Improving Neural Enhancement by Combining Stimulation and Network Analysis

S&T Campaign: Human Sciences
Human Capability Enhancement
Augmentation

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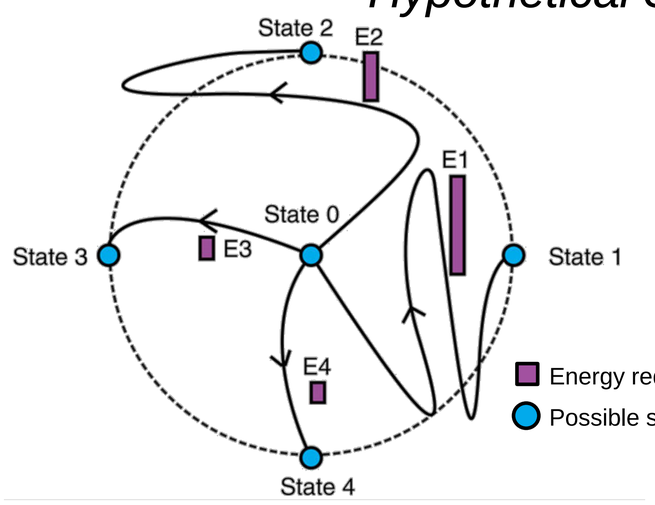
Research Objective

To enhance performance we examine what brain regions or networks are most susceptible to internal influence (via feedback) or external modification (via neurostimulation).

To develop feedback or stimulation protocols that optimize modifications to a network by targeting neural features (e.g., regions, frequency bands, clusters of regions) that (1) are amenable to experimental control, (2) are associated with variability in behavioral performance, and (3) represent the shortest route from any state to the preferred state.

Hypothetical State Space



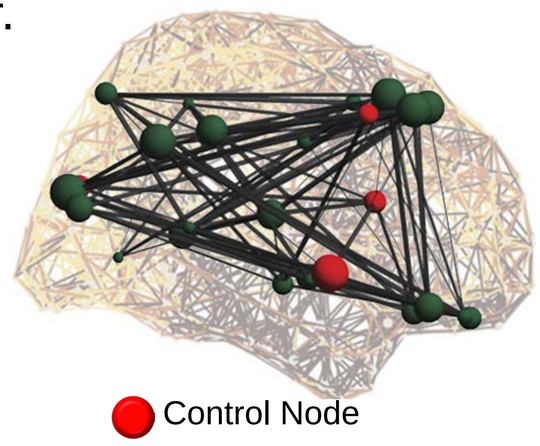
Modified from Gu et al. (2015) to represent the possible states that are of equidistant from the original state (State 0). Arrows represent the path traversed from State 0 to other possible states and size of the energy bars represent the amount of energy needed to traverse the path.

Challenges

Identifying brain networks and regions that define preferred states for enhanced performance.

Applying network theory to brain dynamics to optimally target brain regions or network in feedback or stimulation protocols.

Developing innovative approaches to apply network analyses to fieldable neuroimaging methods, leveraging existing techniques applied to functional neuroimaging from magnetic resonance imaging (MRI) scanner.



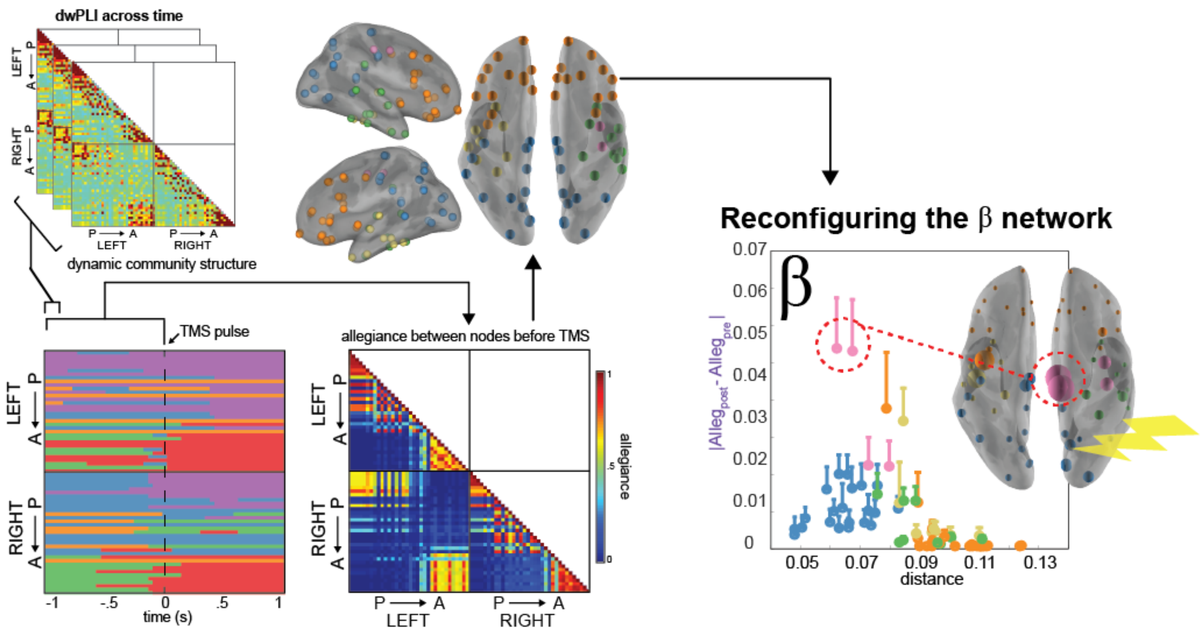
Hypothetical network where the red nodes are the most influential in the network.

ARL Facilities and Capabilities Available to Support Collaborative Research

Ongoing Research

- Frequency-specific effects of stimulation (via single-pulse Transcranial Magnetic Stimulation (TMS)): TMS modulates beta-band electroencephalogram (EEG) activity within a local cluster of nodes but influences whole brain activity within the alpha band.
- Our findings suggest a complex interplay between global dynamics and local stimulation.

Resting β Communities



Garcia et al., submitted

Unique expertise in network science methods

- Neural dynamics, social networks, etc.

Unique access to facilities and collaboration

- DoD Supercomputing Resource Center
- Broad network of academic partners

Complementary Expertise / Facilities / Capabilities Sought in Collaboration

Expertise & access to transcranial alternating current stimulation (TACS) and TMS devices simultaneous with EEG.

Interest in algorithm development, such as extending graph theoretical analysis and novel network and connectivity approaches.