Exploring the functional dynamics of large-scale brain networks within and across individuals

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Background and Rationale

- Human cognition and behavior emerge from the synchrony of brain networks, and disruptions to this synchrony have been observed in human psychiatric illness.
- Resting state MRI has been studied using static analyses, but the brain is inherently dynamic.
- Understanding temporal shifts in network behavior may provide an additional dimension of specificity with which to identify biomarkers of disease.
- Recent evidence suggests network coherence fluctuates across distinct states over time.
- Here we explored the dynamic organization of cortical networks in healthy young adults and patients with schizophrenia spectrum disorders or psychotic bipolar disorder.

Methodological Approach

Participants
- n = 1,939 healthy participants between the ages of 18 and 35 (mean age 21.3; 58% F)
- n = 79 patients who had at least two scans separate within 6 months of each other
- n = 185 patients with psychotic illness (mean age = 31.5; 38% F) and n = 358 matched controls (mean age = 37.1, 23% F)

Scanning Parameters:
- Healthy participants were scanned at Harvard/Massachusetts General Hospital on a 37-Tim Trio. The clinical sample was scanned at McLean Hospital.
- MPAGE: 14x1.2x1.2 mm voxels, TR/1.22s, TE/1.53.65.27.0 ms, 8p angle 7°, 1.2x1.2x1.2-mm voxels, FOV 230.
- EPI sequences: 47-mm slices, TR=3.3s, TE=30 ms, flip angle 85°, 3x3x3-mm voxels, FOV 216.

Analyses
- Cortical networks were parcellated according to prior work demonstrating reliable functional coupling across 57 ROIs in each hemisphere into 17 networks.
- Dynamic connectivity was computed through a sliding window approach using k-means clustering and a 33 second window.

Network architecture shows reconfigurable hierarchy

- 2 and 4, 5, and 8 state solutions can be stably estimated.
- To quantify hierarchical relationships, we examined the scenario that two states of the (n+1) state solution were subdivisions of a component of the n state solution.
- Hungarian matching was used to determine which 2-state combination in n+1 was best matched to the n state solution.
- Correlation matrices Z(r) of the results for state solutions 1 through 8 are shown for each ROI.

State solutions reveal evidence for an attractor state

When transitioning between states participants display an increased probability of entering state A. The probability of transitioning to each state is shown for all non-redundant possible combinations across state solutions 3-8 (1.2 are obligated).

State A displays increased stationary probability for state solutions 2-7. Stationary probability for state solutions 2-8 show probability of remaining in a state from time point t to time point t+1.

In psychosis, reduced frontoparietal and default network connectivity is evident in states A and C. Bar graphs reflect mean network connectivity for each group within Control A and Default A-D. Results suggest that putative network disruption in psychosis may be state specific.

References


Zoom into the text for more details.