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Functional Connectivity in the Healthy Oldest Old

Findings from the McKnight Brain Aging Registry

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Introduction

- Older adults are the fastest growing portion of the population and the oldest-old (85+) are a large contributor to that growth.[1]
- Lack of data has hindered previous research efforts directed at understanding successful cognitive aging and assessment of cognition in the oldest old.
- Studying healthy agers enables examination of brain-behavior relationships of individuals who have lived into the oldest old age range without being affected by diseases related to aging.
- Cognition declines as part of the aging process with certain domains especially sensitive to age, such as executive functioning
- Executive functioning describes cognitive capacity to direct attention, manipulate information, and enact mental flexibility.[2]
- Functional connectivity is a measure of how much information two brain regions share. Regions that are frequently active together are part of the same network and we can examine the properties of those networks including how it interacts with other networks.[3]
- Previous research has shown that as age increases, network segregation decreases, as does cognitive performance. [4]
- **Goal: To understand how network structure (segregation) relates to cognition in a healthy oldest old adult brain.**

Methods

Participants
- N=124, Age range: 85-99
- All participants were screened for major health issues (strokes, Parkinson's Disease, dementia, etc.) and cognitive impairment.

Data collection
- Participants' data were collected in collaboration with all 4 McKnight Brain Aging Registry sites (UAB, UF, UA, and UM).
- The resting-state BOLD fMRI was collected in 8 minutes with 2x2x2mm voxels (TR=2400ms).

Analyses
- Factor Analysis was used to derive executive functioning factor scores.
  - Block Design, Symbol Search, Coding, Stroop, Trails B, Matrix Reasoning
- MATLAB was used for statistical analyses.
- .5mm threshold for frame-wise displacement and .2mm for motion censoring

