

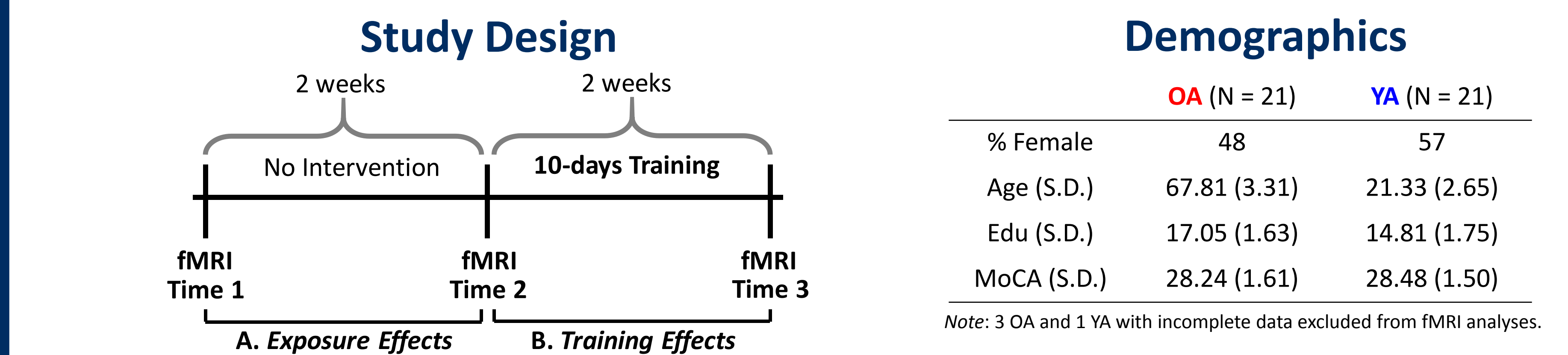
Introduction

Demanding cognitive functions (e.g., working memory, WM), depend on the balance of neural network segregation and integration¹, which declines with age².

Cognitive training can improve performance and change brain activity even in older adults³. Less is known about training effects on functional connectivity.

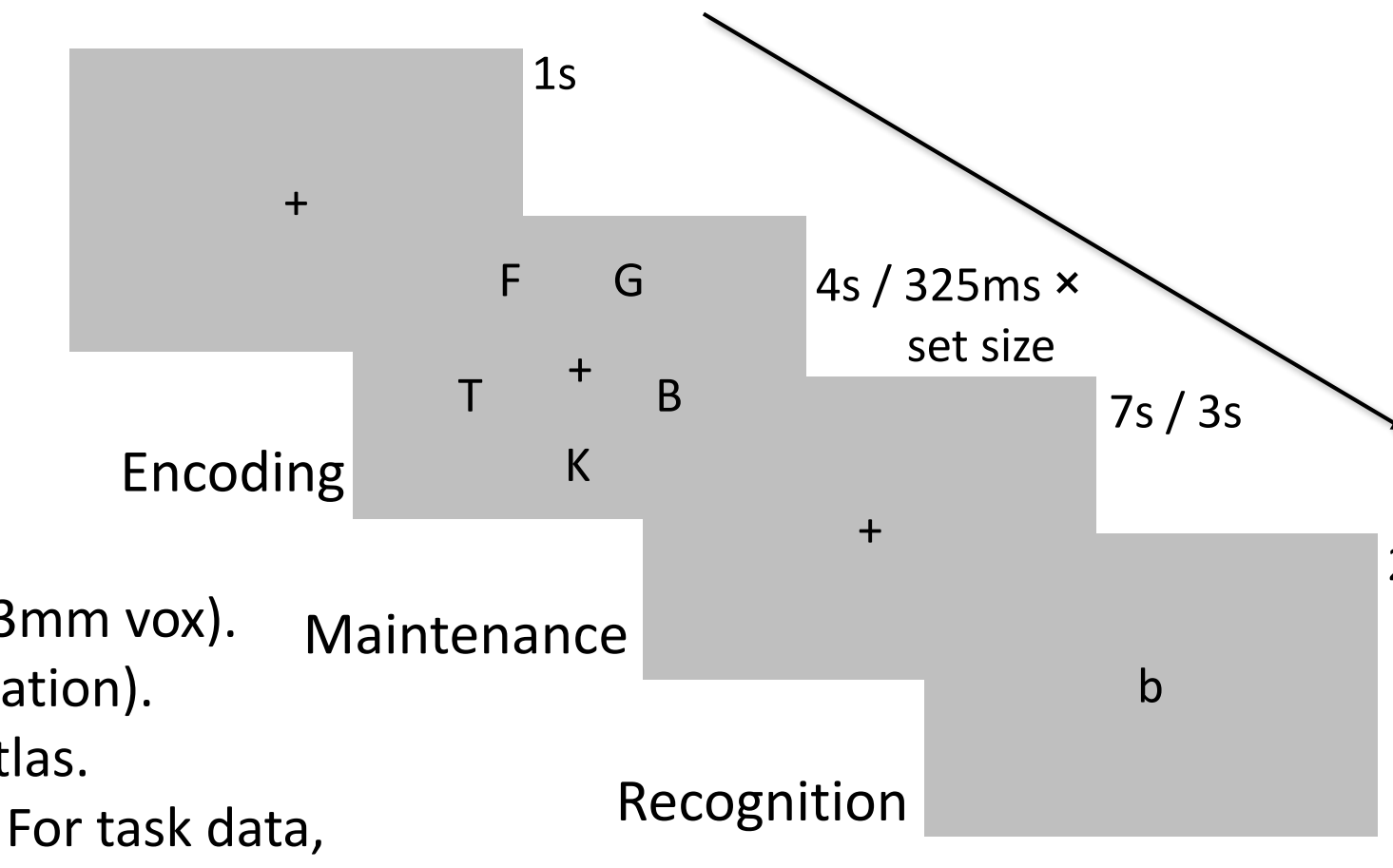
Goal: To assess functional network reconfiguration in younger (YA) and older adults (OA) after 10 days of verbal WM training.

