Behavior measures are predicted by how information is encoded in an individual's brain

Jennifer Williams
Carnegie Mellon University
jlw1@cmu.edu

Leila Wehbe
Carnegie Mellon University
lwehbe@cmu.edu

Computational Biology Department

Machine Learning Department

Neuroscience Institute

Summary

- **Motivation:** How can we map differences in our brains to differences in our behavior?
- **Open question:** Do individual differences in how information is encoded in the brain predict behavior measures?
- **Proposed framework:** Use encoding-models to identify individual differences in brain representations and test if these differences can predict behavior.

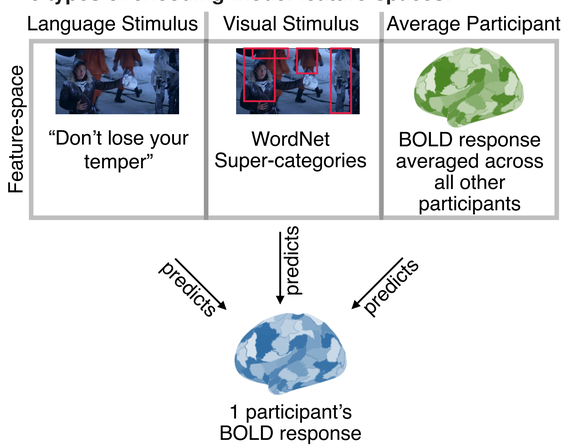
Takeaways:
- Individual differences in brain encoding:
  (1) are feature-space and task specific
  (2) can be used to predict variability in cognitive behavior
- Researchers should optimize their choice of task and encoding-model for their behavior of interest

Hypothesis

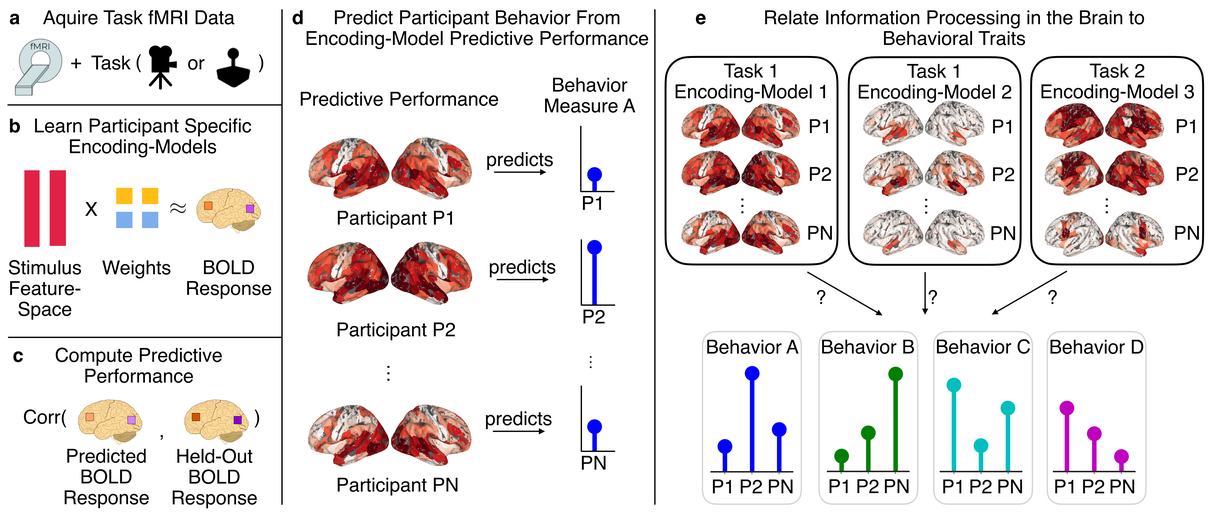
- **Prior work** predicted behavior measures from individual differences in brain anatomy, functional connectivity, and structural connectivity. What about the stimulus-driven response in the brain regions?
- **We hypothesize** that individual differences in how information is encoded in the brain are task-specific and predict different behavior measures
- **Analogy:** Athletic ability is not only related to muscle size or the connections between muscles, it is also related to how the athletic task recruits the muscles.

