The Neural Basis of Working Memory Load: Within vs. Between-Subjects Variation

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Introduction

- **Neuroimaging studies of working memory (WM)[1]:** Typically focus on one of two different ways of analyzing brain networks:
  - **Within-subjects analysis:** Tends to identify the network that is the most consistently activated in the sample.
  - **Between-subjects analysis:** Tends to identify the network that shows the largest variability in the sample.
- **Frontal and parietal network functional dissociation[2]:**
  - **Frontally-centered network:** contributes to attention dependent performance.
  - **Parietally-centered network:** contributes to working memory dependent performance.
- **Most human functional MRI (fMRI) studies have low statistical power[3]**

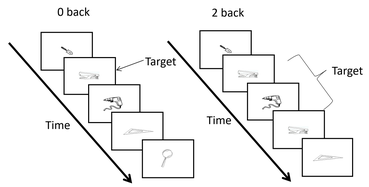
Current Study Questions

- **Question1:** Are effect sizes at the level of brain parcels reliably larger than at the level of brain voxels (c.f. Poldrack et al., 2017)?
- **Question2:** Are parcels that show large within-subject effects also the ones that show large between-subject effects?
- **Question3:** How well do parcels showing significant effects during in-scanner task predict out-of-scanner task performance (c.f. Satterthwaite et al., 2013)?

General Method

Data:

- HCP 1200 subjects release.
- N-back task (categorical): 2bk ,0bk
- Gordon Parcellation[4] scheme masked.

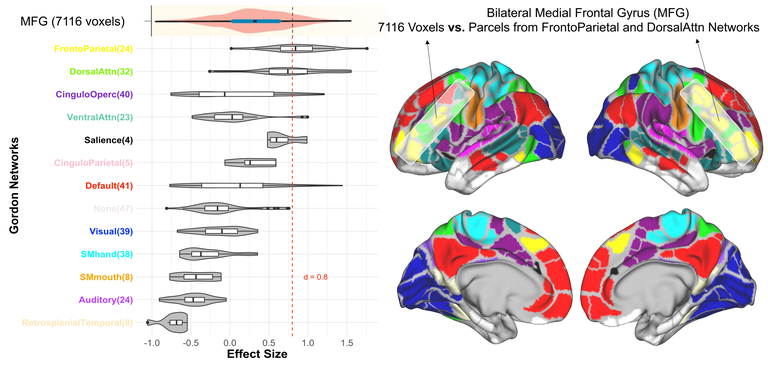


Measures:

- **Within-subjects effect size: Cohen's d** (every parcel)
  - Standardized difference between the mean activation during 0-back and the mean activation during 2-back.
- **Between-subjects effect size: r** (every parcel)
  - Correlation between each parcel's activation contrast (2bk – 0bk) and individual n-back performance.

Parcels Have Larger Effect Sizes

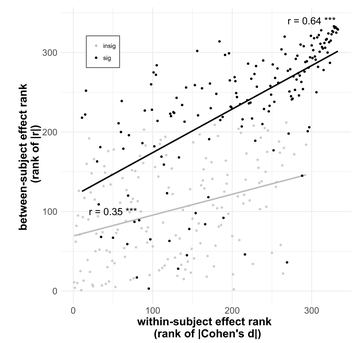
Effect Size at the level of Parcel (vs. voxel) (Gordon Parcellation)



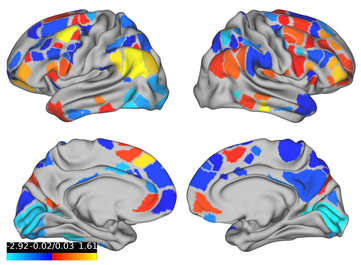
- HCP 500-subject release of the HCP data: mean Cohen's d is under d=0.8 for voxels in the selected ROI (Poldrack et al., 2017).
- Effect sizes at the level of **parcel** are larger than those at the level of **voxel**.

The Most Consistently Activated Parcels Also Have the Most Variability

Significant vs. Insignificant Parcels



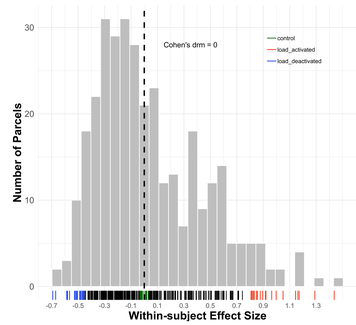
Within vs. Between WM Network

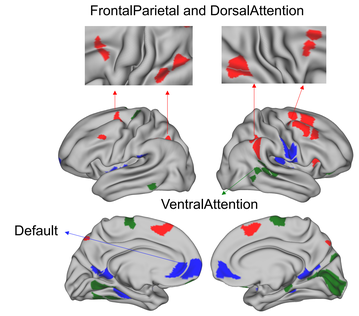


- For WM-involved parcels, within-subjects effect sizes strongly predict between-subjects effect sizes (r=0.64).
- Left DLPFC: between-effect size > within-effect size
- Right DLPFC: within-effect size > between-effect size
- PFC and PPC contribute to within and between-subject variations in WM-related tasks equivalently.

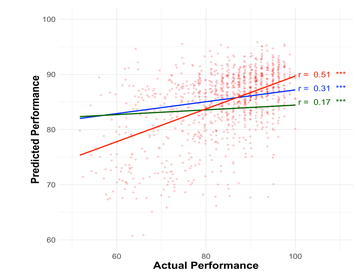
Multivariate Model (SVR) Has Greater Predictive Power

Predictive Power of Load-activated vs. Load-deactivated networks

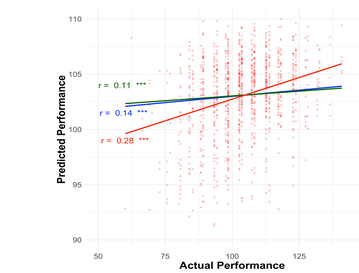




Predicting in-scanner performance (n-back)



Predicting out-scanner performance (list-sorting)



- Cross-validated support vector regression model: Stronger prediction with load-activated network (r = 0.51) predictors vs. load-deactivated network predictors (r = 0.31) (cf. Satterthwaite et al., 2013); multivariate model has greater predictive power than univariate (single parcels; 0.51 vs. .35)
- Load-activated network also predicts out-of-scanner performance (r=0.28) but predictive power is lower than in-scanner task performance (r = 0.51)

Future Directions

- Test whether within vs. between-subject perspective is useful for cognitive abilities other than working memory.
  - Do the most consistently activated regions always show the largest activation variability?
- Cross-participants predictive power:
  - Does the load-activated network identified above have the same predictive power for out-of-sample dataset and a different working memory load manipulation?

1. Yarkoni, T., & Braver, T. S. (2010). *Handbook of individual differences in cognition* 2. Egli et al., (2018). *Cognition and Behavior* 3. Poldrack et al., (2017). *Nature reviews Neuroscience* 4. Gordon et al., (2014). *Cerebral Cortex* 5. Correspondence: Peeta Li (yichen.li@wustl.edu)