

Sleep deprivation and resting state functional connectivity: increased global signal variability

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Background

Sleep deprivation has been reported to affect intrinsic brain connectivity, notably in the default mode network. Studies to date have however shown inconsistent effects, in many cases lacked monitoring of wakefulness, and largely included young participants.

Aims

We aimed to investigate effects of partial sleep deprivation on intrinsic brain connectivity in young and older participants.

Methods

Participants aged 20-30 (n = 30) and 65-75 (n = 23) years underwent partial sleep deprivation (3 h sleep) in a cross-over design, with two 8 minute eyes-open resting state functional magnetic resonance imaging (fMRI) runs in each session, monitored by eye-tracking. We assessed intrinsic brain connectivity using independent components analysis (ICA) as well as seed-region analyses of functional connectivity, and also analysed global signal variability, regional homogeneity, and the amplitude of low-frequency fluctuations.

Results

Sleep deprivation caused increased global signal variability (figure 1). In contrast to several previous studies, sleep deprivation did not cause major changes in investigated resting state networks, nor did it cause changes in regional homogeneity. In a cross-correlation analysis of the default mode network and the task-positive network, effects of sleep deprivation were in the expected direction, with lower connectivity within the DMN and reduced anticorrelation to the task-positive network, but effects did not reach statistical significance (figure 2). Younger participants had higher functional connectivity in most examined resting state networks (figure 3), as well as higher regional homogeneity in brain areas including anterior and posterior cingulate cortex.

Discussion

We speculate that the increased global signal variability observed after sleep deprivation may be caused partly by transient sleep events during scanning, causing changes in respiratory and cardiac activity as well as neural activity affecting local blood flow. The finding of increased global signal variability after sleep deprivation requires replication and warrants further investigation with concurrent registration of EEG, respiratory, and cardiac activity.

References

Nilsson G, Tamm S, Schwarz J, Almeida R, Fischer H, Kecklund G, Lekander M, Fransson P, Åkerstedt T. (2016). Intrinsic brain connectivity after partial sleep deprivation in young and older adults: results from the Stockholm Sleepy Brain study. *bioRxiv*, 73494. <https://doi.org/10.1101/073494>

