Single-Subject Cortical Structural Networks

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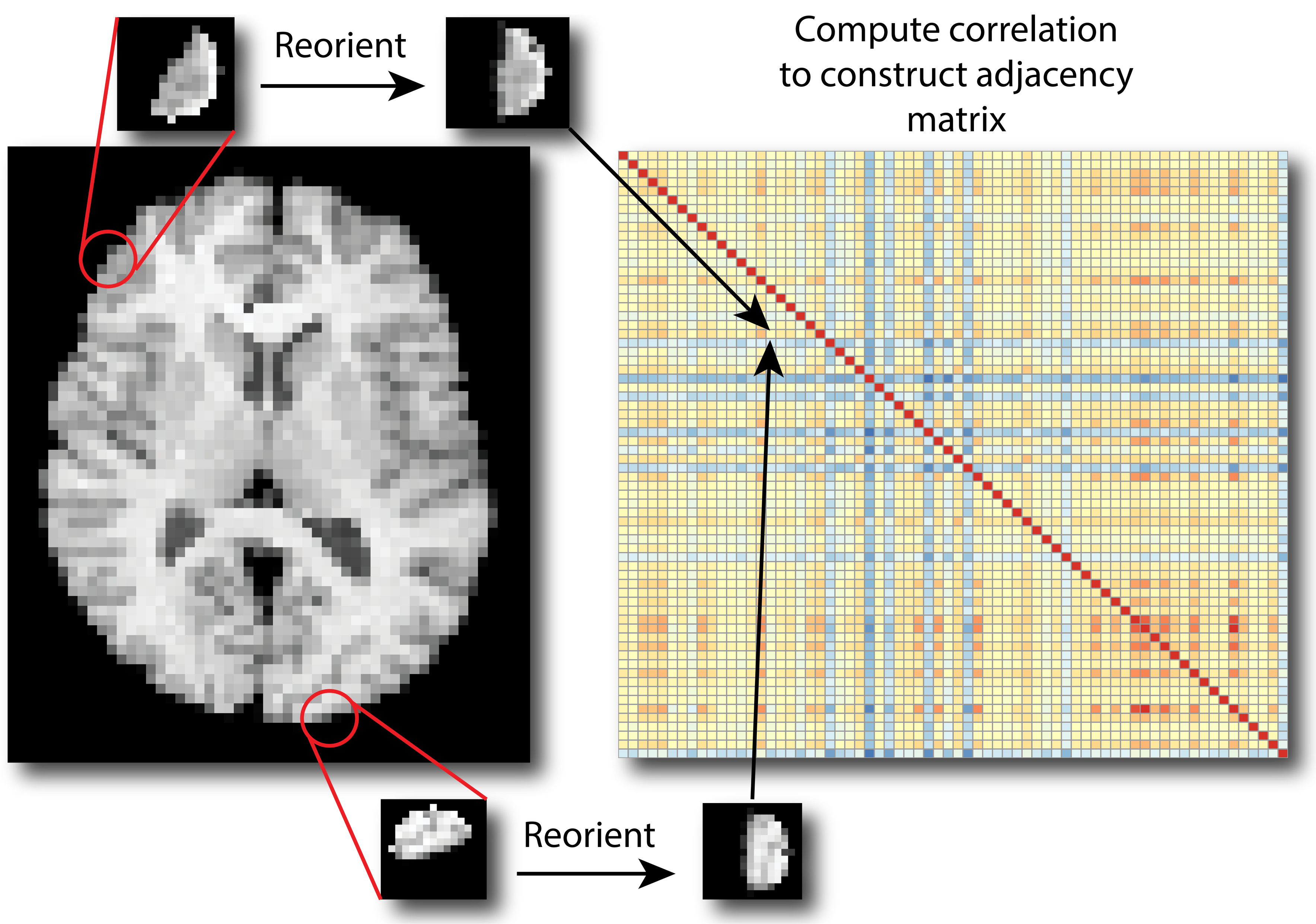
Background

- Cortical connectivity has emerged as a dominant theme in recent brain mapping work
- Most cortical connectivity studies use either correlation of functional MRI (fMRI) time-series or diffusion imaging-weighted connectivity estimates
- Cortical thickness-based connectivity metrics typically use population-wide data, examining correlation of cortical thickness across subjects
- Methods for constructing single-subject cortical connectivity graphs based on cortical morphology are not well developed

Key Idea

- Use rotation-invariant correlation between patches centered at different cortical voxels to define cortical similarity
- Use cortical similarity between different cortical regions to populate cortical similarity graph



- Similarity across cortex provides insight into how homogeneous cortical structure is
- Because this homogeneity may be disrupted or increased during development or in neurodegenerative disease, the graphs may yield a novel biomarker

