Detecting Boredom in fMRI tasks

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Boredom: *"The Aversive State of Wanting, but Being Unable, to Engage in Satisfying Activity"*

Dataset: We chose to work with the HCP dataset because it includes resting state scans as well as WM task state scans from a 339 individuals (large N)

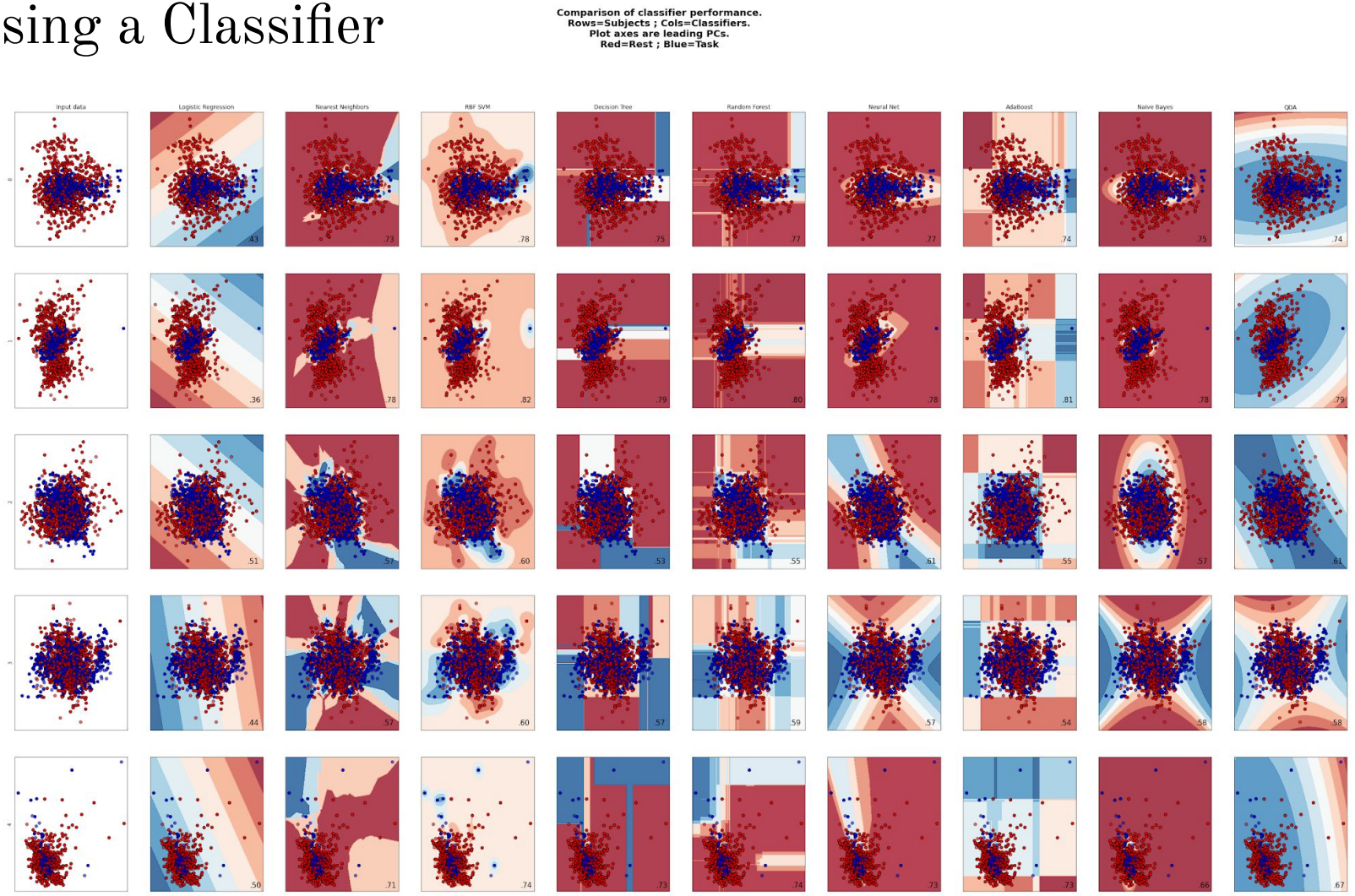
Scientific Question: Is it possible to detect boredom from fMRI data while participants are supposed to be performing a task?