Figure 1

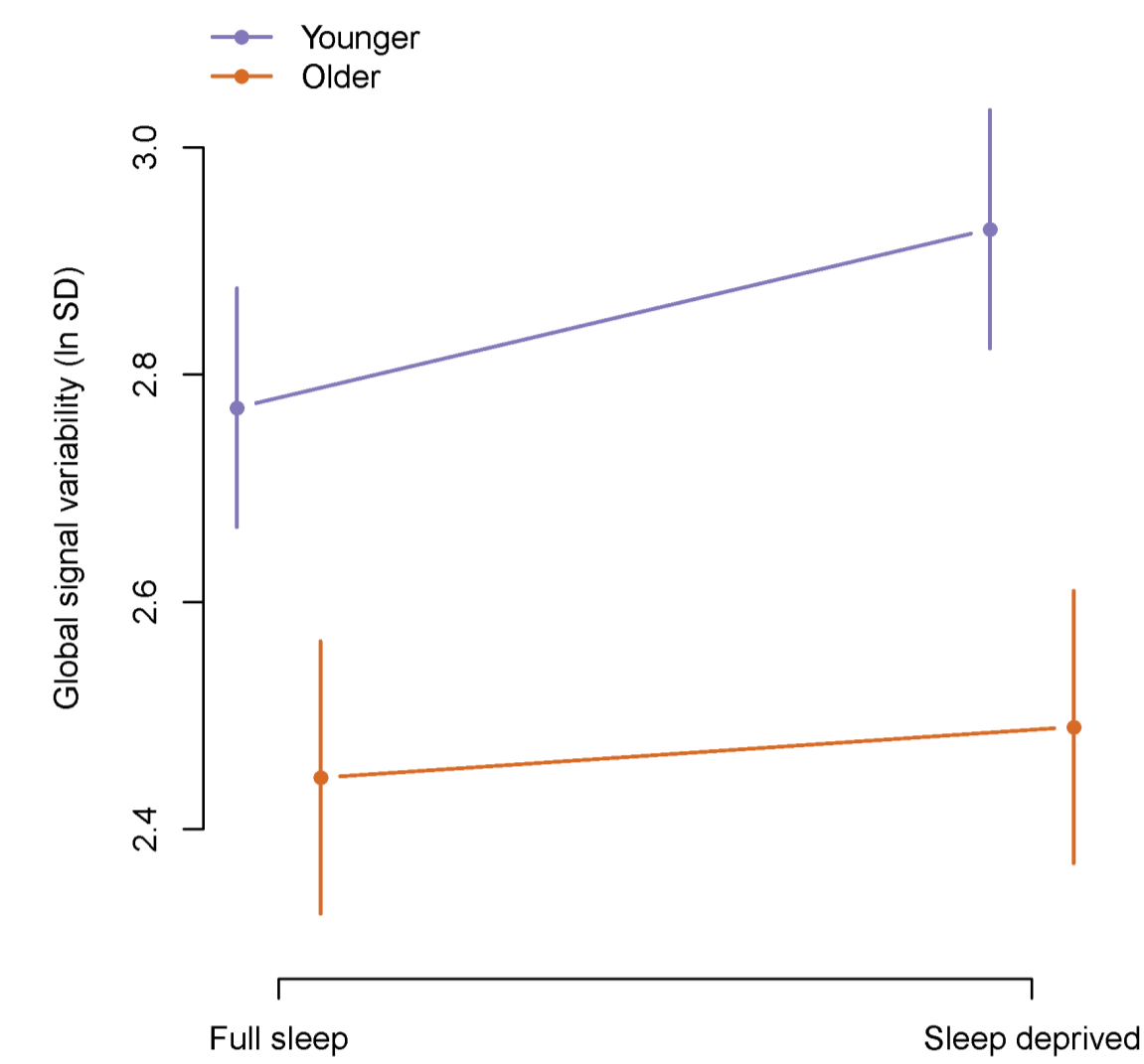


Figure 1: Global signal variability. Log-transformed standard deviation of signal from the gray matter; estimates and 95% confidence intervals.

