Age Differences in Predicting Executive Functioning from Structural and Functional Neuroimaging Data

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Introduction

- **Healthy aging** is associated with altered behavioral performance and brain activation patterns in **executive functions** (EFs)
- The neural correlates of these changes, however, remain unclear
- Earlier studies reported age-related differences in **resting-state functional connectivity** (RSFC), **grey-matter volume** (GMV) and **regional homogeneity** (ReHo) within brain networks associated with EFs [1,2,3]
- The current study aimed to gain a better understanding of the neural implementations of EFs and its change throughout the lifespan

We therefore

a) defined an extended EF-network (eEFN) based on meta-analyses, reflecting diverse EF-facets and then

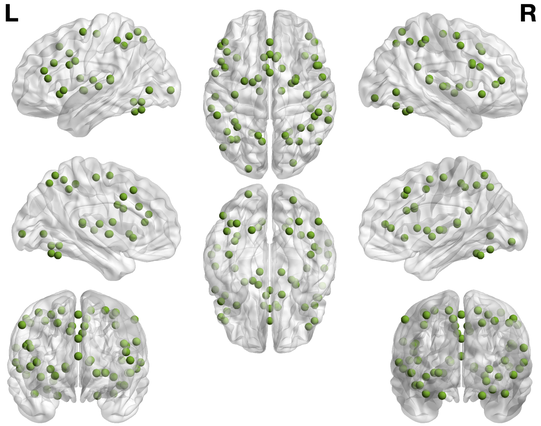
b) examined to what degree individual abilities in three important EF-subcomponents, i.e. inhibitory control (IC), cognitive flexibility (CF), and working memory (WM) [4] can be predicted from RSFC, GMV, and ReHo within this network in young and old adults

Methods

- The eEFN comprised three **meta-analytically defined networks** reflecting CF [5], IC [6], and WM [7] as well as **sensorimotor networks**, to also include regions linked to input or output processing in typical EF-tasks
- Whole-brain imaging data of 138 younger (age range = 20-40 years, 82 females) and 116 older (age range = 60-80 years, 76 females) healthy adults were obtained from the enhanced Nathan Kline Institute-Rockland Sample (eNKI)
- We controlled for intracranial volume in the GMV and multimodal model
- **EF-related performance scores** provided in the eNKI dataset were used as behavioral target variables
- We performed **data reduction** via principal component scores for IC, CF, and WM abilities
- Individual z-transformed scores were then predicted from within-network RSFC, GMV, ReHo and the three modalities combined, using **partial least squares** with 100 repetitions of a 10-fold cross-validation scheme

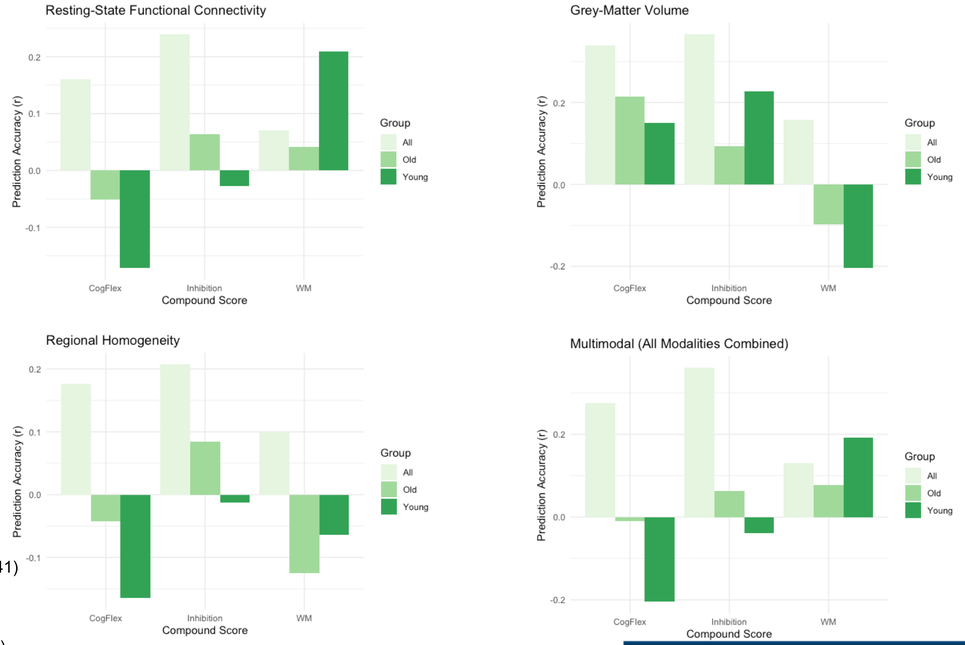
Results

Meta-analytically defined extended EF-network



- Prediction accuracy of r > .2 is reported
- RSFC predicted IC performance ($\bar{r}$=.24; $\overline{MAE}$=.45) in the full sample
  - and WM performance in the younger subgroup ($\bar{r}$=.21, $\overline{MAE}$=.55)
- Regional GMV predicted IC and CF performance in the full sample ($\bar{r}$≥.35; $\overline{MAE}$≤.41)
  - IC and WM in the younger subgroup ($\bar{r}$≥-.21; $\overline{MAE}$≤.64)
  - and CF in the older subgroup ($\bar{r}$=.21; $\overline{MAE}$=.47)
- ReHo predicted IC in the younger subgroup ($\bar{r}$=.21; $\overline{MAE}$=.43)
- The multimodal approach predicted CF and IC in the full sample ($\bar{r}$≥-.28; $\overline{MAE}$≤.42)
  - and CF in the younger subgroup ($\bar{r}$=-.21; $\overline{MAE}$=.34)

Predictability of EF-performance



Discussion

- EF-performance prediction accuracy was generally rather low, but higher for eEFN regional GMV than network RSFC, ReHo, and the multimodal approach
- Our results raise the question if even a very comprehensive EF-network may **not be sufficient to capture the neural implementation of EFs**
- The findings suggest that **GMV may be a better predictor for EF-performance** compared to the other modalities
- Even the multimodal approach does not surpass regional GMV's predictive power
- Our results bring into question **if executive functioning can or should be defined in a network**
- The overall low prediction accuracy raises the question **if individual differences in EF-performance even manifest in canonical networks**, i.e. the recruitment of these networks might reflect executive processes but not the level of productivity

Conclusion

- **Our results show an overall low prediction accuracy for EF-performance which is higher for eEFN regional GMV than for network RSFC, ReHo, and the combined multimodal approach**
- **These findings question the predictability of EF-performance with the modalities used and call for further investigations testing more modalities**

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Acknowledgments

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