Functional connectivity dynamics in the aging brain

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Introduction

Aging is associated with a loss of network segregation, due to decreases in functional connectivity (FC) within networks and increases between networks[1]. However, it is unknown how aging affects the temporal dynamics of FC (dFC). Previous studies have hypothesized that aging might be associated with an inability to flexibly change between distinct connectivity patterns[2]. The questions we address in this work are:

1. How is dFC affected by age?
2. Are changes in dFC associated with changes in segregation?

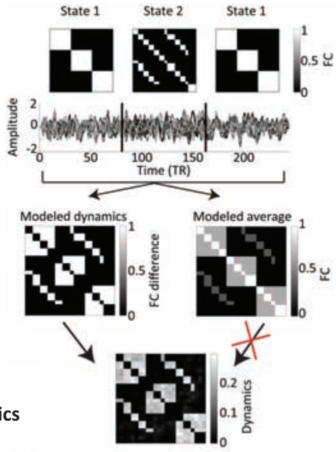
Method and Simulations

Participants (N=587, 18-88, mean age=54, SD=18.2) were taken from the Cambridge Centre for Ageing and Neuroscience (Cam-CAN). fMRI data were recorded during three cognitive states: 1) eyes-closed rest, 2) a sensorimotor task and 3) movie watching.

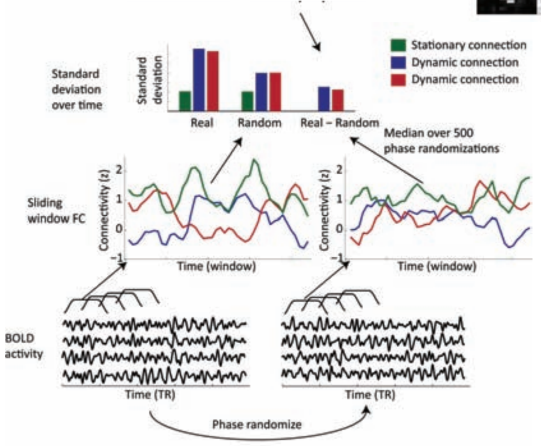
After extensive pre-processing and motion correction, a mean signal was extracted for 748 regions of interest[3]. Consensus partitioning[4] was used to achieve a stable network decomposition across all participants and cognitive states.

For each participant and task, FC was computed using a 49 s tapered sliding window, with steps of 10 s (4-5 TRs) on data filtered 0.025-0.15 Hz. For each connection, the standard deviation of its FC was computed over all windows. dFC was quantified as the difference between standard deviation of the real data and the median standard deviation of phase randomized data.

Simulation Results

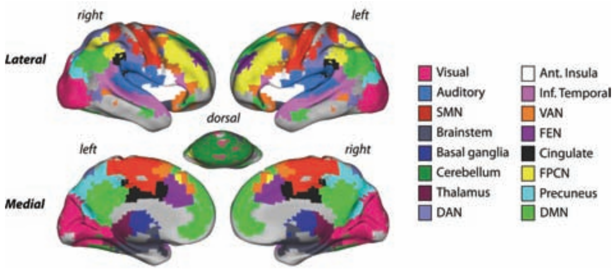


Functional Connectivity Dynamics

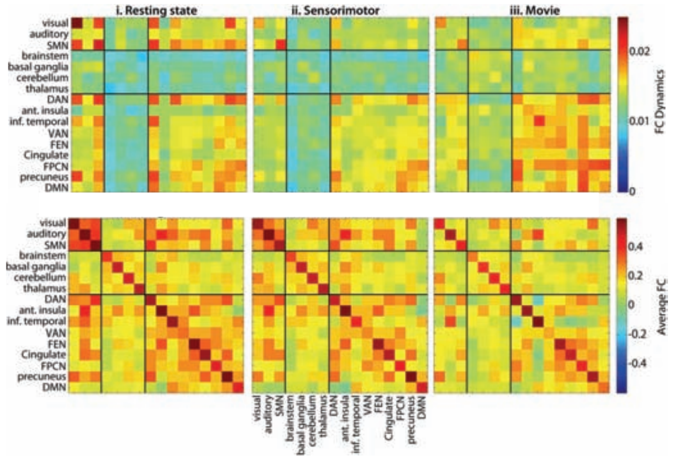


Results

Functional networks

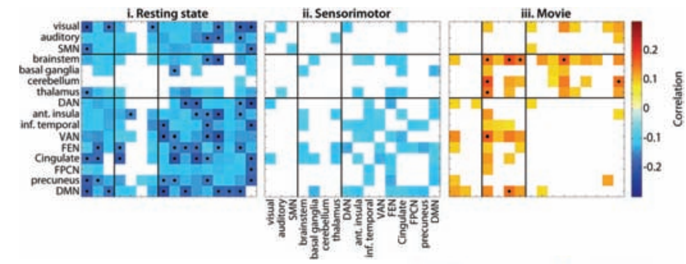


Average FC and FC dynamics across participants

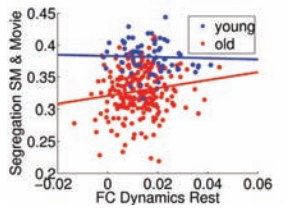


Our dFC measure provides information that is additional to, and independent from, average FC measures. While average FC is high within and weaker between networks, dFC is strong in specific networks, such as the dorsal attention network (DAN) and the fronto-parietal control network (FPCN).

Relation between aging and FC dynamics



Aging is associated with reduced dFC in resting state, where dynamics are internally generated, but not in task states, where dynamics are driven by external stimuli. Only in older adults, greater dFC is associated with stronger segregation of average connectivity patterns (average FC of within versus between network connections).



Conclusions

These results show that dynamic FC can be measured independently of average FC and can provide complementary information regarding effects of age and task. We found that aging is associated with a reduction of internally-driven dynamics, but does not affect externally-driven dynamics. Moreover, changes in FC dynamics with age are related to changes in network segregation, suggesting potential common underlying processes.

References

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