Predicting Executive Functioning from Brain Networks: Modality Specificity and Age Effects

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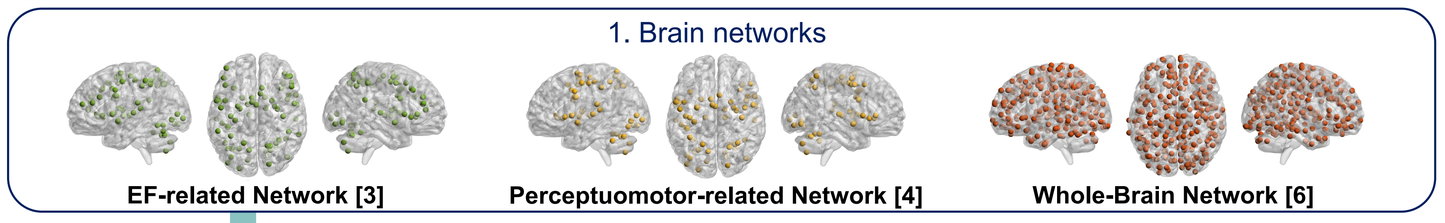
Introduction

- **Healthy aging** is associated with structural and functional changes in brain networks associated with **executive functioning** (EF)
- Despite a known association between **resting-state functional connectivity** (RSFC) and EF [1], its potential as a **marker for individual differences in EF performance** has been questioned [2]
- Therefore, we examined to what degree **individual EF abilities** in low-demand (LD) and high-demand (HD) task conditions can be **predicted** from different brain metrics: RSFC, **gray-matter volume** (GMV), **regional homogeneity** (ReHo), **and fractional amplitude of low frequency fluctuations** (fALFF) from an EF-related and EF-unrelated brain networks

Research Questions:

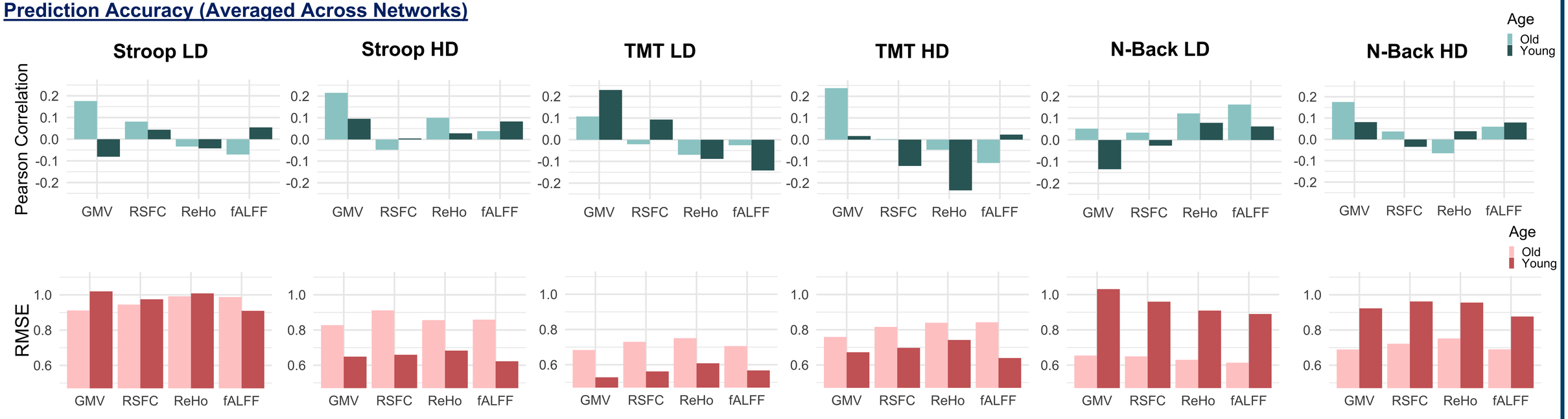
- ***Does one of the metrics outperform the others in predicting EF?***
- ***Does this pattern change depending on network, task-demand, or age group?***
- ***Do young and old adults differ in their predictability depending on metric, network, or task-demand level?***

Methods



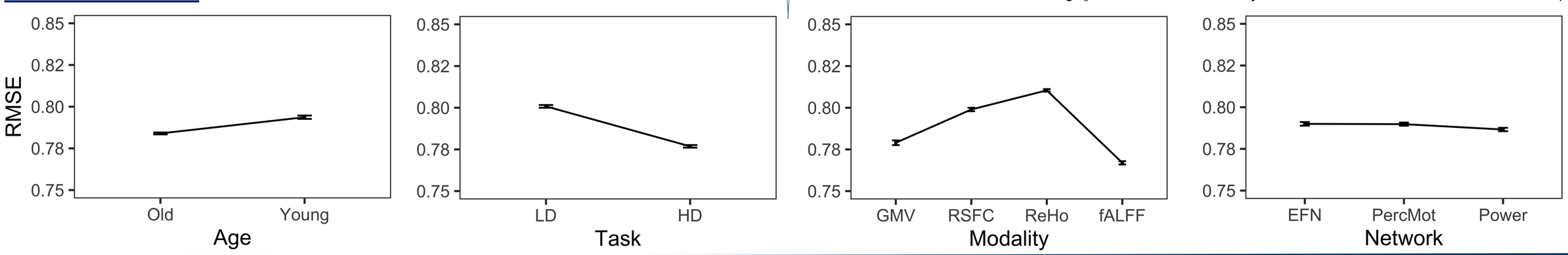
Results

Prediction Accuracy (Averaged Across Networks)

