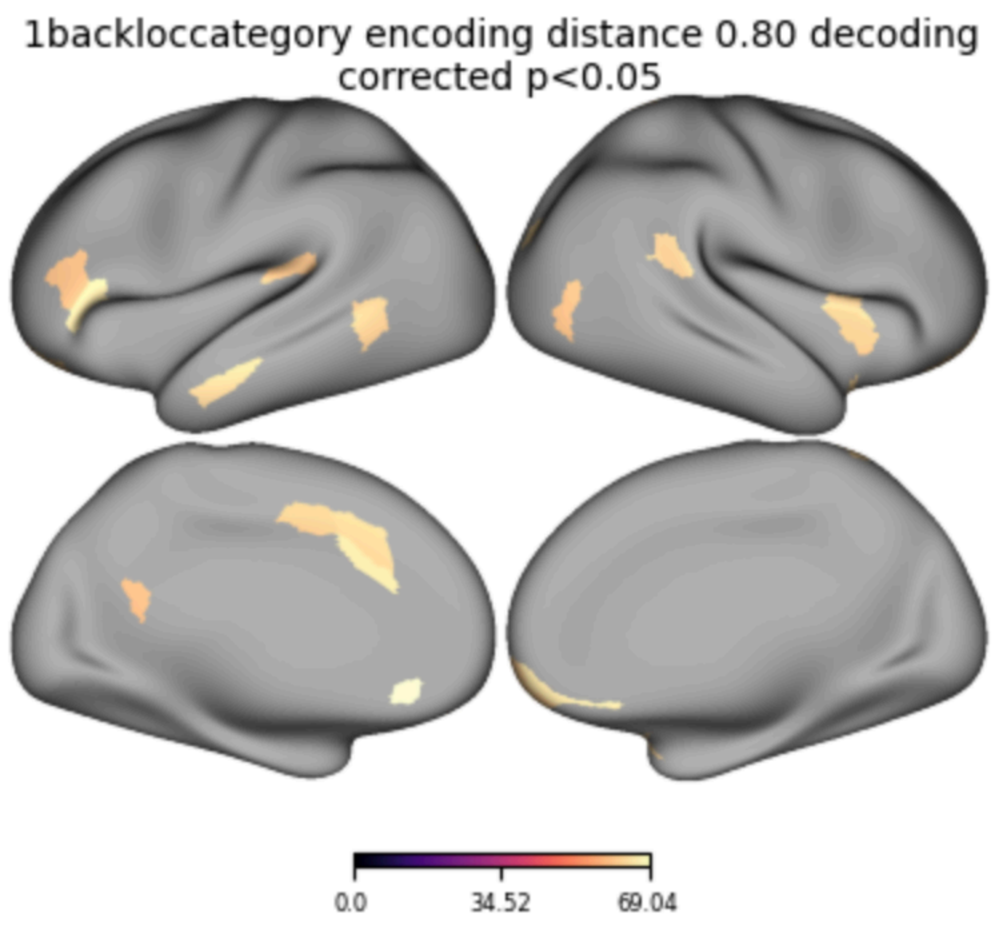


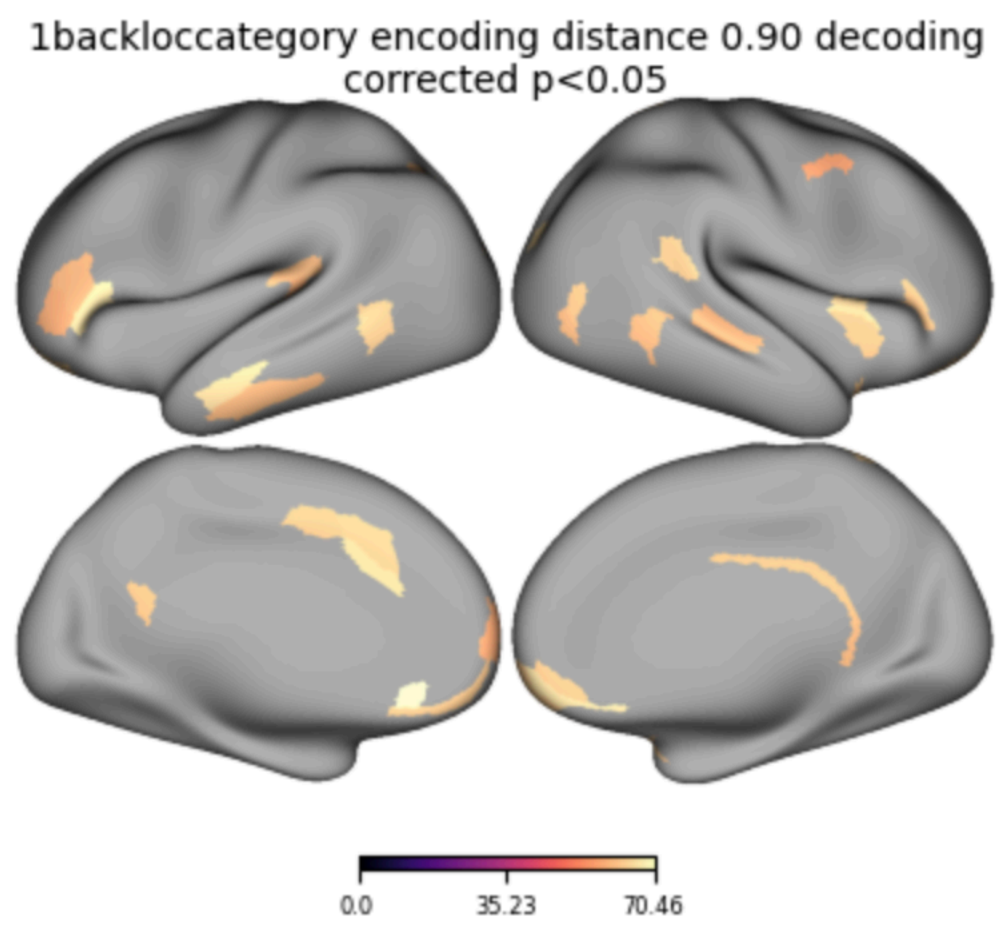


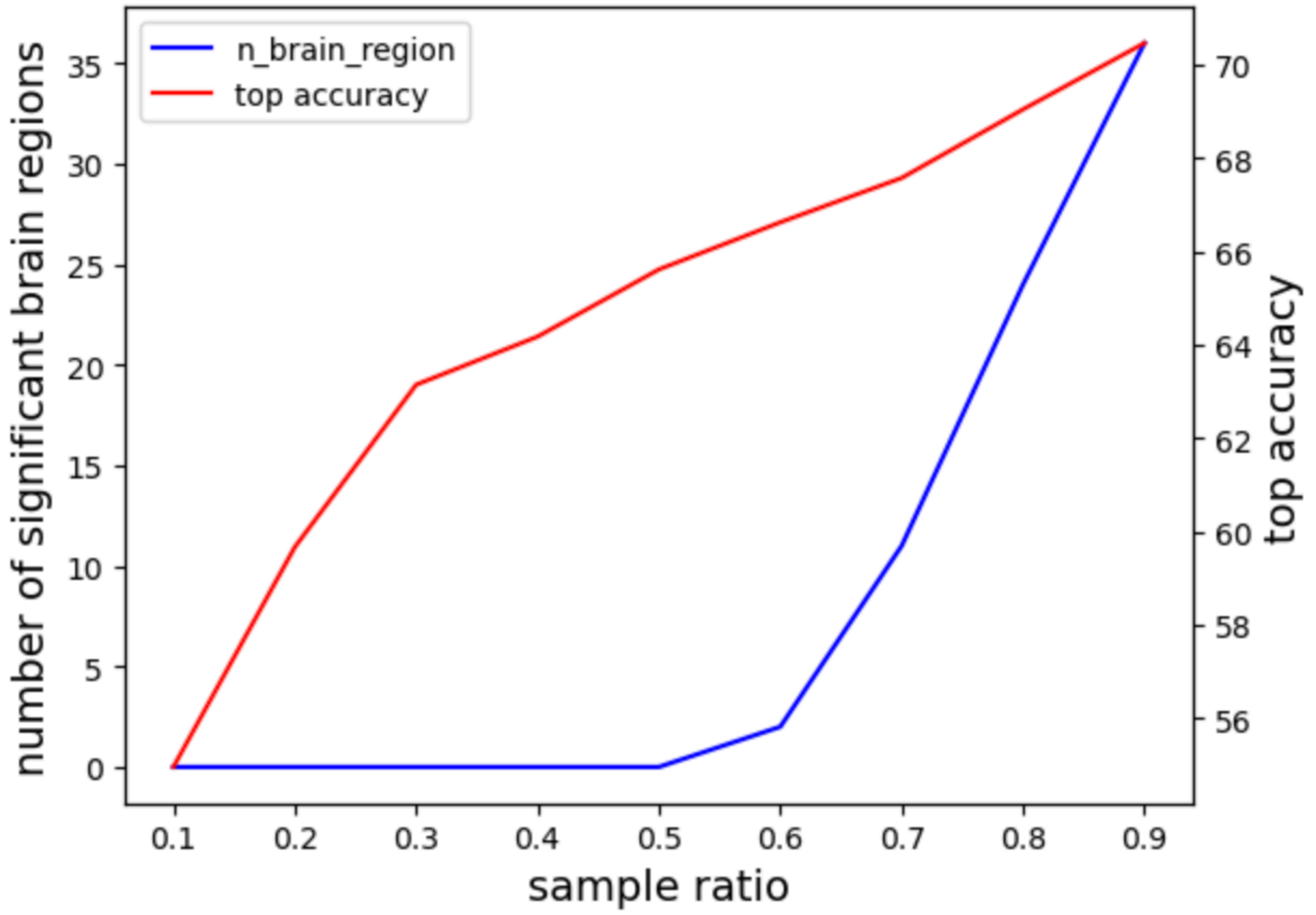