Methods



fMRI (Criterion) Task / Adaptive Training Task

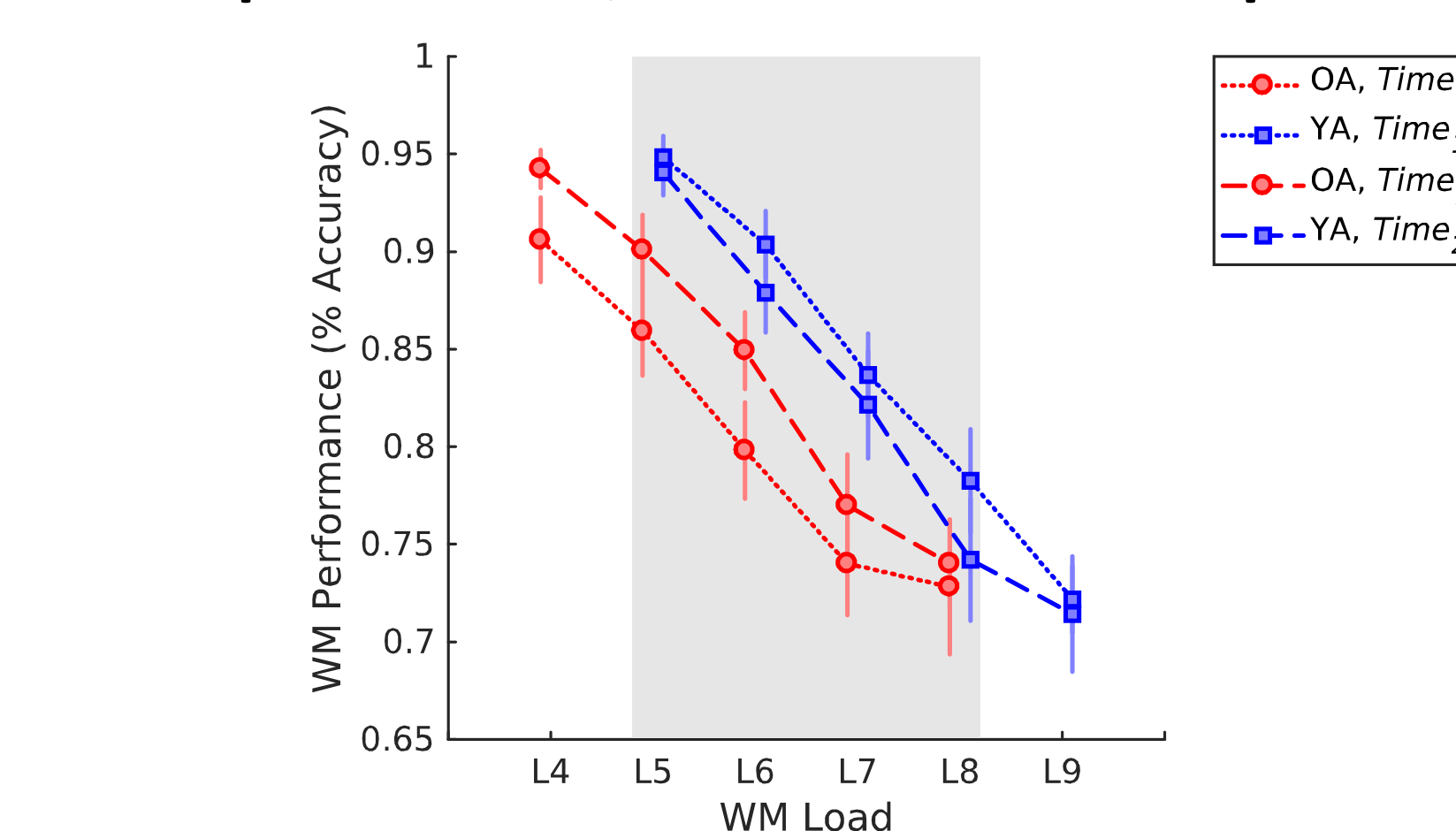
fMRI Task: Verbal WM (Sternberg) task with varying Load
 • OA: Loads 1, 4-8; YA: Loads 1, 5-9; displayed in random order; 6 blocks of 24 trials
Training Task: Adaptive Verbal WM (Sternberg) Task
 • Initial set size = 3 letters; sets increased if accuracy >86%, decreased if <72%
 • 6 blocks of 14 trials/training session; duration ~20 min, consecutive weekdays
fMRI Acquisition & Analysis Whole-brain images (43 slices; TR=2s, TE=30ms, 3.4×3.4×3mm vox). Rest-state and task data preprocessed with SPM12 (slice-timing, realignment, normalization). Functional connectivity analysis performed with CONN, using the Power et al. (2011) atlas. Linear regression corrected for motion, outlier scans, and white matter and CSF signal. For task data, covariates accounted for encoding, probes, and incorrect trials; focus was on the maintenance interval. Residuals were band-pass filtered (.01-.15 Hz). Pearson correlations calculated between ROIs and z-transformed.