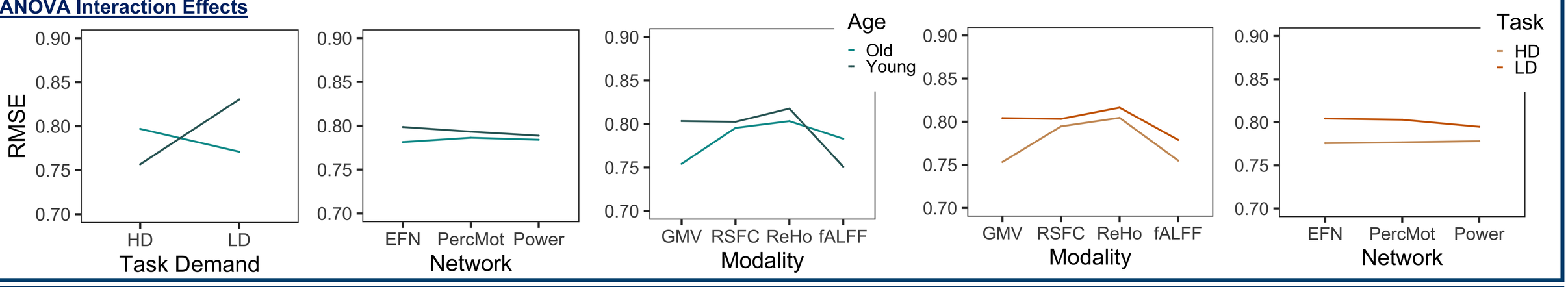


ANOVA Main Effects

All main and interaction effects sig. ($p < .00005$, Bonferroni-adjusted for the 10 × 100 cross-validation scheme)



ANOVA Interaction Effects



Discussion

- The overall **low to moderate prediction accuracies** together with the **missing network specificity** across modalities question the utility of the brain metrics examined as biomarkers for individual differences in EF performance
- However, our results point out a **superiority of GMV and fALFF** compared to ReHo and RSFC – possibly, because these metrics are **less susceptible to state effects** (e.g., mind wandering, thinking about a task) [7]
- In particular, structural measures of **overall atrophy** might be more informative in older adults, while functional measures of **brain variability** [8] might contain more information of individual differences in EF performance in younger adults
- Our results stress the need for **adaptive behavioral testing** in order to capture meaningful brain–behavior associations as prediction accuracies in LD (vs. HD) task conditions were better for older and in HD (vs. LD) conditions for younger adults

Conclusions:

- ***Still a long way to go to identify practically useful brain-based biomarkers of EF abilities***
- ***Global properties of the brain might contain more information about individual differences in EF abilities***
- ***Our results stress the need for adaptive behavioral testing (age × task demand)***

References: [1] Langner, R., et al. (2015), 'Aging and response conflict solution: behavioural and functional connectivity changes'; Steffener, J., et al. (2009), 'The Impact of Age-Related Changes on Working Memory Functional Activity'. [2] Heckner, M.K., et al. (2023), ` Predicting Executive Functioning from Functional Brain Connectivity: Network Specificity and Age Effects`. [3] Worringer, B., et al. (2019), 'Common and distinct neural correlates of dual-tasking and task-switching: a meta-analytic review and a neuro-cognitive processing model of human multitasking'; Langner, R., et al. (2018), 'Towards a human self-regulation system: Common and distinct neural signatures of emotional and behavioural control'; Rottschy, C., et al. (2012), 'Modelling neural correlates of working memory: A coordinate-based meta-analysis'. [4] Heckner, M.K., et al. (2021), 'Delineating visual, auditory and motor regions in the human brain with functional neuroimaging: A BrainMap-based metaanalytic synthesis'. [5] Power, J.D., et al. (2011). 'Functional network organization of the human brain'. [6] Nooner, K., et al. (2012), 'The NKI-Rockland Sample: A model for accelerating the pace of discovery science in psychiatry'. [7] Gregory, M.D., et al. (2016), `Thinking About a Task Is Associated with Increased Connectivity in Regions Activated by Task Performance`. [8] McIntosh, A., et al. (2010), 'The development of a noisy brain'; Garrett, D.D., et al. (2011), 'The importance of being variable'.

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