A priori Regions of Interest: Default Mode Network - hallmark of resting state; strong overlaps with boredom

Conclusion: Based on our preliminary analyses, in trials with behavioral lapses, offline and online processing can be reliably distinguished - suggesting that a signature of boredom exists within task data

References: Moreira, P. S., Marques, P., & Magalhães, R. (2016). Identifying functional subdivisions in the medial frontal cortex. Journal of Neuroscience, 36(44), 11168-11170. Van Den Heuvel, M. P., & Pol, H. E. H. (2010). Exploring the brain network: a review on resting-state fMRI functional connectivity. European neuropsychopharmacology, 20(8), 519-534. Danckert, J., & Isacescu, J. (2017, September 27). Danckert & Isacescu fMRI of boredom replication. Greicius, M. D., Krasnow, B., Reiss, A. L., & Menon, V. (2003). Functional connectivity in the resting brain: a network analysis of the default mode hypothesis. Proceedings of the National Academy of Sciences, 100(1), 253-258. Eastwood, J., Frischen, A., Fenske, M., & Smilek, D. (2012). The Unengaged Mind: Defining Boredom in Terms of Attention. Perspectives on Psychological Science, 7(5), 482-495. Retrieved July 31, 2020, from www.jstor.org/stable/44280796

Choosing a Classifier



Introducing the Boredom Detector

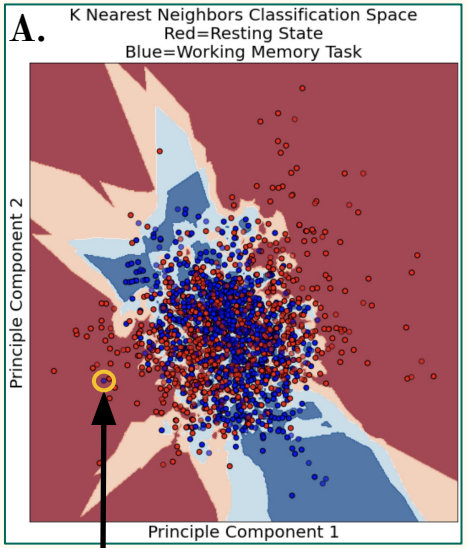
Input

- BOLD samples with task state labels (WM vs. Rest)
- Subset of HCP data: Just working memory task and resting state
- Equalized number of samples for each label