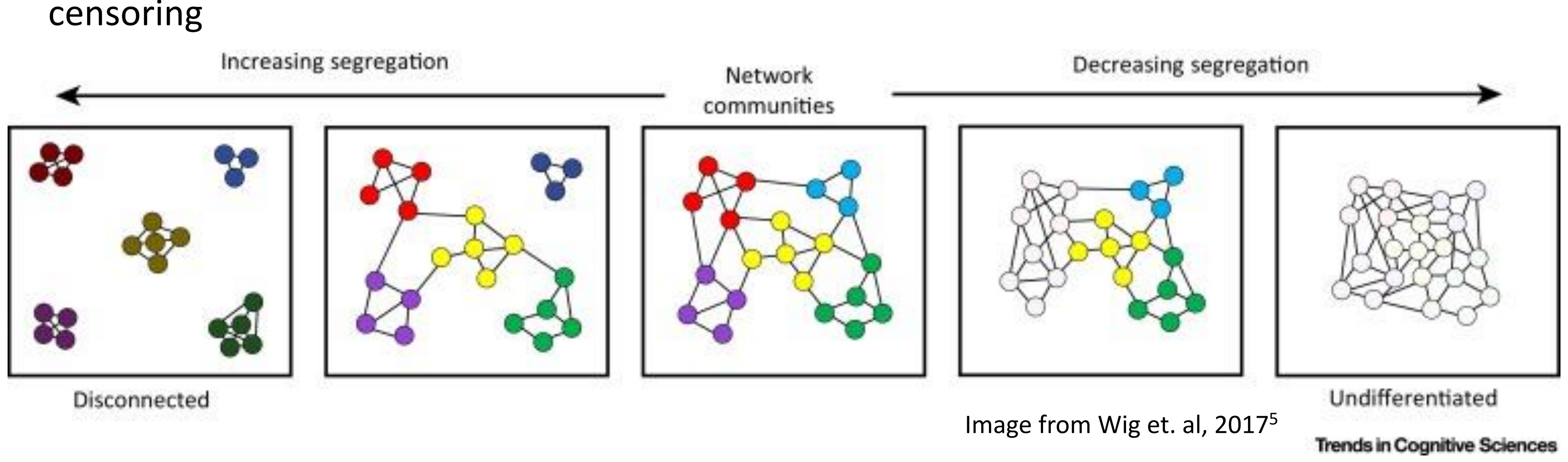
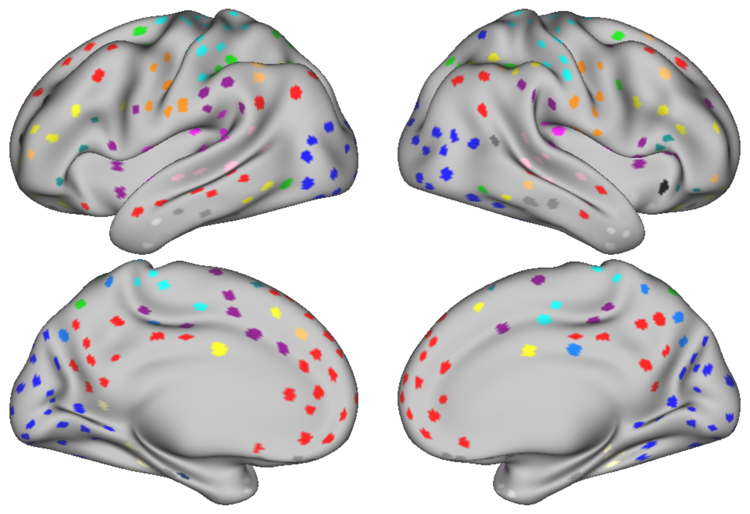
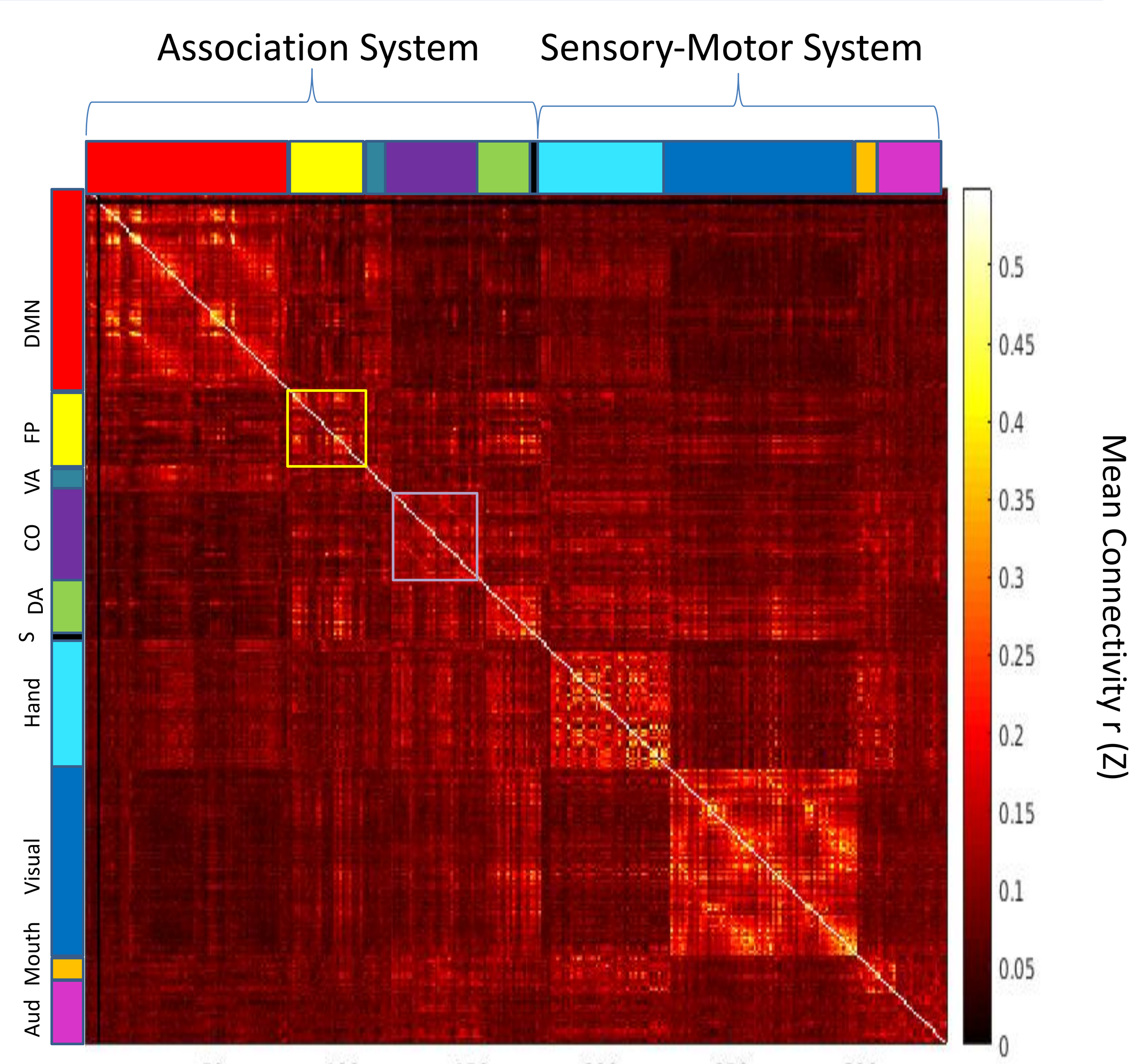


Image from Wig et. al, 2017[5]



Network Nodes were identified using area centers of resting-state functional connectivity boundary mapping. System membership was assigned based on the network parcellation by Power et al. (2011).[6]