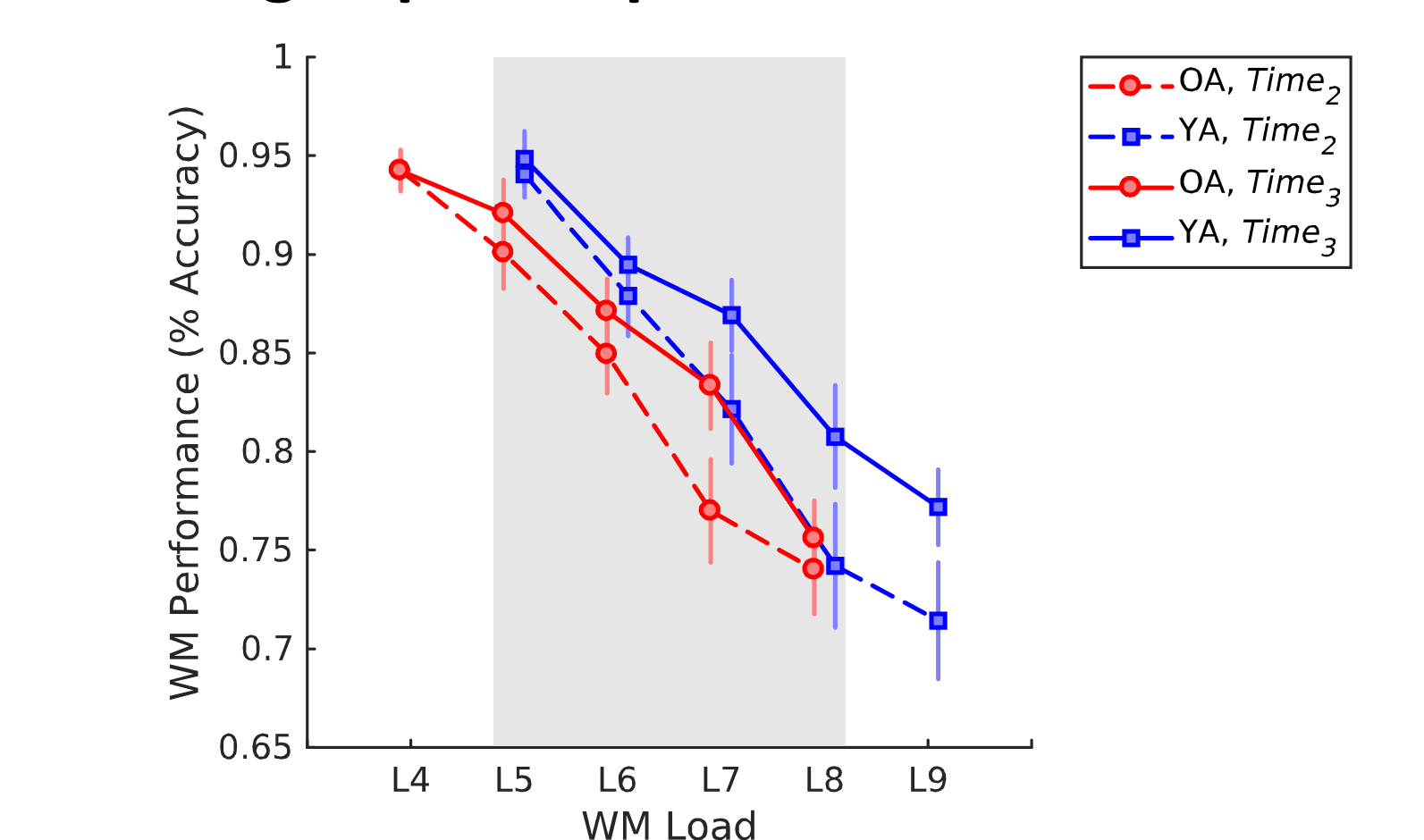
Behavioral Analysis: Within-subjects dissociation of task-exposure (Time1 vs. Time2) from training (Time2 vs. Time3) effects.
Graph-Theory Analysis performed with BCT. Matrices density-thresholded 10%-30%. Analyses performed at 3 levels:
 (1) **Whole-brain.** Modularity assessed strength of network segregation. Calculated with Louvain algorithm ($\gamma=1.3$). Scores normalized by division to Maslov-Sneppen null. Consensus clustering used for representative partitions ($\tau=.4$). Variation of information (VIn) quantified differences.
 (2) **Individual networks.** Time1 node-module assignments used for pre- vs. post-training comparisons (Time2 vs. Time3). Global efficiency (E_{glob} ; capacity for parallel information exchange) and participation coefficient (Partic; distribution of node's connections across modules) assessed within- and between-network communication, respectively.
 (3) **Pairwise connectivity.** Differences due to training, load (highest vs. lowest), and their interaction assessed with Network Based Statistics (NBS).