Figure 2

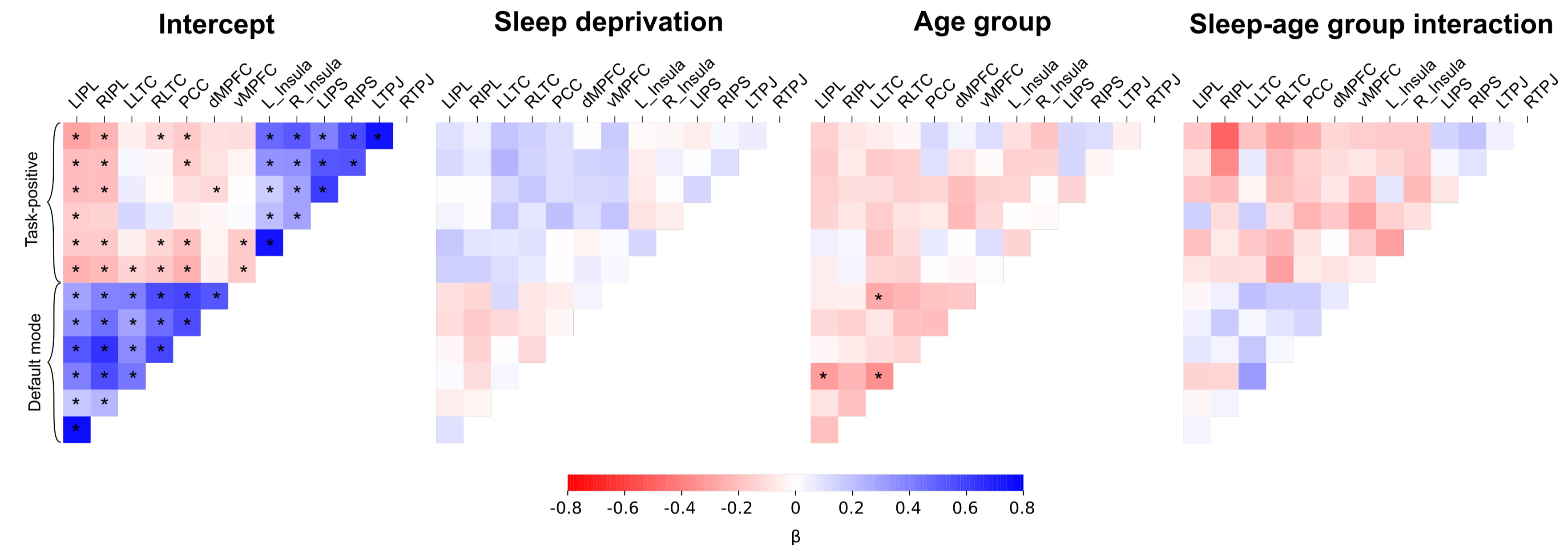
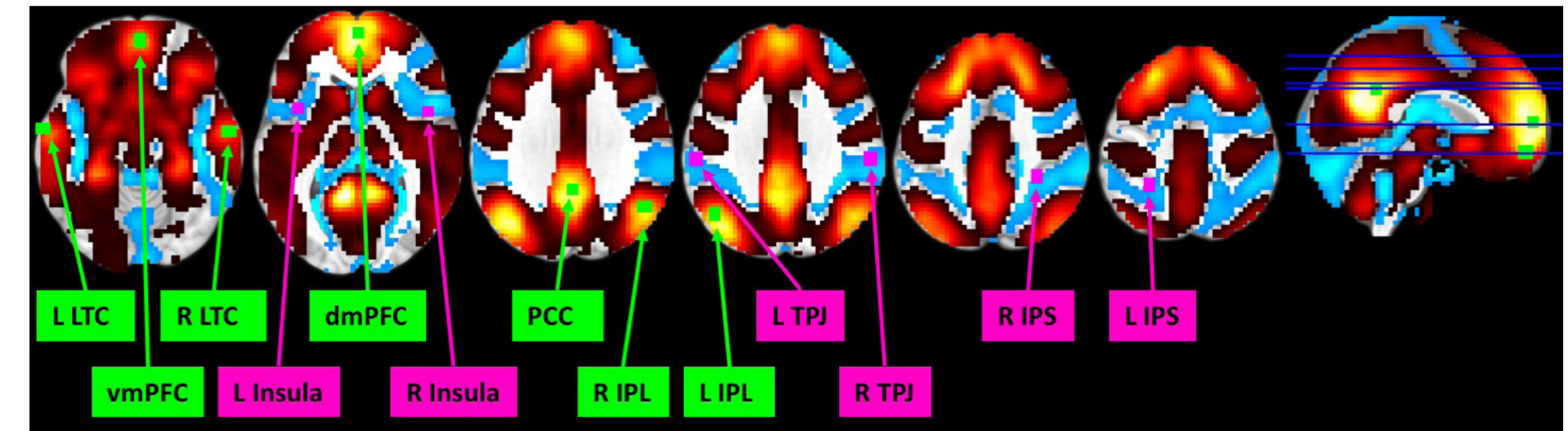


Figure 2: Cross-correlation analysis of the default mode network. **Top:** Seed regions defined following de Havas et al. 2012, superimposed on a connectivity map based on a posterior midline seed. Regions represent the default mode network and the anti-correlated task-positive network. **Bottom:** Correlation matrix. Associations between time courses from each roi were determined for each run and entered into a mixed-effects model. Thus, the intercept represents the overall association between nodes; sleep deprivation represents the main effect of sleep deprivation vs full sleep; age group represents the main effect of older vs younger age group membership; and the sleep-age group interaction represents the interaction effect of sleep deprivation and older age. β is the standardized regression coefficient. False discovery rate correction was performed within each of the four sets of comparisons, and node pairs where $p_{FDR} < 0.05$ are indicated with an asterisk (*).

Figure 3

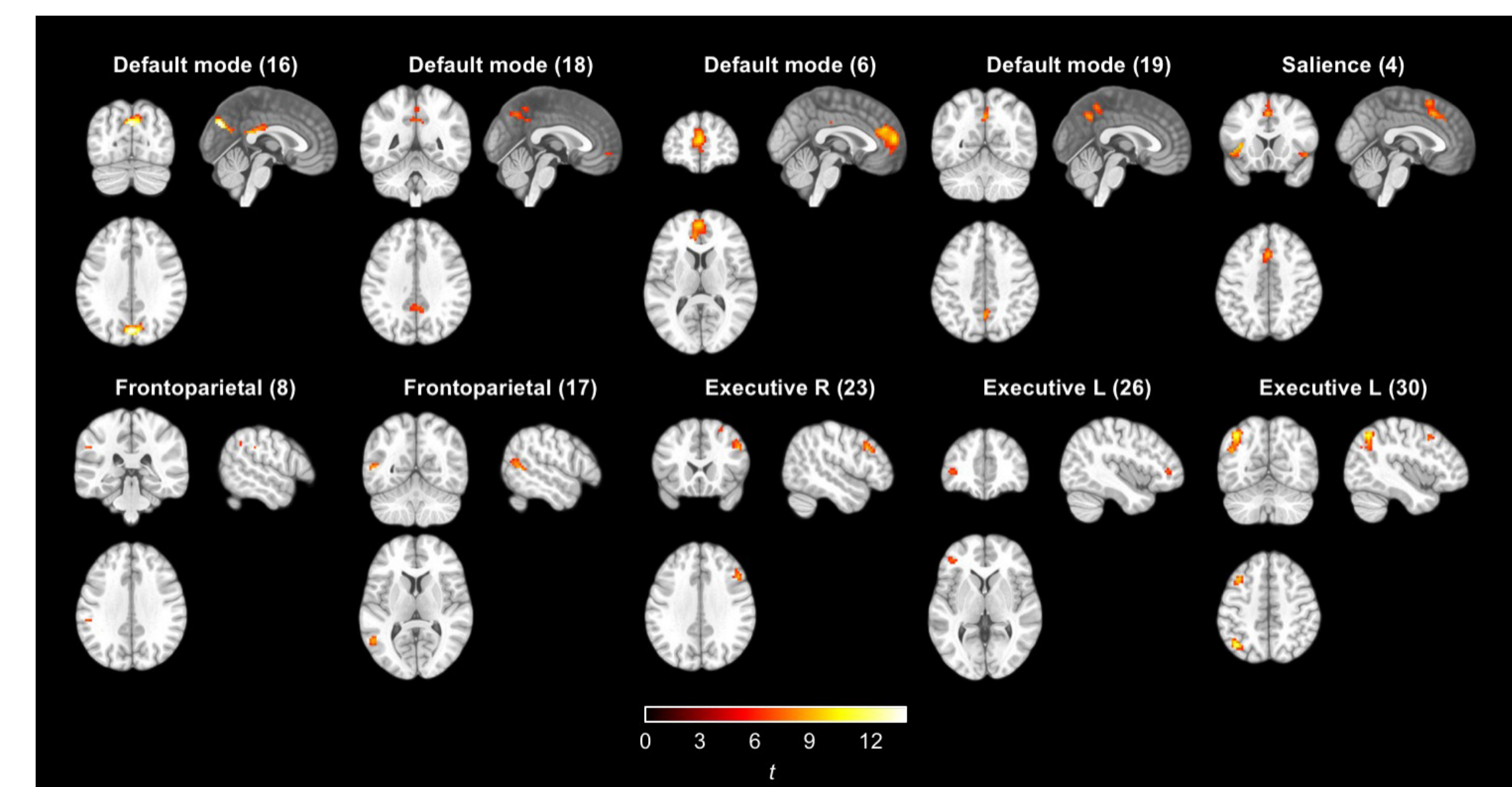


Figure 3: Connectivity differences between younger and older participants in ICA-derived networks. Areas with higher connectivity in younger participants.