Understanding Neural Mechanisms of Cognitive Control in Neurodevelopmental Disorders

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SPECIFIC AIMS

The overall goal of this research is to characterize the neural mechanisms underlying cognitive control in typical development and neurodevelopmental disorders. We will test the central hypothesis that distinct patterns of neural network dysfunction contribute to cognitive control deficits in ADHD and ASD through the following specific aims:

Aim 1: Characterize developmental trajectories of cognitive control networks in typically developing children using multimodal neuroimaging.

Aim 2: Identify disorder-specific patterns of neural dysfunction in cognitive control networks in children with ADHD and ASD.

Aim 3: Develop predictive models of individual differences in cognitive control abilities based on neural network characteristics.

RESEARCH STRATEGY

Significance

Despite significant advances in understanding the neural basis of cognitive control, there remains a critical gap in our knowledge of how these processes develop and function in individuals with neurodevelopmental disorders. This project addresses this gap by investigating the neural mechanisms underlying cognitive control processes in three distinct populations: typically developing children, children with attention deficit hyperactivity disorder (ADHD), and children with autism spectrum disorder (ASD).

Our preliminary data indicate significant differences in neural activation patterns during cognitive control tasks between these groups, suggesting distinct neurodevelopmental trajectories that may inform targeted interventions.

Innovation

This proposal is innovative in several ways:

1. It employs a novel multimodal neuroimaging approach combining functional magnetic resonance imaging (fMRI) with electroencephalography (EEG) to capture both the spatial and temporal dynamics of neural activity during cognitive control tasks.
2. It utilizes advanced computational modeling techniques to characterize individual differences in neural network dynamics, moving beyond group-level analyses to capture heterogeneity within diagnostic categories.
3. It incorporates a developmental perspective by examining age-related changes in cognitive control networks across a wide age range (7-18 years), allowing for the identification of critical periods for intervention.

Approach

Participants: We will recruit 60 typically developing children, 60 children with ADHD, and 60 children with ASD, aged 7-18 years. Groups will be matched on age, sex, and IQ. All participants will undergo comprehensive clinical assessment.

Procedures: Participants will complete a battery of cognitive control tasks during simultaneous fMRI-EEG recording. Tasks include the Stop Signal Task, Flanker Task, and Task-Switching paradigm, all adapted for the developmental population.

Analysis: We will employ both traditional univariate analyses and advanced multivariate pattern analysis to identify neural signatures of cognitive control. Dynamic causal modeling will be used to characterize effective connectivity between brain regions. Machine learning approaches will be applied to predict individual differences in cognitive control abilities from neural data.

Expected Outcomes: This research will yield a comprehensive understanding of the neural mechanisms underlying cognitive control in typical development and neurodevelopmental disorders. Findings will inform the development of targeted interventions and contribute to the identification of biomarkers for early diagnosis and treatment monitoring.

BIBLIOGRAPHY & REFERENCES CITED

Bibliography

BUDGET & JUSTIFICATION

[**Personnel (Direct Costs):**

Principal Investigator (Dr. Joey Trampush): 2.4 calendar months effort per year

Research Scientist: 12 calendar months effort per year

Graduate Research Assistant: 12 calendar months effort per year

Undergraduate Research Assistant: 6 calendar months effort per year

Equipment:

- EEG system maintenance and calibration: $15,000
- Scanning costs: $180,000 (600 hours at $300 per hour)
- Computer workstation for data analysis: $8,000

Supplies:

- EEG electrodes and conductive gel: $3,000
- Participant compensation: $36,000 ($200 per participant for 180 participants)
- Office supplies and materials: $2,000

Travel:

- Conference presentations: $8,000
- Collaborative meetings: $4,000

Other Direct Costs:

- Publication fees: $6,000
- Data storage and backup: $3,000

Total Direct Costs per Year: $265,000

Indirect Costs (30%): $79,500

Total Project Costs per Year: $344,500

Total Project Costs (5 years): $1,722,500]