Behavioral Results (fMRI task)

A. Exposure Effects (T1 vs. T2)



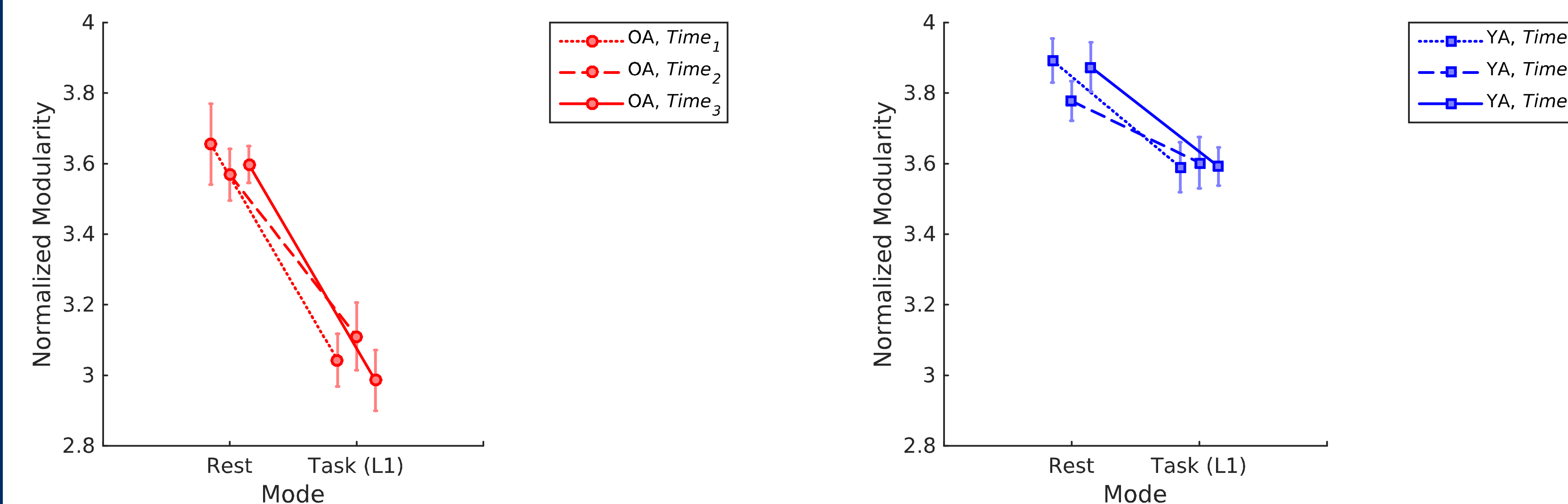
B. Training Effects (T2 vs. T3)