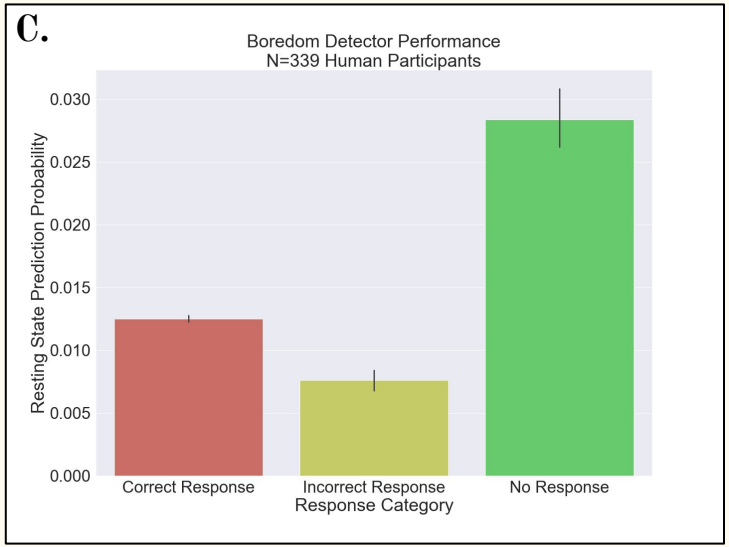
K Nearest Neighbors Classifier

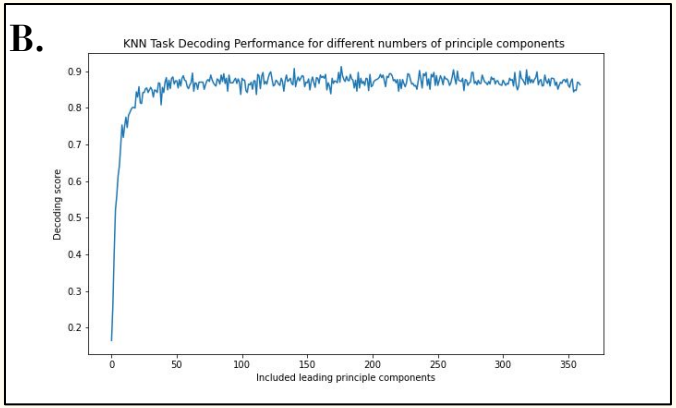
Output

- Prediction probability that each sample belongs to resting state task

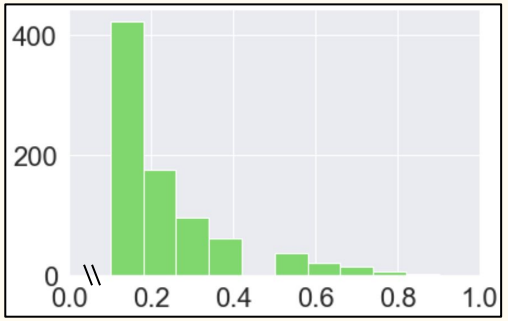


A. Some WM task trials closely resemble resting state trials in classifier space. We predicted that these trials would show behavioral signs of boredom. **B.** Reduced dimensionality data can be used to perform this analysis, increasing potential for practical application of the boredom detector in a research setting. **C.** Our KNN classifier assigned significantly higher resting state prediction probabilities to No-Response WM trials, validating the boredom detector hypothesis, incorrect response trials notwithstanding. **D.** Prediction probability, not just prediction accuracy, is a sensitive measure of boredom.





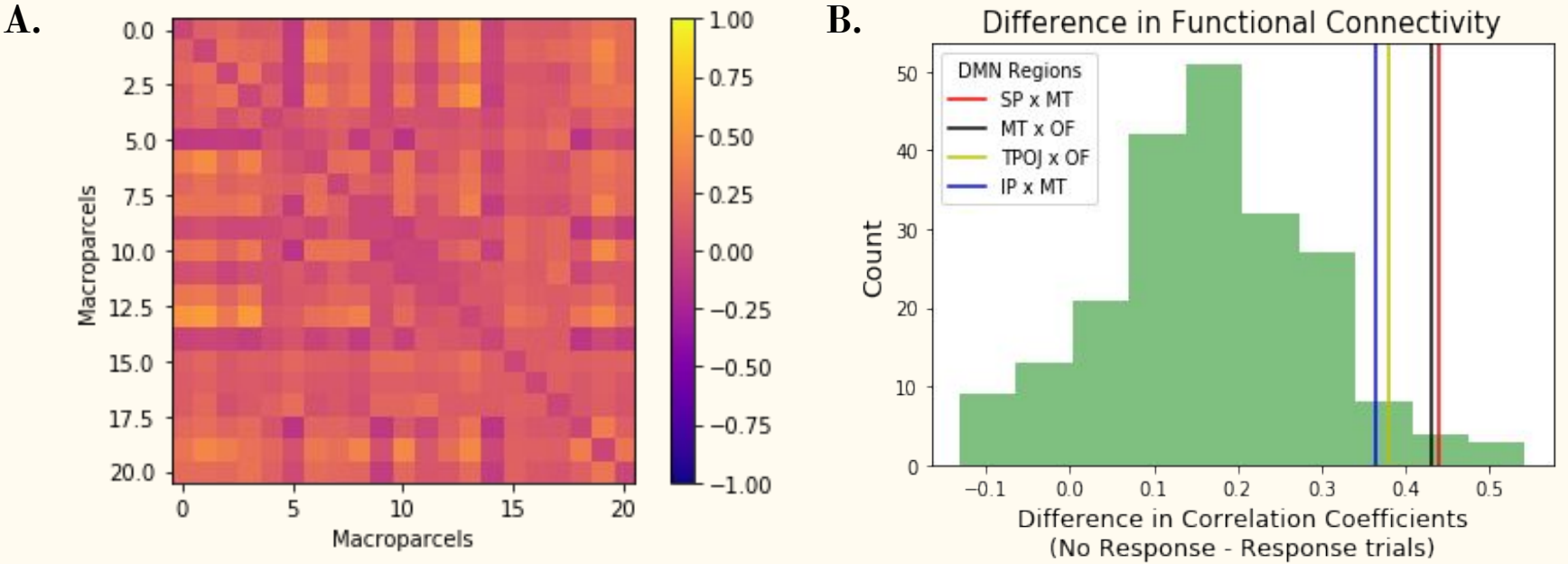
Histogram of rest state prediction probabilities in No-Response trials



An

Production

Supporting Evidence for Boredom



A. The resulting correlation matrix when we take the difference between the candidate-bored and the non-bored correlation matrices. **B.** Difference in resulting correlation coefficients between no-response and response trials during working memory task. Vertical lines represent coefficient differences for functional associations implicated in the Default Mode Network (see Moreira et al, 2016; Van Den Heuvel et al, 2010; Greicius et al, 2003).

Future Directions

- Applying cross-validation to make task classifier more robust
- Level 2 analysis - using functional connectivity matrices to classify boredom
- Correlating classifier performance with eye-tracking (if available)
- Developing a real-time boredom classifier (or even a boredom predictor) to minimize task response loss in a cogneuro laboratory context
- Evaluating boredom propensity (predictive model) or prevalence (classification model) across demographics, tasks, and pathologies
- Revisiting prior analyses with different methods (DNNs, dynamical systems)