

Beyond Network Disconnection: Unveiling a Dynamic Mechanism Of Behavioral Dysregulation in Mild Behavioral Impairment

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Using a unified neuroimaging pipeline of fc-MVPA, Seed-to-Voxel, ROI-to-ROI, and Dynamic ICA, we demonstrate that MBI is driven by a two-stage brain network cascade where pathological circuit locking across striato-insular and limbic hubs paradoxically drives dynamic instability, providing a novel system-level framework for early dementia risk detection.

INTRODUCTION

RESULTS

FIGURES

Table 1: Participants at baseline

Mild behavioral impairment (MBI) is an early neurobehavioral marker of Alzheimer's disease, preceding cognitive decline across five domains: motivation, emotional regulation, impulse control, social behavior, and abnormal perception. Prior resting-state fMRI studies have relied on static, seed-based approaches, missing the full extent of MBI-related network reorganization. This study addresses that gap using a unified, data-driven pipeline fc-MVPA, Seed-to-Voxel, ROI-to-ROI and Dynamic ICA to characterize MBI-related connectivity across spatial, topological, and temporal dimensions.

fc-MVPA identified five MBI-modulated hubs: Left Insula/Opercular Complex, Right Frontal Operculum, Left Temporal Pole, Right Caudate/Superior Frontal Gyrus, and Left Posterior Insula. Seed-to-Voxel analyses revealed MBI severity–dependent increases in limbic-insular connectivity and decreases in sensorimotor/attentional connectivity. ROI-to-ROI analysis confirmed hyper-synchronization among four hubs (Insula, Frontal Operculum, Temporal Pole, Posterior Insula) with progressive decoupling from external regulatory systems. Dynamic ICA localized temporal instability to the striato-insular circuit, with both spatial and temporal effects significantly predicted by MBI severity.

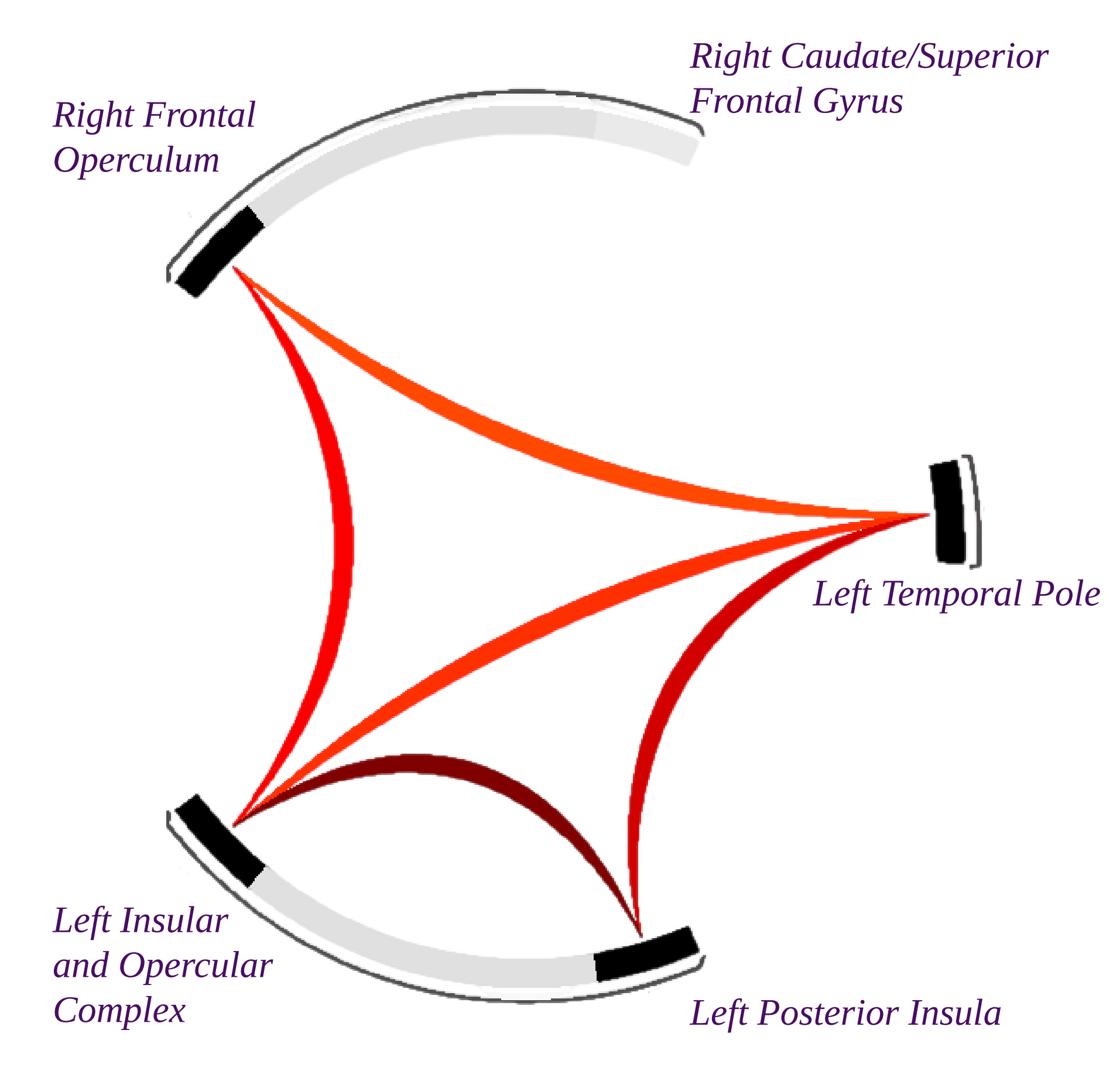


Figure 1: Functional connectogram between identified Hubs sowing MBI-severity linked to greater connectivity.