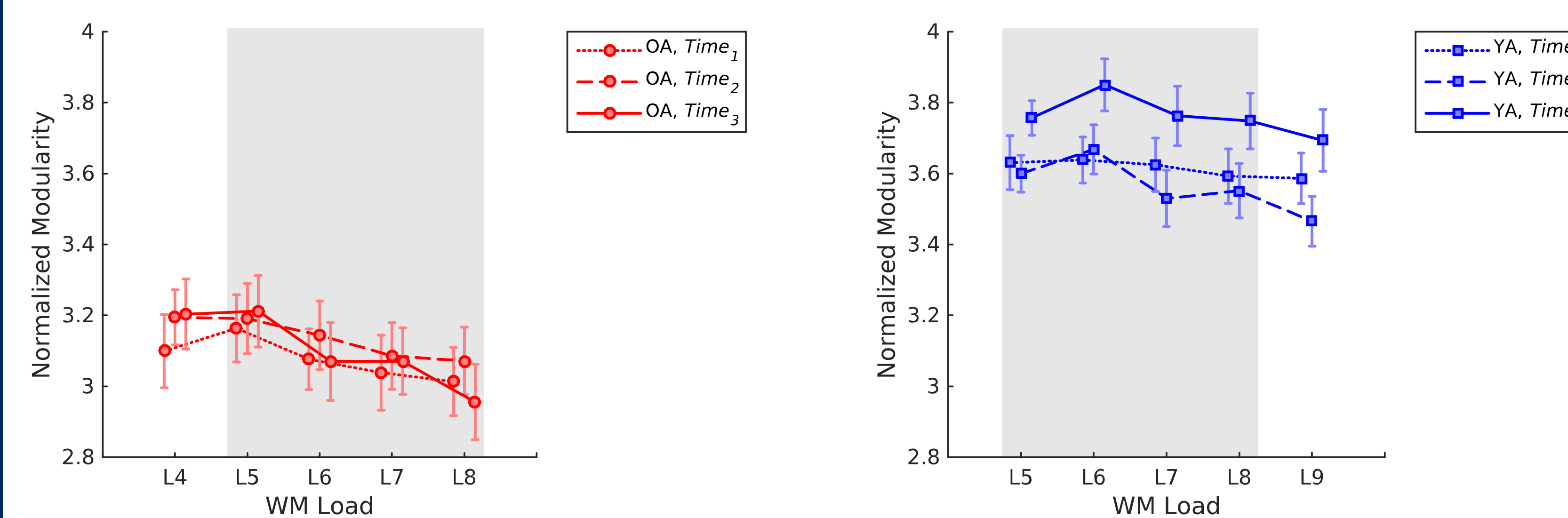
1. Whole-Brain Results

Modularity

Lower modularity and greater decrement with rest-to-task shift in OA

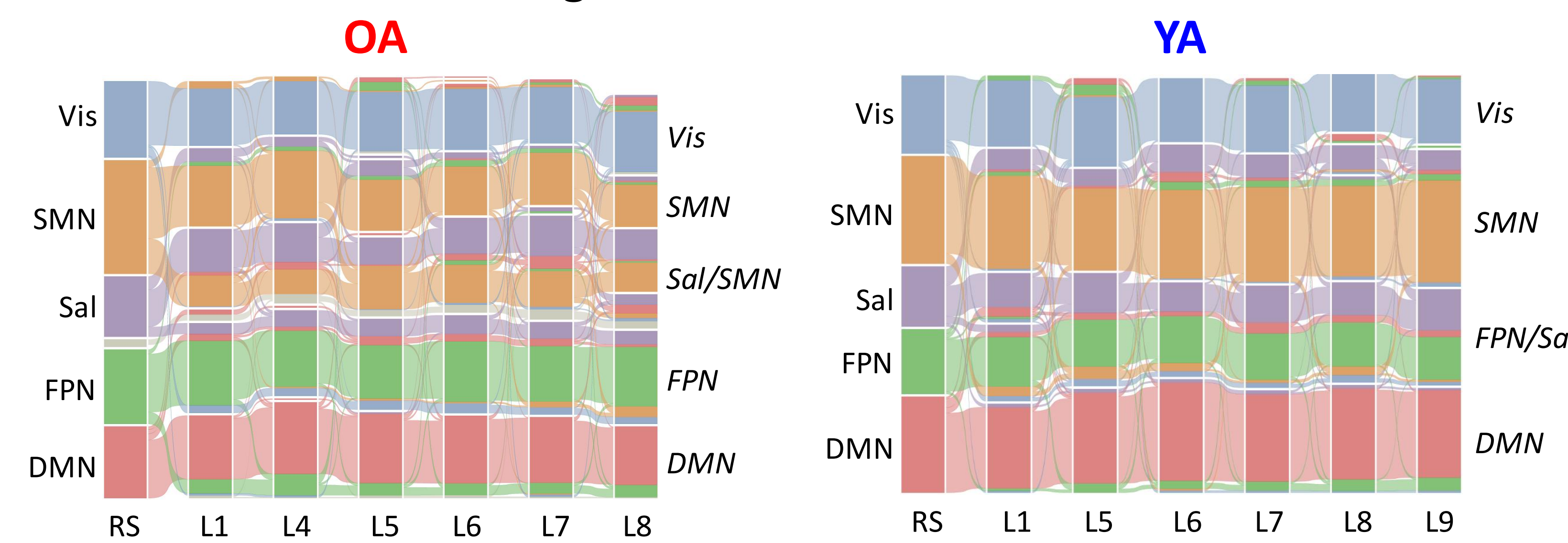