Methods

- Use proposed method to create cortical graphs for each subject in population
- Study population: 119 pediatric subjects, ages 7-17 years, 61 females and 58 males; all scanned with 1x1x1mm isotropic T1-weighted MRI
- For each subject's graph, calculate average graph closeness: $\sum_{j \neq i} K_{i,j}$, where K is matrix of edge weights and i and j index the nodes (AAL label regions)
- Evaluate correlation of mean graph closeness with age
- Comparative methods: 1) Cortical thickness; 2) Graph closeness computed from graphs derived from cortical thickness (Dai et al., MLMI 2011)

Results

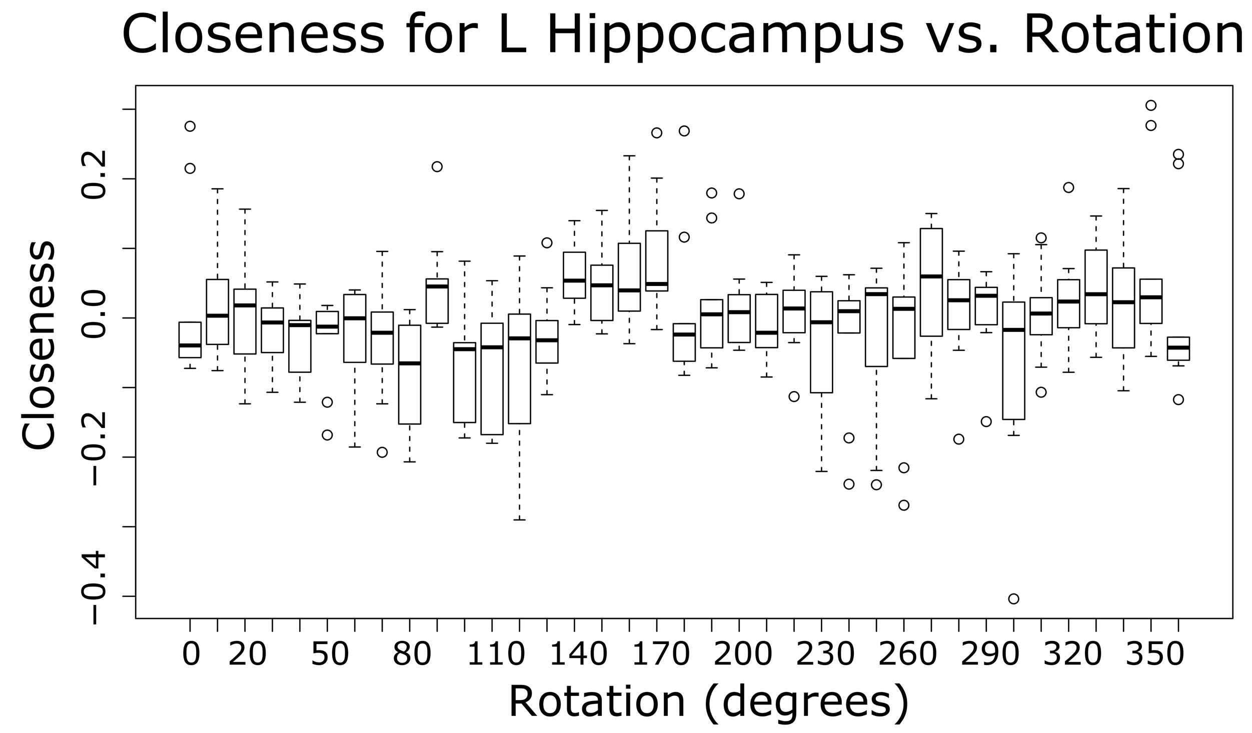


Fig. 1: Orientation of brain does not affect measured graph closeness

