Age-related differences in brain connectivity and cognition

Fluid cognitive abilities, which depend on the rapid and flexible coordination of attention and memory, decline during healthy aging, relative to knowledge-based and expertise-based (crystallized) abilities, which often exhibit age constancy

structural and functional connectivity are statistical mediators of the relation between age and fluid cognition

The age-related decline in structural connectivity is consistent across studies. However, the functional connectivity between cortical regions may be indirect or rely on multiple white matter pathways and as a result, both increases and decreases in functional connectivity with age have been observed across selected cortical regions

Studies of younger adults suggest that structural connectivity constrains functional connectivity

Networks of structural and functional connectivity are not isomorphic, however, and tend to diverge in higher-order association cortical regions

Under the best of circumstances, structural connectivity accounts for 50% of the variance in functional connectivity

The relation between age-related effects for structural and functional connectivity, even less clear

Positive relation between functional connectivity and regional white matter integrity (fractional anisotropy; FA) for older adults

Specific pattern of structural-functional connectivity coupling predicted age more reliably than did either form of connectivity alone.

Functional connectivity within anatomically defined white matter tracts was not consistently higher than functional connectivity to regions outside of the tract

Cross-sectional age-related trajectories differed for structural and functional connectivity, and these measures changed in a largely independent manner across a 3.3 years longitudinal span, leading Fjell et al. (2017) to conclude that structural connectivity only weakly constrained the age-related differences in functional connectivity.

Graph theoretical measures of brain connectivity

Functional connectivity between modules is better preserved as a function of age than within-module connectivity

Functional modules become less distinct or separate with increasing age, expressed in graph theoretical terms as decreased modularity and system segregation.

Reflecting a greater age-related decrease in the strength of within-module functional connectivity relative to between-module connectivity, particularly for modules in association cortex.

This pattern of functional connectivity was more prominent for individuals over 50 years of age

decline in the distinctiveness of modules, based on measures of the strength and efficiency of within-module and between-module connectivity

graph theoretical investigations of resting-state functional connectivity support the concept of age-related neural dedifferentiation, the idea that aging is associated with a decline in the specialization or separation of functional neural modules

Graph theoretical investigations of age-related differences in brain structure more consistently report age-related decline in structural connectivity, with some variation in the degree to which strength and efficiency decline.

connectivity strength between cortical nodes declined with age, whereas the global efficiency of the connections (i.e., the shortest path between any 2 nodes in the whole network) was constant

found that structural global efficiency declined with increasing age to a greater extent than did local efficiency, and that fewer between-module connections were evident in the older adults' data, yielding a more localized and segregated network.

Age-related differences in the interaction of structural and functional connectivity

nodes with direct (efficient) structural connections exhibited relatively little age-related change in functional connectivity, whereas nodes with less efficient structural connections were more likely to exhibit an age-related increase in functional connectivity.

suggests that the age-related decrease in functional system segregation reported in other studies (Chan et al., 2014; Chong et al., 2019) may be a result of decreased structural efficiency, with functional connections between structurally disconnected regions relying on indirect paths

We extend the earlier findings by using graph theoretical measures to characterize different aspects of network connectivity: strength, efficiency, and system segregation, for both structural and functional data, with 3 overarching hypotheses.

First, in the functional connectivity data, we expected to confirm previous findings indicating that with increasing age, modules tend to become less distinct, as expressed in the age-related decline in the graph theoretical measure of functional system segregation (Chan

functional system segregation would have a medi- ating influence on the negative relation between age and fluid cognition