Imaging data analysis: Results











UPDATED tasks

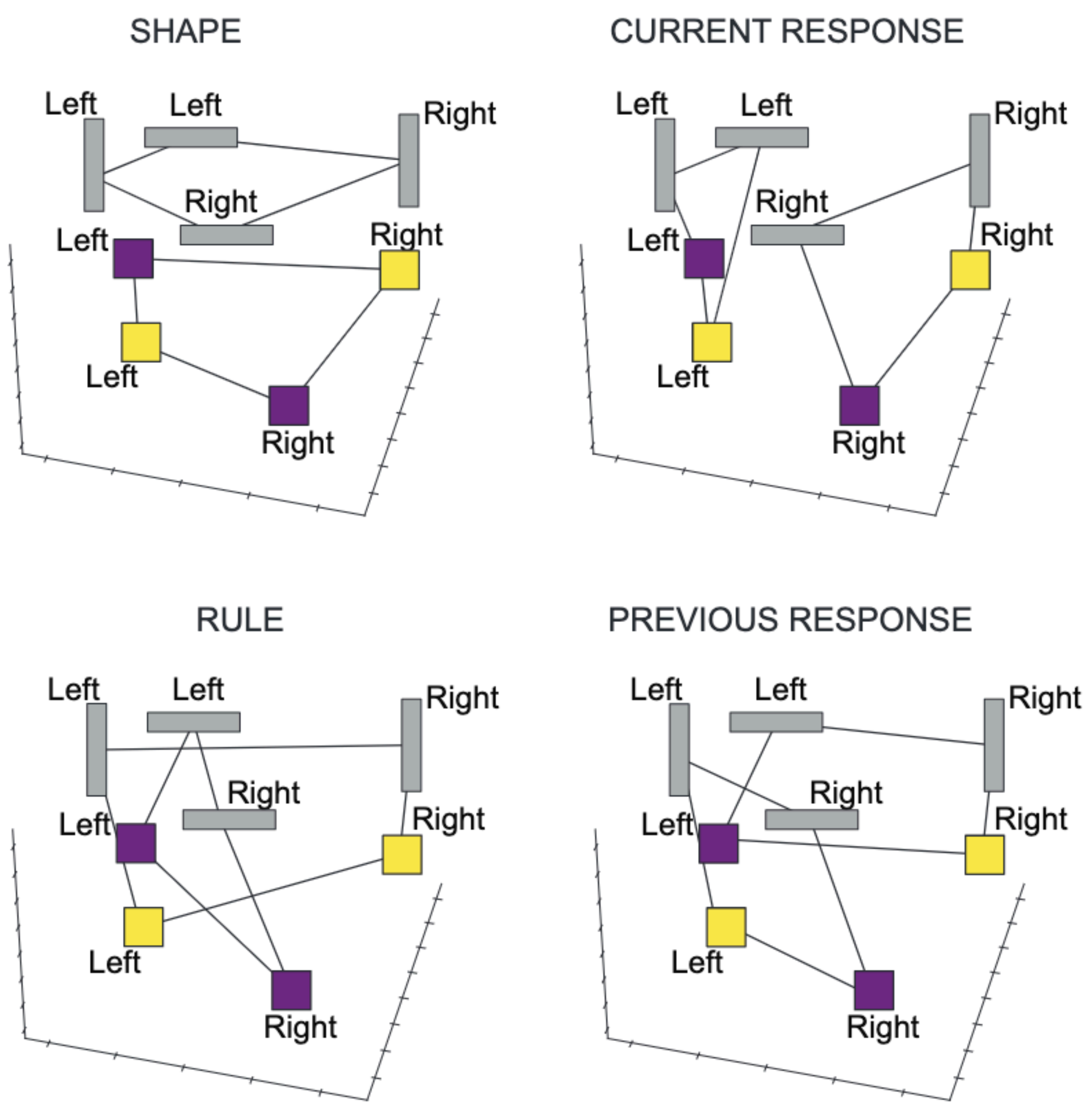
1. Longer stimulus presentation and delay period (to include at least 1TR + 2TR, detailed calculation see next page)
2. To guarantee decodable category/object information, replace car with faces
3. Make sure for each run, MRI trigger stimulus onset.

