Intrinsic Brain Activity, via Resting-State EEG, and Executive Functioning Abilities in Children with and without Autism Spectrum Disorder (ASD): The GENDAAR Study

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Background

Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder characterized by social communication impairments and restricted, repetitive behaviors (APA 2013).

- Children with ASD often have impairments in executive functioning (EF), a broad term for cognitive processes including working memory, planning, impulse control, inhibition, and mental flexibility. Previous research has supported an executive functioning theory that has found direct links between executive functioning problems and restrictive, repetitive behaviors in children with ASD.
- Executive brain activity, measured by Resting-State Electroencephalograph (RS-EEG), particularly activation of the beta (12-30 Hz), alpha (8-12 Hz), and theta (4-8 Hz) bands, has been shown to reflect memory and inhibition. Specifically, alpha power is associated with cognitive inhibition, beta power is associated with active task engagement, and theta power is related to memory processes (Wang, 2013).
- Prior RS-EEG research has found links between reduced theta and beta activation and increased alpha activation in children with ASD.

This study asked the following questions and hypothesized:

1. How will the whole-head alpha, beta, and theta activity levels compare for ASD and TD participants?
   - Hypothesis: ASD participants will have higher theta and beta power and lower alpha power in comparison to TD participants.
2. How will the theta-beta ratio differ for ASD and TD participants?
   - Hypothesis: ASD participants will have a higher theta-beta ratio than TD participants.
3. How well EF abilities in participants correlate with alpha, beta, and theta activity levels?
   - Hypothesis: There is a negative correlation with alpha power and EF and a positive correlation with beta power and EF.

Methods

Participants and Measures

109 participants with a confirmed diagnosis of ASD and 109 age and sex matched TD participants with typical development (TD) ages 8 to 17 (M=12.6, SD=2.88) with IQ in the average to above average range were included in this study.

Table 3: Details on the measures used in this study.

Table 2: Participants were separated by ASD diagnosis. Mean scores across two EF subindices and the GEC are noted.

Table 4: Differences in alpha band activity for ASD and TD participants

Table 5: Differences in theta band activity for ASD and TD participants

Table 6: Differences in the theta-beta ratio for ASD and TD participants

Question 2: Theta-Beta Ratio

A t-test was run to compare ASD and TD participants in their theta-beta ratios. A Pearson’s correlation was run separately for ASD and TD participants to determine associations between EF scores and the theta-beta ratio. The theta-beta ratio was set as an independent variable and total GEC score as measured by the BRIEF was set as the dependent variable.

Table 7: Bivariate correlations between theta-beta ratio and GEC

Results

Table 3: Differences in alpha band activity for ASD and TD participants

Table 4: Differences in beta band activity for ASD and TD participants

Table 5: Differences in theta band activity for ASD and TD participants

Table 6: Differences in the theta-beta ratio for ASD and TD participants

Table 7: Bivariate correlations between theta-beta ratio and GEC

Question 3: EF Abilities and EEG Correlations

A series of Pearson’s correlations were run for ASD and TD participants separately to determine associations between EF scores and RS-EEG activity levels. The whole-head alpha, beta, and theta activity levels were set as independent variables, and total GEC score, the Metacognition index, and the Behavioral Regulation index as measured by the BRIEF were set as the dependent variables.

Table 8: Bivariate Correlation of Alpha, Beta, and Theta RS-EEG levels with GEC for ASD and TD participants

Discussion

Summary

- The lack of significant differences in whole head RS-EEG in the alpha, beta, and theta bands between ASD and TD participants is consistent with some literature that finds no differences across these three bands for ASD and TD children (Chen, 2007) and inconsistent with other literature that found a significantly lower alpha power in ASD children in comparison to TD children (Neuhaus, 2019).
- The theta-beta ratio reflects cognitive processing and is typically higher in children with ADHD, although with high heterogeneity, when compared to TD children (Picken, 2020). However, no significant difference was found in this ratio between ASD and TD participants.
- The positive correlation of beta power and GEC for ASD participants and negative correlation of alpha power and GEC for TD participants warrants more research the use of EEG to distinguish between high EF and low EF ASD populations.
- Further research revealed a significant positive correlation between frontal beta power and the behavioral regulation subscale measured by BRIEF.

Limitations

- The large heterogeneity of ASD participants in this study as evidenced from the BRIEF scores may mean that significant differences between ASD and TD participants are unlikely without controlling for age, sex, IQ, or other factors.
- The BRIEF, which is a parent-report measure of executive functioning, may not be as robust in measuring executive dysfunction for participants as a task-based activity.

Future Directions

- Exploring correlations of executive functioning with EEG data and finding whether EEG can serve as a moderator of relationships between ASD traits and EEG data might be a useful next step to learn more about the heterogeneity of ASD.

References