Increased task-related modularity with training in YA



Community Structure

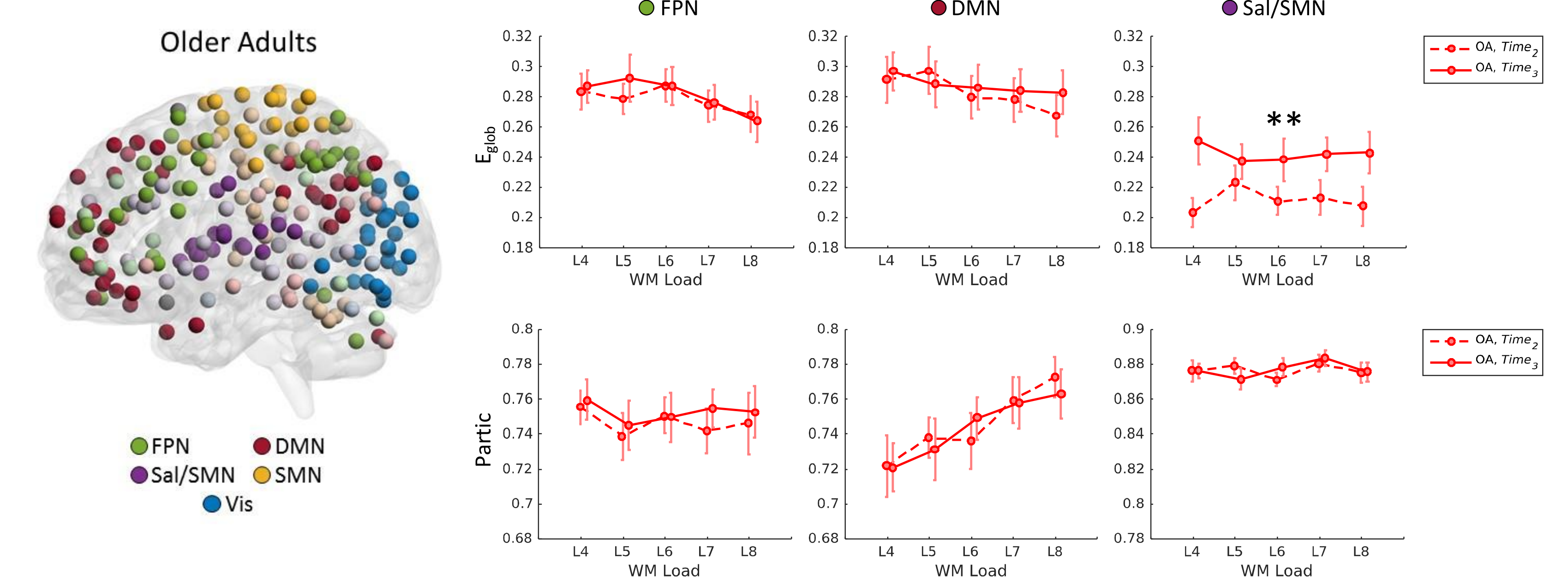
Node-module assignments across rest and task loads at T1