Behavioural Performance of the updated dataset

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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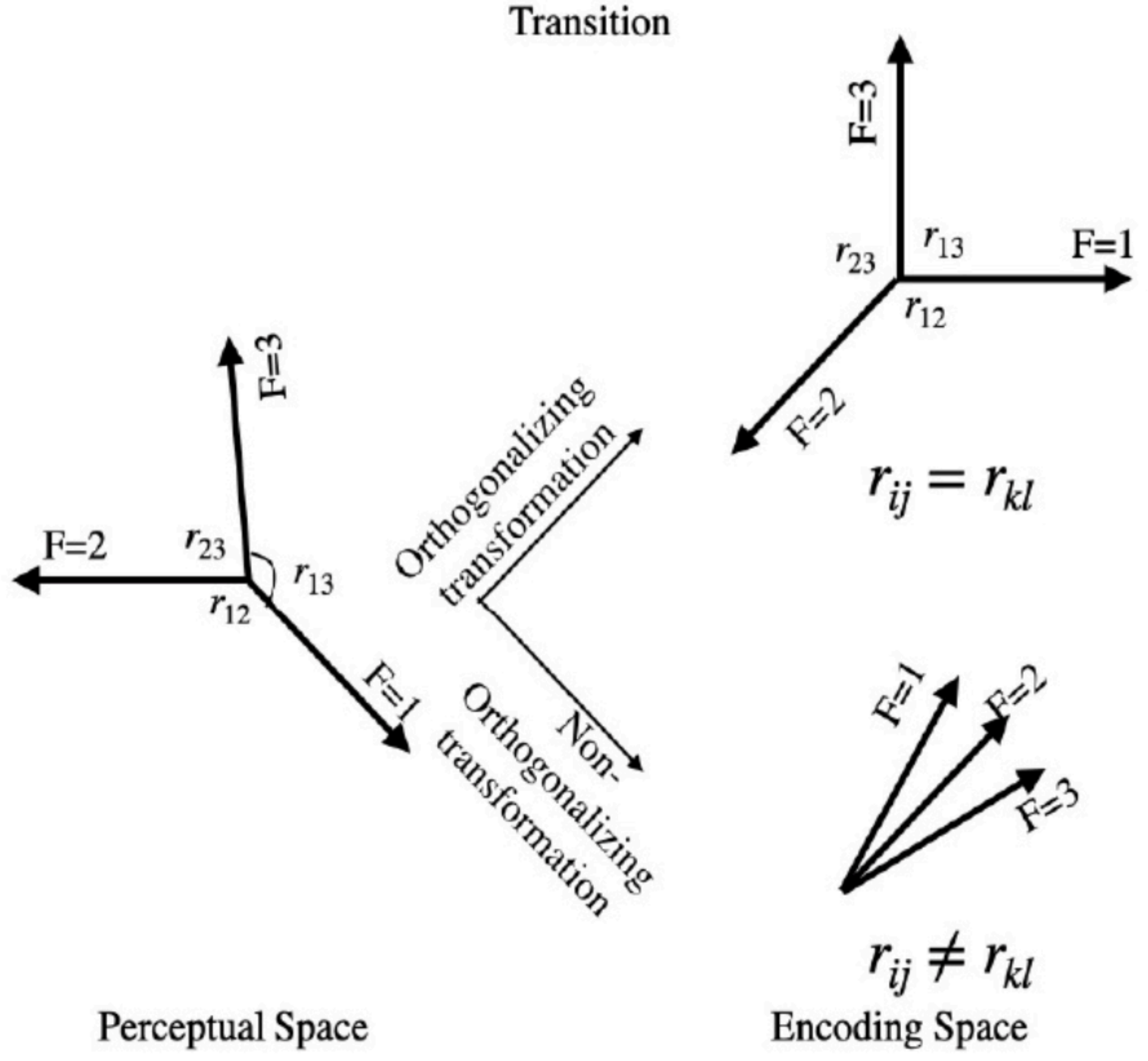
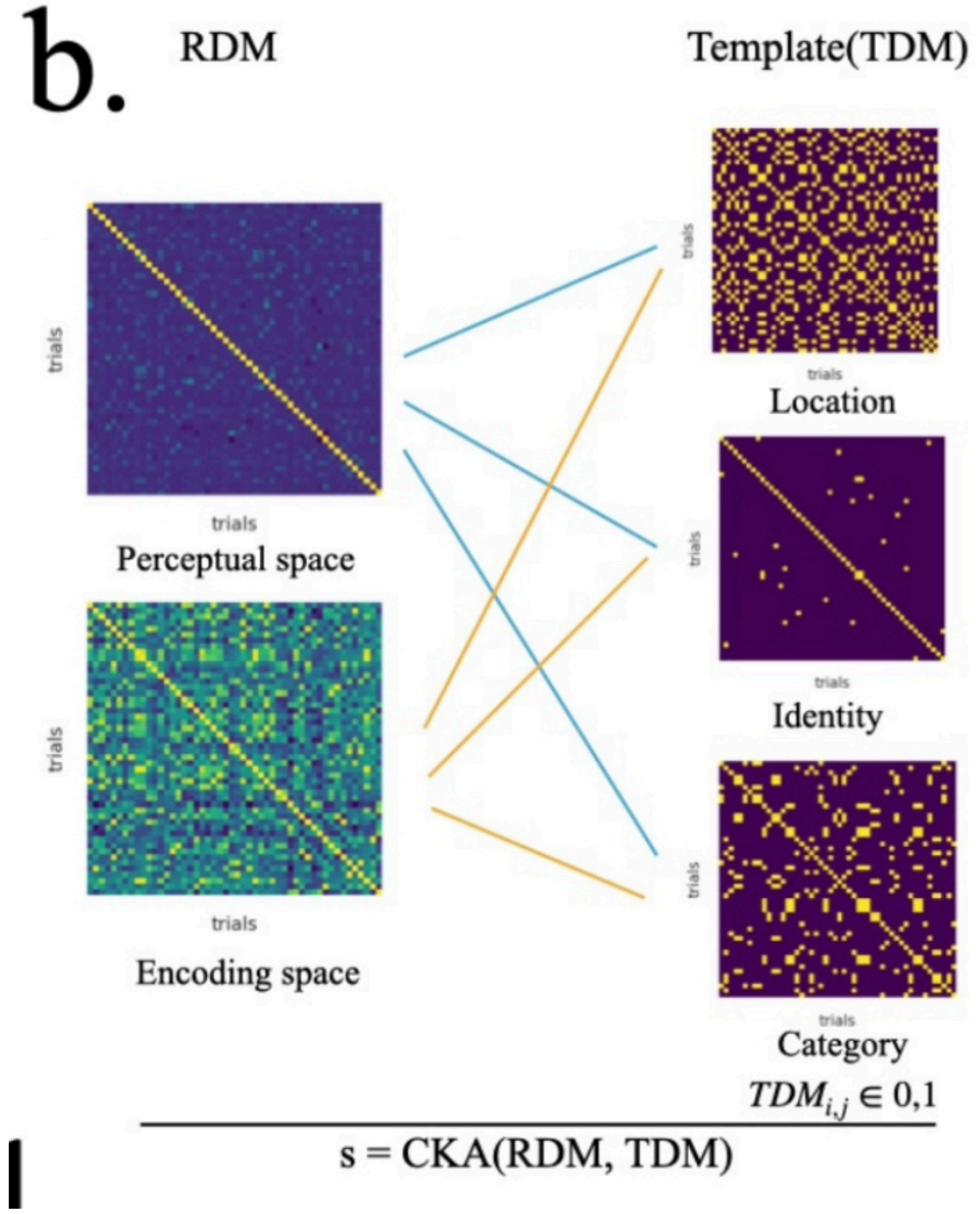
List of Research questions