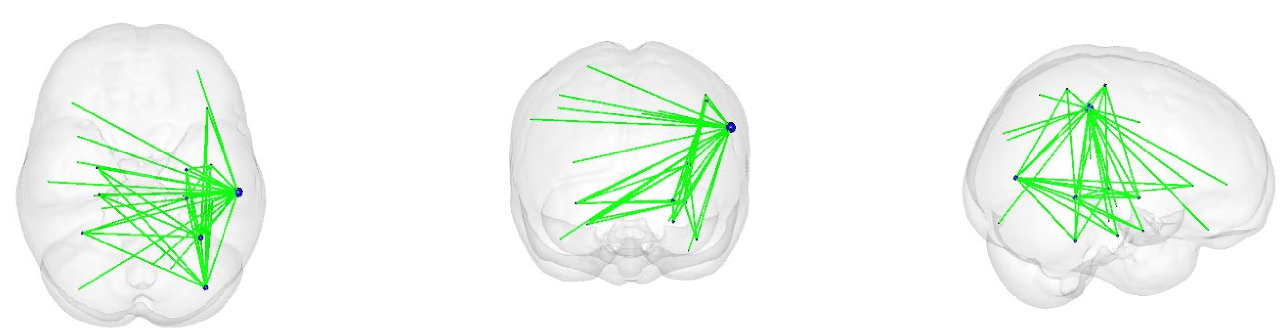


Fig. 2: Sample subject connectivity

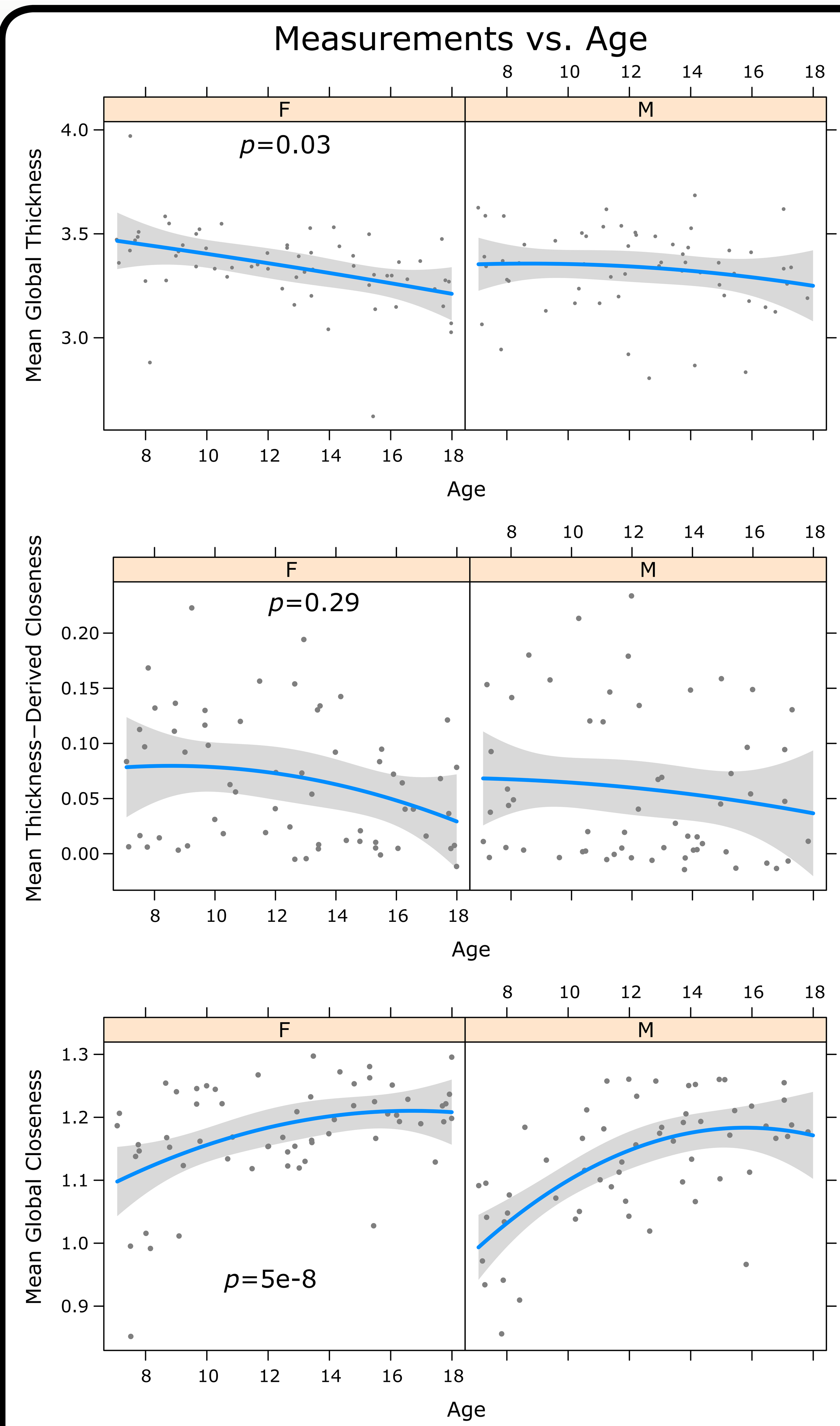


Fig. 3: Mean structural graph closeness (bottom) is more highly correlated with age when correcting for brain volume than cortical thickness (top) or thickness-derived graphs (middle)

p-value is from ANOVA comparing (1) metric ~ Sex + BrainVolume to (2) metric ~ Sex + BrainVolume + Age + Age:Sex + Age^2 + Age^2:Sex + Age

Discussion

- Cortical structural graphs may be less noisy than fMRI-based graphs
- Cortical structure may provide a complementary source of connectivity information to diffusion and functional imaging