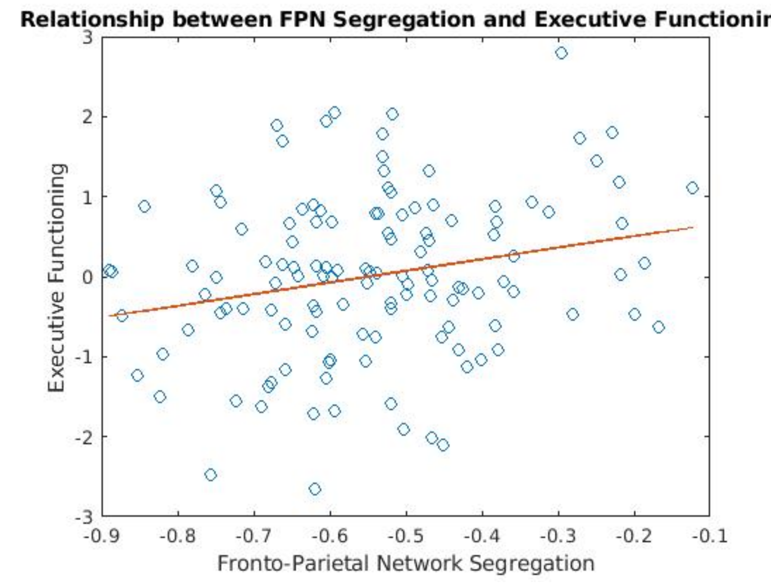
Results



Group average Fisher's z- transformed correlation matrix of 333 nodes. The Association system consists of the Default mode (red), Frontal-parietal control (yellow), Ventral attention (teal), Cingulo-opercular control (purple), Dorsal attention (green) and Salience Networks (black). The Sensory-Motor system consists of the Hand somato-motor (light blue), Visual (blue), Mouth somato-motor (orange), and Auditory networks (pink).

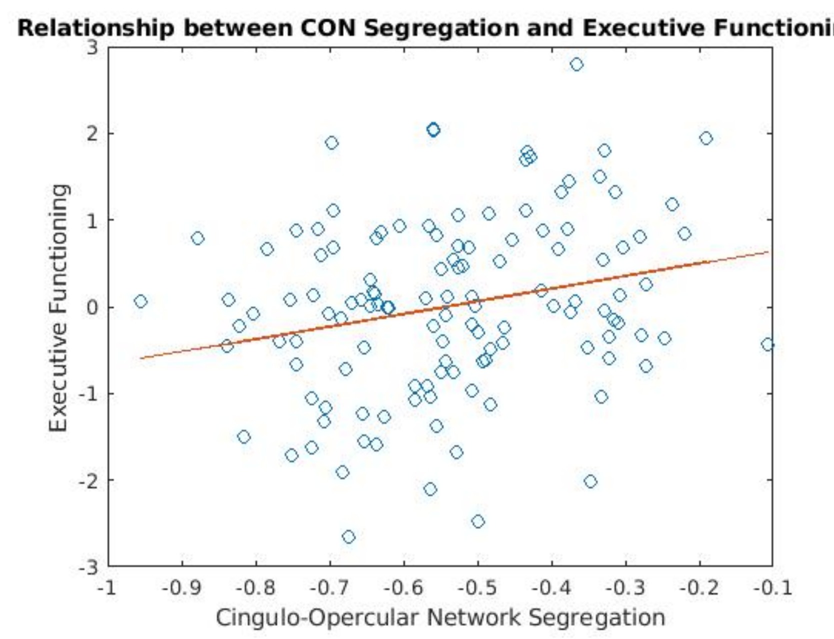
$$\text{System segregation} = \frac{\bar{Z}_w - \bar{Z}_b}{\bar{Z}_w}$$

Equation for system segregation from Chan et. al, 2014 [4]. We adapted this equation to measure network segregation. Network segregation is a normalized measure of the mean connectivity of nodes within a given network minus mean connectivity of those nodes to other, non-network nodes. When network segregation is high, this means that a network is well-differentiated from other networks.



Greater Fronto-Parietal Network Segregation is associated with better executive functioning (r=.234, p<.01)

Greater Cingulo-Opercular Network Segregation is associated with better executive functioning (r=.24, p<.01)



There was no significant relationship between executive functioning and the default-mode network (r=.1492, p=.0981) between MoCA and association system segregation (r=.1252, p=.166).

Conclusions

- Network Segregation is a measure of how well the brain's interconnected networks are distinct from one another.
- Executive functioning is important in the aging context and can impact daily functioning in older adults.
- **We observed that greater FPN and CON segregation is associated with better executive functioning in the healthy oldest old.**
- Previous work (e.g., Chan et al, 2014) has shown that effective brain systems incorporate strong sub-networks that segregated from each other and that brain systems become less segregated with age.
- In this work, we identified the relationship between specific networks (FPN and CON) and executive functioning in the healthy aging context.
- The breakdown of these individual networks may be part of what happens in the decline of executive functioning in cognitive aging.
- Studying the relationship between executive functioning and network segregation in healthy agers can help us understand how to preserve cognition with age.
- Future research with the entirety of the MBAR dataset will examine the relationships between network segregations and other measures of cognition within other cognitive domains (such as memory).

References:
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Thank you to the McKnight Brain Research Foundation for funding this work, Dr. Gagan Wig and Dr. Micaela Chan at the University of Texas at Dallas for help with algorithms, our McKnight Brain Institute collaborators, the members of the Visscher Lab for help with analyses, and many individuals across UAB who have been instrumental to data collection, storage, and processing. Please direct questions and comments to Sara Sims (snolin@uab.edu).