# Resting EEG Architecture is Atypical in Children with ASD and Sleep Problems

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## Background

- Children with Autism Spectrum Disorder (ASD) present with a high rate of psychiatric and medical comorbidities, including sleep problems.
    - 40-80% of children with ASD have sleep difficulties, compared to just 20% of their typically developing (TD) peers.
- Resting EEG provides a measure of baseline brain activity, which changes as a function of age and mental state.
- Frontal theta power is associated with both age and sleepiness: theta power is expected to decrease with age and increase with sleep deprivation in TD children.
- However, the relationship of theta power and sleepiness in children with ASD has not been determined.

**Specific Aims:**
1. Determine resting EEG power architecture associated with sleep problems in children with TD and ASD.
2. Compare resting EEG power between diagnostic groups over the course of development.

## Method

| | | Mean (SD) | | | | |
|---|---|---|---|---|---|---|
| | N (% male) | Age | IQ * | ADOS CSS | CSHQ total score | n sleep problems (% total N) |
| ASD | 23 (67%) | 13.3 (2.4) | 97 (19) | 7.2 (1.7) | 32.0 (6.5) | 13 (57%) |
| TD | 17 (57%) | 12.0 (2.3) | 113 (9.2) | --- | 28.8 (5.7) | 7 (41%) |

\* = Diagnostic groups differ significantly in IQ (*p*=.001)

### Participants and Measures
- ASD diagnosis was based on the Autism Diagnostic Observation Schedule (ADOS), Autism Diagnostic Interview – Revised, and DSM-5 diagnostic criteria.
- Participants completed the **Children's Sleep Habits Questionnaire (CSHQ)** at their research visit, scored with Katz, et. al (2018) modified scoring.
    - Subscales were calculated, where increased scores represent greater impairment in that area: Sleep Initiation, Sleep Anxiety, Daytime Sleepiness, and Parasomnias.

### EEG Data Acquisition and Analysis
- Participants sat in a dimly lit room for 60 seconds with their eyes open followed by 60 seconds with their eyes closed.
- EEG was recorded at 500 Hz using a 128 channel Hydrocel Geodesic Sensor Net.
- EEG recordings were preprocessed in EEGlab:
    - Filtered from 0.1 to 100 Hz
    - Re-referenced to common average reference
    - Segmented into 2 second epochs of eyes open data
    - Trials were rejected for movement artifact
- Participants with <20 seconds of artifact free data were excluded from further analyses.
- Power spectra were extracted from the frontal region (Fig. 1) for all frequency bands:
    - Delta (δ; 1-4 Hz)
    - Theta (θ; 4-8 Hz)
    - Alpha (α; 8-12 Hz)
    - Beta (β; 13-25 Hz)
    - Gamma (γ; 25-50 Hz)
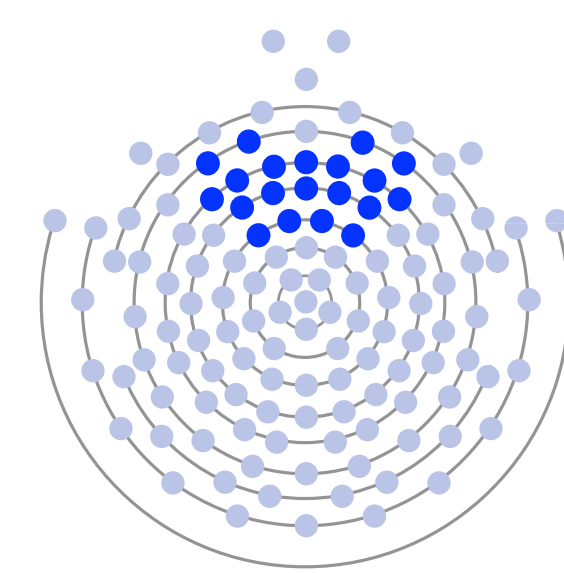- Relative power was calculated for each frequency band.

### Statistical Analysis
- Participants were classified by 2 variables:
    1. Diagnosis (ASD or TD)
    2. Sleep group (Sleep Problems or Sleep Typical)
        - Sleep problems = CSHQ total score ≥ 29 (sample median)
        - Sleep typical = CSHQ < 29
- Mean relative EEG power for each frequency band was analyzed in a two-way ANOVA with between subject variables of diagnosis (ASD or TD) and sleep group (sleep typical or sleep problems).
- Relationships between brain power and CSHQ subscales were assessed with Pearson correlations.