Data and Feature-spaces

- **Data:** fMRI data collected when 90 Human Connectome Project participants watched 1 hr of naturalistic video clips and performed a tightly controlled motor task for 7 min.
- **3 types of encoding-model feature-spaces:**

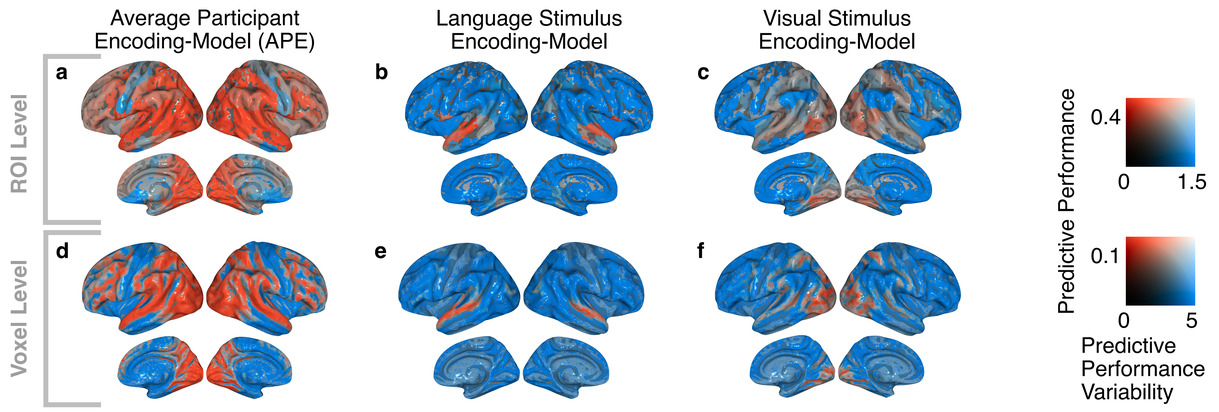


Framework



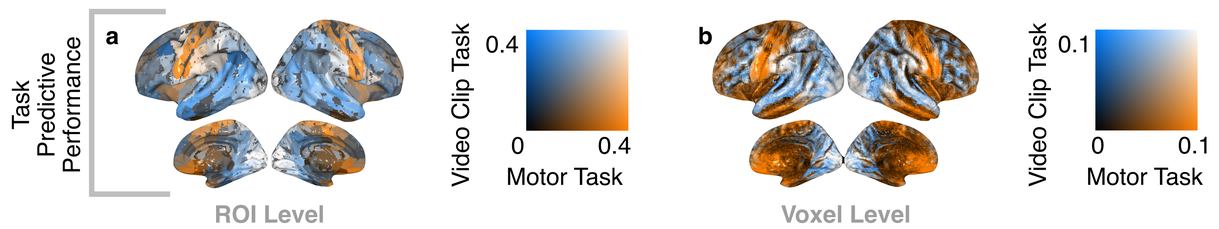
Enables testing of what task/encoding-model combinations predict different behavior measures.

Encoding-model performance is feature-space specific

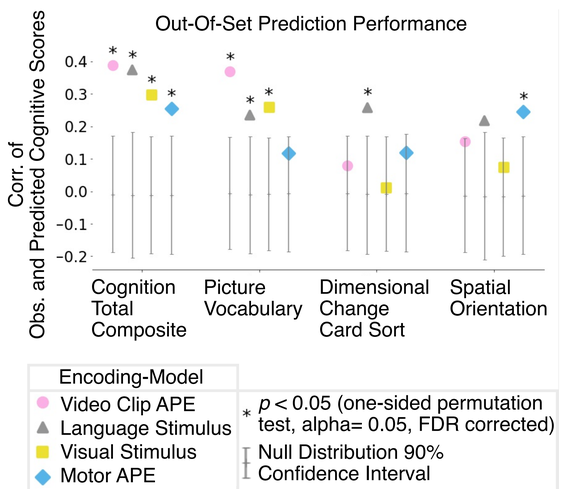


Comparison of average predictive performance (across participants) to its variability.

Encoding-model performance is Task Specific



Behavior Measures are Predicted



Individual differences in encoding-model performance predict cognitive behavior.

For both tasks, head motion is not significantly:
- correlated with any cognitive behavior measure
- predicted by encoding-model performance
- predictive of cognitive behavior

Significance: $p < 0.05$, FDR corrected

Conclusion

- Encoding-models can reveal individual differences
- We can improve our understanding of the brain behavior relationship by relating how information is encoded to behavior

Paper & Code

Paper: arXiv 2112.06048
Code: github.com/brainML/great-apes

References

1. Van Essen et al. 2013. The WU-Minn Human Connectome Project: An overview. NeuroImage.
2. Mikolov et al. 2013. Distributed representations of words and phrases and their compositionality. NIPS.
3. Fedorenko et al. 2010. New Method for fMRI investigations of language: defining ROIs functionally in individual subjects. Journal of neurophysiology.

Acknowledgements:
JW was funded by the Center for Machine Learning and Health. LW by the Google Faculty Research Award.