Characteristic	NC	MCI
Age (Years)	74.2 (6.4)	73.0 (7.4)
Gender (Female)	39 (58.2%)	33 (48.5%)
Education (Years)	16.0 [2.0]	16.0 [4.0]
MoCA Score	27.0 [3.0]	23.0 [3.5]
MBI Score	0.0 [0.8]	2.0 [7.0]

Abbreviation: NC: Normal cognition
MCI: Mild cognitive impairment.
MoCA: Montreal Cognitive Assessment
MBI : Mild Behavioural impairment

METHODS

CONCLUSIONS

ACKNOWLEDGEMENT

Resting-state fMRI from ADNI (N=135; 67 cognitively normal, 68 Mild Cognitive Impairment [MCI]) was analyzed using MBI total score as a continuous regressor, adjusting for age, sex, education, and MoCA. Functional Connectivity Multivariate Pattern Analysis (fc-MVPA) identified whole-brain hubs modulated by MBI severity without pre-defined seeds; Seed-to-Voxel mapped their projections across large-scale networks; ROI-to-ROI assessed synchronization within the resulting hub network; and Dynamic ICA (30-second sliding window) examined temporal fluctuations across these circuits.

MBI severity was associated with significant connectivity reorganization across five neuroanatomical hubs spanning insular, opercular, temporal, caudate, and frontal regions, marked by increased limbic-insular connectivity and sensorimotor/attentional decoupling. A hyper synchronous network among these hubs progressively isolated from external regulatory systems, while temporal instability remained confined to the striato-insular circuit, with both spatial and temporal patterns significantly predicted by MBI severity. These findings characterize MBI-related network reorganization across spatial, topological, and temporal dimensions.

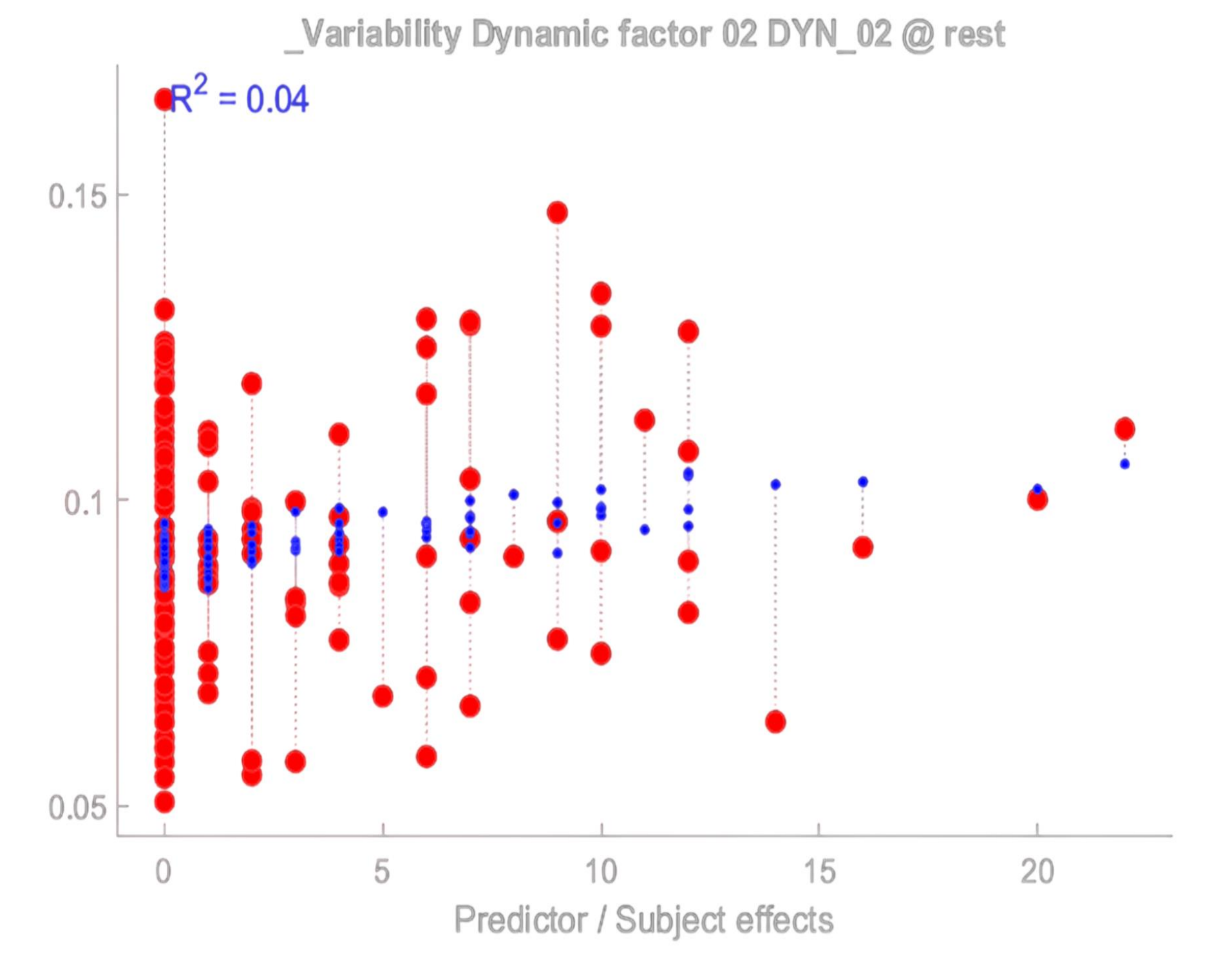


Figure 2: Scatter plot showing the association between MBI_Score and temporal variability of dynamic functional connectivity in rest state

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The circuits are locked.
The PhD is not.