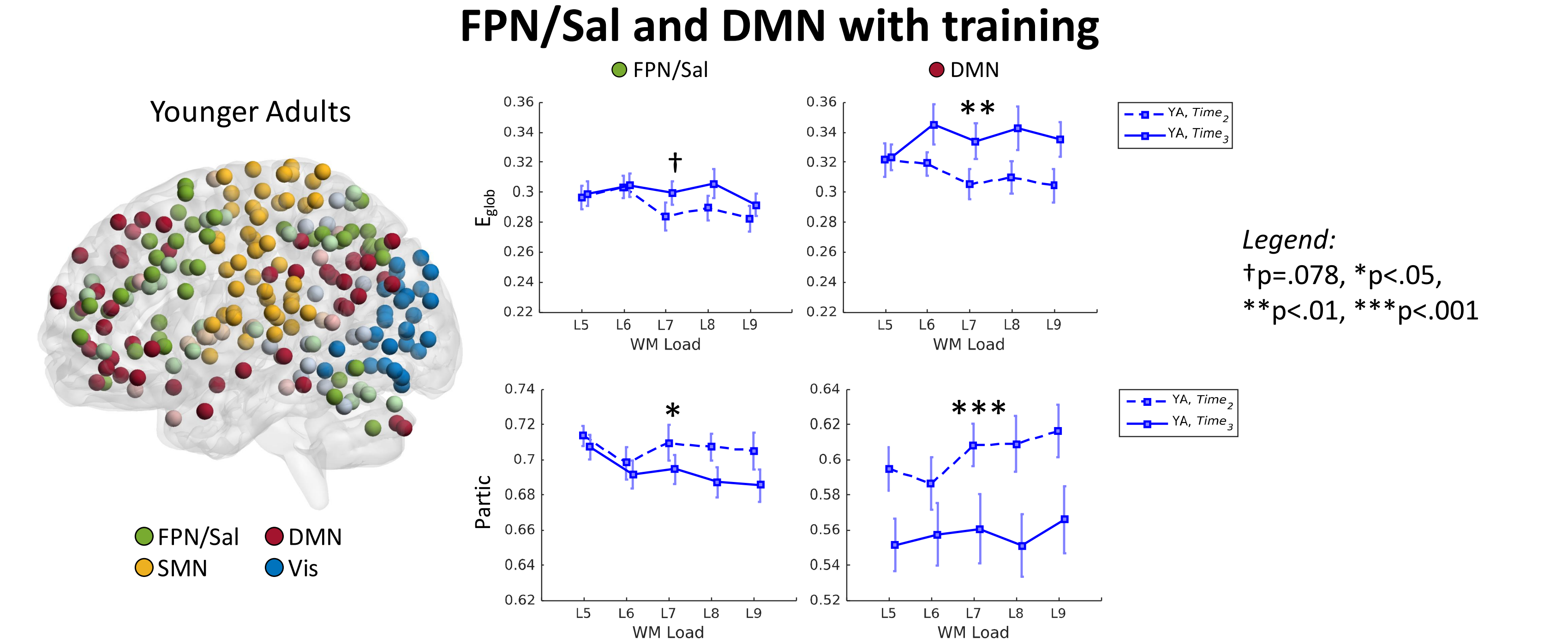
Greater reconfiguration (VIn) when switching from rest (RS) to task mode (L1) in OA than YA, $F_{1,36}=67.35, p<.001, \eta_p^2=.65$. Permutation tests across Load and Time: RS is different from all WM loads. No sig. differences between loads or across time. Legend: DMN, default-mode; FPN, fronto-parietal; Sal, salience; SMN, sensorimotor; Vis, visual network.