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

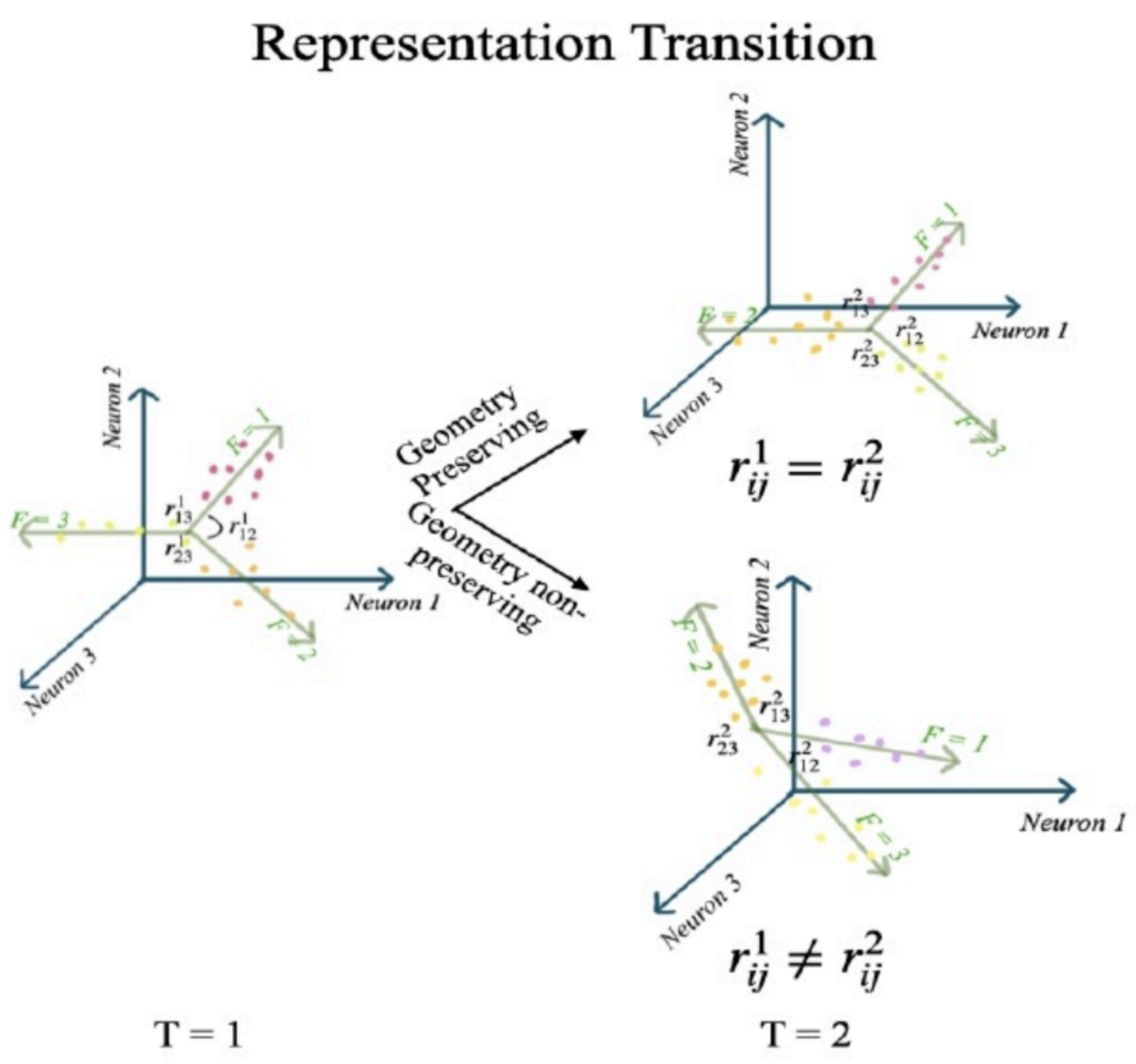


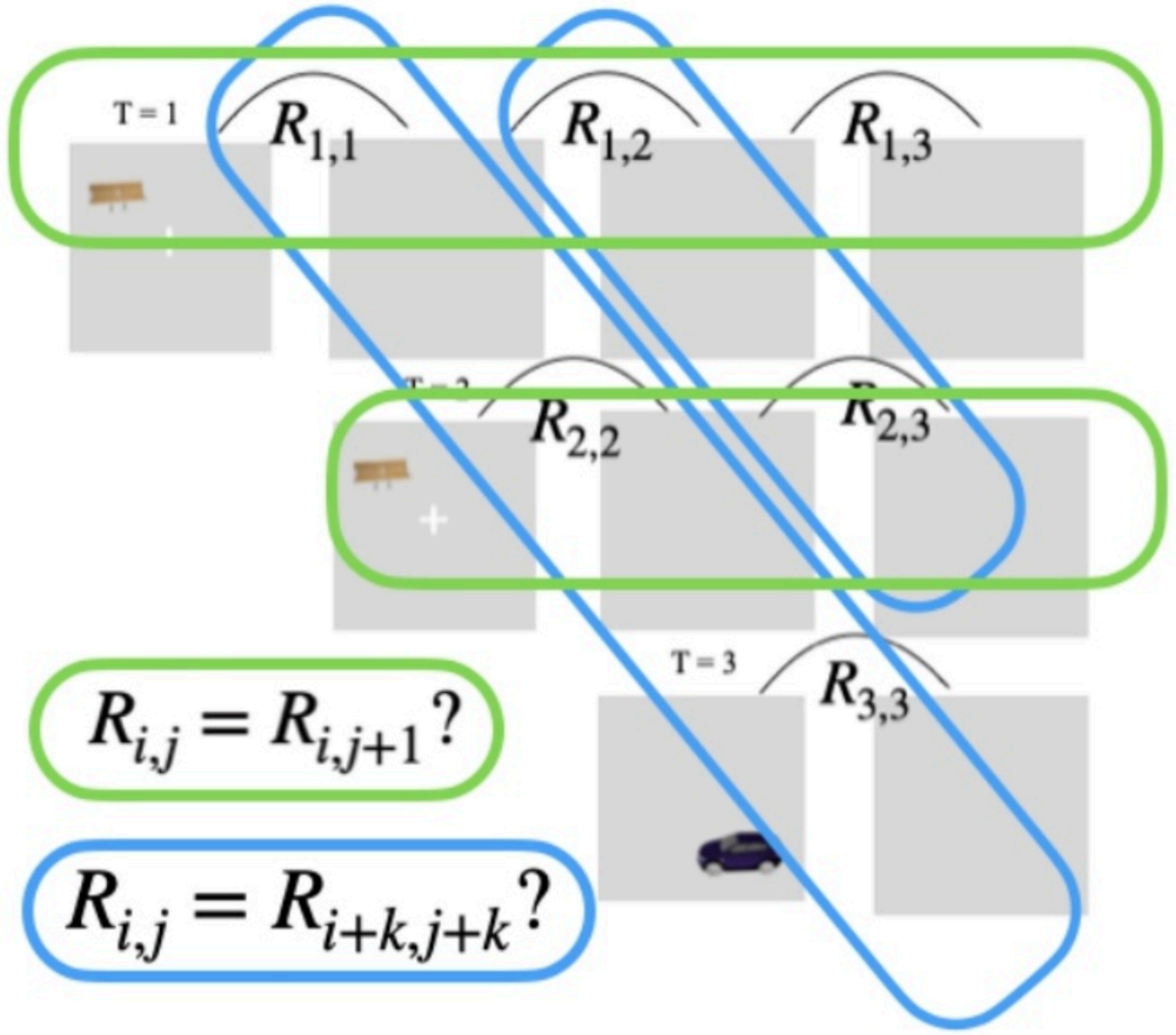


Updated idea of the previous Slide

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.





Idea list

1. (Pouya) Quantifying task independence vs. task dependence of representations across the brain
2. (Pouya) Representations during error trials task decoding
3. (Xiaoxuan)testing decoders across time persistence of task-relevant and irrelevant information: encoding and delay decoding of feature values cross-task generalization: representational stability across tasks orthogonolization of representations (from RNN analysis)dynamics of representation (cross time, cross-stage decoding) — decoding generalization across time for encoding, memory 1, memory 2, … the second analysis will be done using the ABAB taskfig 2b of science pape
4. (Ali) using a regularizer to force rotation matrices across time points to match with RDM matching or random projection angle matching. It could lead to more human-like WM Capacity because of remapping to selfUse column subset selection to pick the most informative voxel
5. (Ozhan) eigen-decomposition on the RDM or the activation matrix: https://elifesciences.org/articles/78606
6. (Lucas)time decoding across TRs within the same delay period: https://www.sciencedirect.com/science/article/abs/pii/S1053811917306651

How to access the data:

If you can:

```
source /lustre03/project/def-pbellec/share/data_admin/etc/bashrc
datalad install --reckless ephemeral -d . -s ria+file:///lustre03/project/rrg-pbellec/ria-beluga#~cneuromod.multfs.fmriprep@dev data/cneuromod.multfs.fmriprep
```

Otherwise:

Download from onedrive:

Scripts for accuracy analysis: