THINGS-fMRI/MEG: A large-scale multimodal neuroimaging dataset of responses to natural object images

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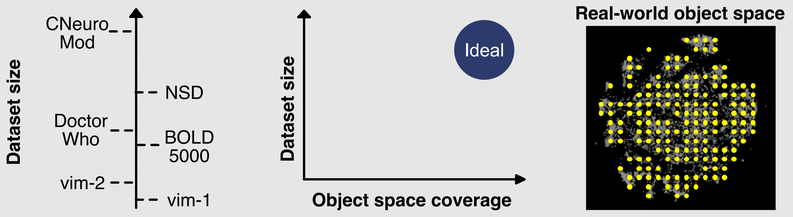
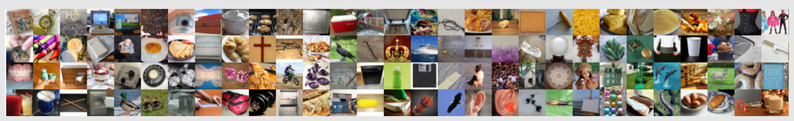
NIH National Institute of Mental Health

Background

- A detailed understanding of visual object representations benefits from **large-scale neuroimaging datasets for training and testing computational models**[1].
- Existing datasets[2, 3, 4, 5, 6, 7] focus on **dataset size** by presenting participants with large sets of images from computer vision research.
- However for object recognition research, another important dimension is **object space coverage**, i.e. extensive and representative object sampling.
- Previous large-scale efforts focused on **spatial** responses using fMRI - the **temporal** response profile remains largely unaccounted for.



The THINGS[8] object image database

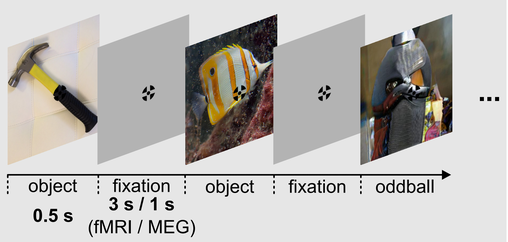


- **1,854 object concepts** (concrete, picturable nouns)
- **> 26,000** high-quality naturalistic object **images**
- **Rich annotation**
  (categories, typicality, size, semantic embeddings, core dimensions[9])

  → **Extensive and representative sampling**

Experiment

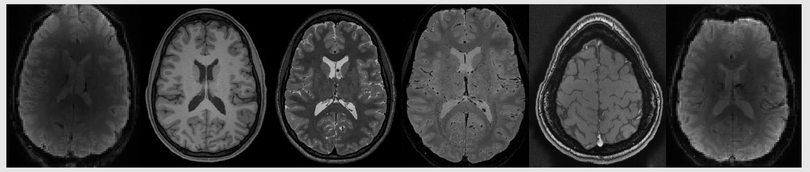
- **Oddball detection** task
- **12 sessions**
  10 runs per session
- Repeated images:
  fMRI: 100, MEG: 200
- Additional **NSD**[6] images



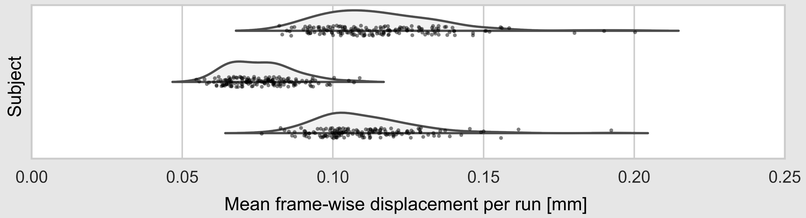
- **(f)MRI**: **3 Participants**, **8,740 unique images** of **720 objects**
- **MEG**: **4 Participants**, **22,448 unique images** of **1,854 objects**

fMRI dataset

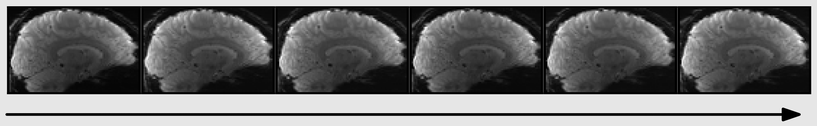
- **3 Tesla** fMRI, **2mm** functional resolution, 1.5 s TR, whole-brain coverage, physiological recordings
- **Comprehensive neuroimaging data**



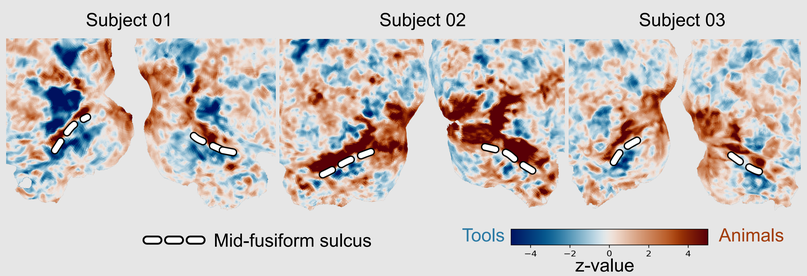
- Custom head casts → **Very little head motion** (MRIQC[10])



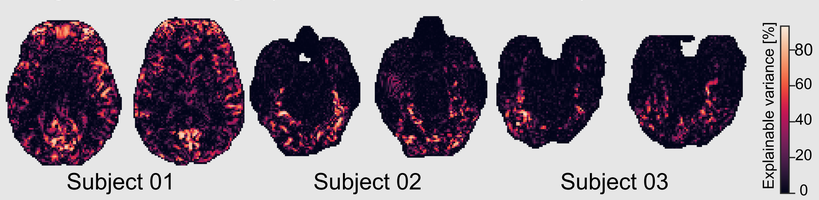
- **High image stability** after preprocessing (fMRIPrep[11])



- **Validation: "Animals vs. Tools"** contrast replicates[12] animacy effect.

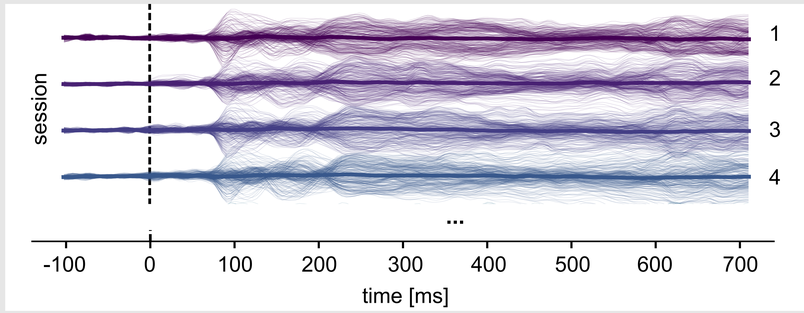


- High **noise ceilings** (Monte Carlo simulation[13,14])

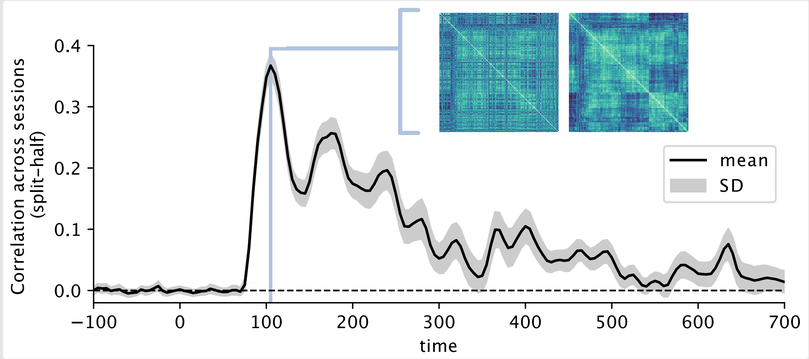


MEG dataset

- **272 channels** → high spatial and temporal resolution



- **Consistent responses** across sessions (split-half correlation)



Conclusion

- We present two neuroimaging datasets that combine
  a. **Extensive and representative sampling of object images**
  b. **Large number of measurements per subject**
  c. **High spatial and temporal resolution**
  d. **High data quality**
  e. **Rich annotation**
- These datasets may provide a basis for an extensive evaluation of object recognition in the human brain.
- Data will be made publicly available upon manuscript publication.

References

[1] Naselaris & Kay, *Current Opinion in Behavioral Sciences* (2021)
[2] Kay et al., 2008, *Nature* (2008)
[3] Nishimoto et al., *Current Biology* (2011)
[4] Chang et al., *Scientific Data* (2019)
[5] Seeliger et al., *bioRxiv* (2019)
[6] Allen et al., *bioRxiv* (2021)
[7] Bellec & Boyle, *PsyArXiv* (2019)
[8] Hebart et al., *PLOS ONE* (2019)
[9] Hebart et al., *Nature Human Behavior* (2020)
[10] Esteban et al., *PLOS ONE* (2017)
[11] Esteban et al., *Nature Methods* (2019)
[12] Konkle & Caramazza, *Journal of Neuroscience* (2013)
[13] Lage-Castellanos et al., *PLOS Computational Biology* (2019)
[14] Kay et al., *Journal of Neurophysiology* (2013)

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