2. Individual Networks Results

OA: Increased global efficiency within Sal/SMN with training

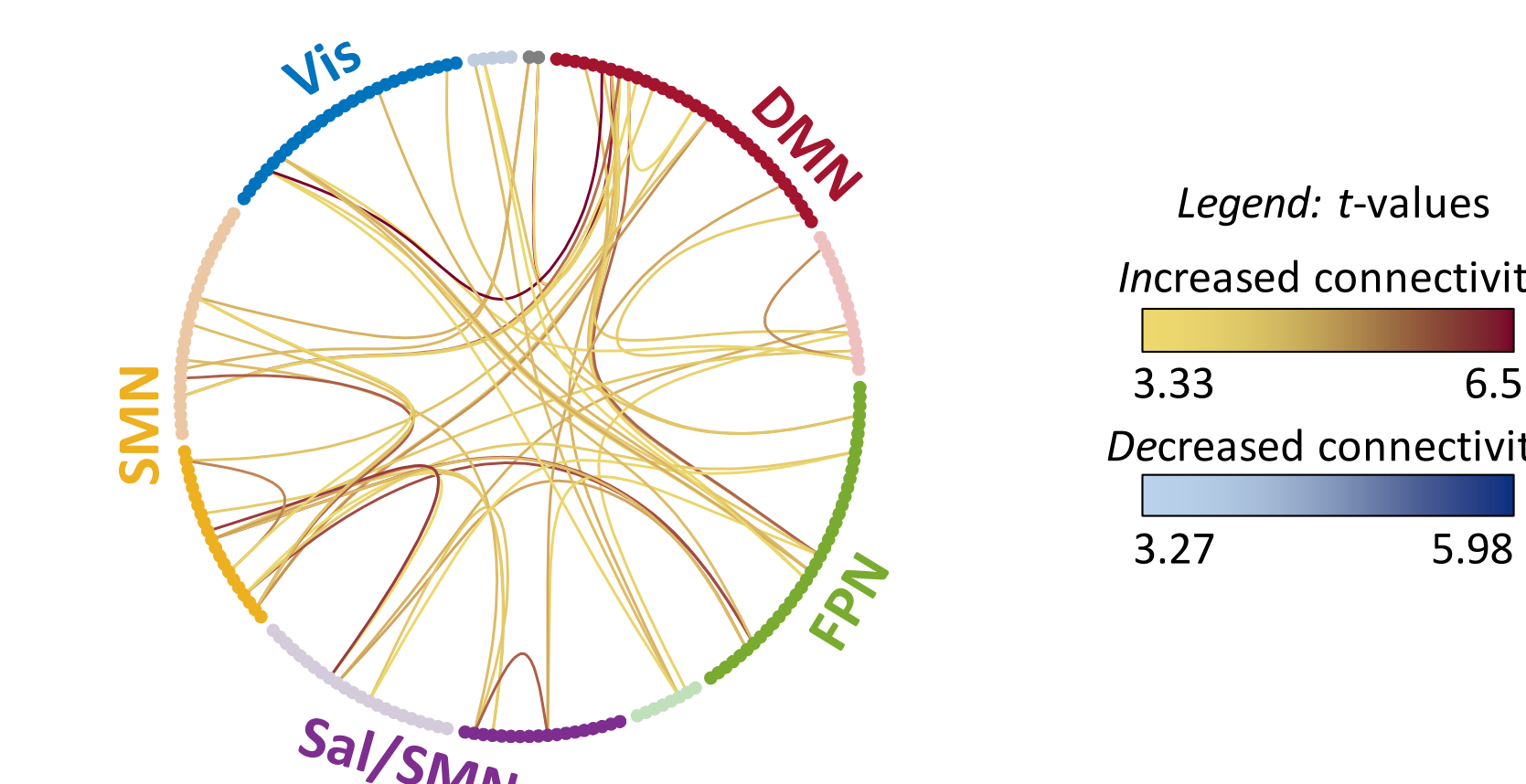


YA: Increased global efficiency within and lower participation of FPN/Sal and DMN with training

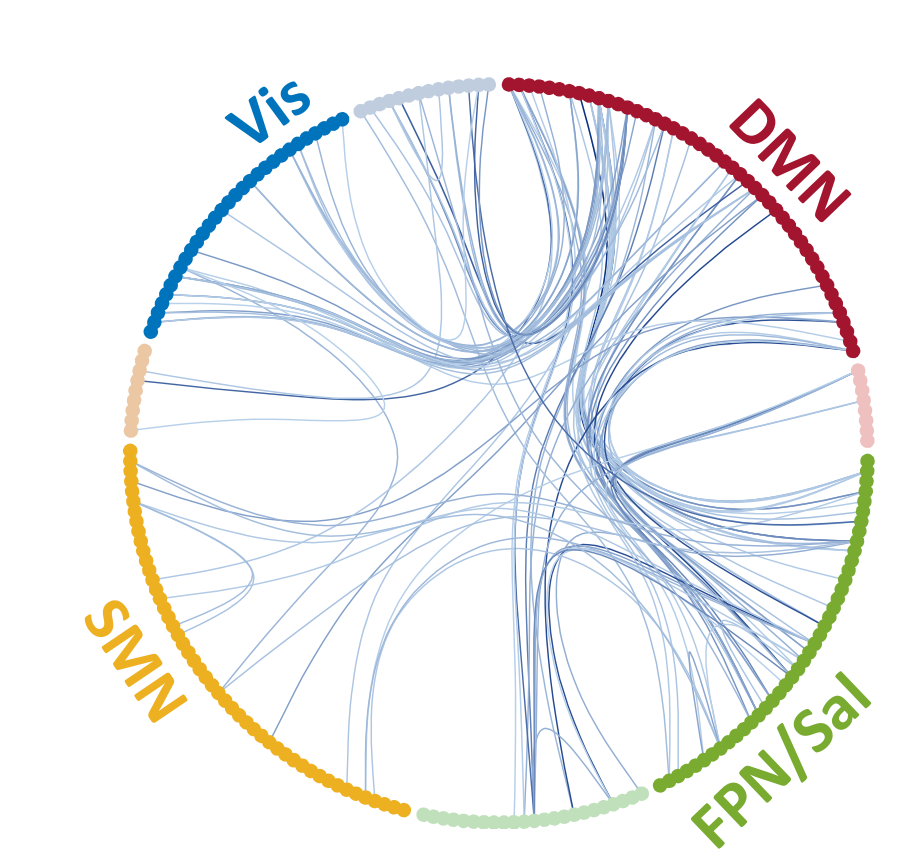


3. Pairwise Connectivity Results

OA: Diffusely increased between-network connectivity with training



YA: Increased DMN segregation from FPN/Sal and Vis with training



Results displayed at $p<.002$ ($p_{FWE}<.05$). Bright/faded colors identify nodes with stable/variable module affiliation across WM loads.

Discussion

- Despite behavioral gains in both age groups, younger and older brains responded differently to WM training.
- Younger adults increase network segregation with training, suggesting more automated processing with enhanced expertise.
- Older adults maintain, and potentially amplify, a more integrated global workspace, which may enhance capacity for network engagement.
- In conclusion, WM training promotes different trajectories in functional network reconfiguration for younger and older adults.