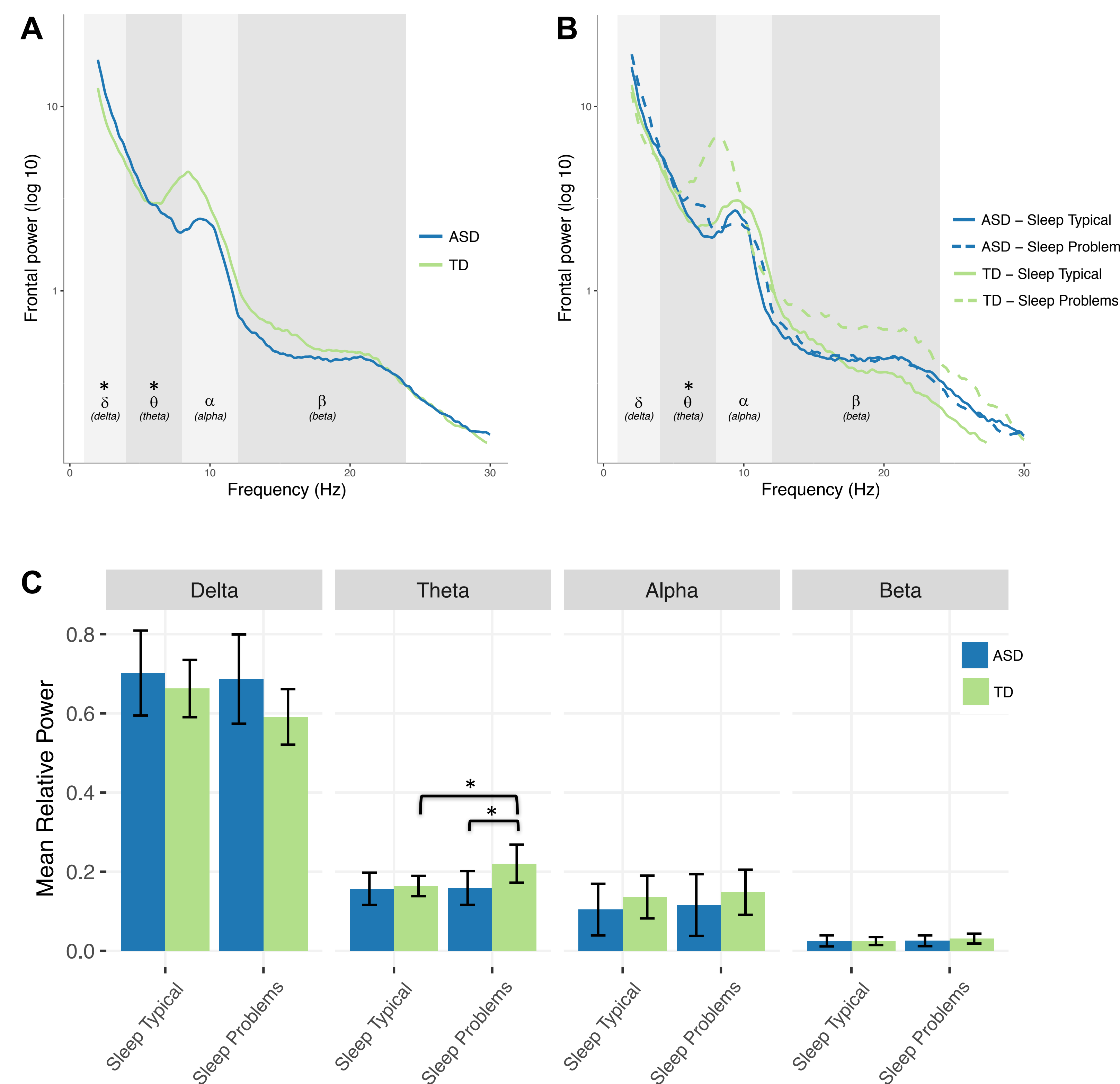**Figure 1.** Frontal electrodes used for analysis

## Results



**Figure 2.** Spectral analysis of eyes open resting EEG by diagnosis (A), and by diagnosis and sleep group (B). Mean relative powers for each frequency band (C), grouped by diagnosis and sleep group. (* = Indicates a significant difference between groups, *p*<.05)

**Relative Delta Power:**
- There was a significant main effect of diagnosis [*F*(1,35)=5.95, *p*=.02] such that children with ASD had increased relative delta power compared to their TD peers.

**Relative Theta Power:**
- There were significant main effects of diagnosis [*F*(1,35)=7.22, *p*=.011] and sleep group [*F*(1,35)=5.07, *p*=.031] such that the TD group had greater relative theta power than the ASD group, and the sleep problems group had greater relative theta power than the sleep typical group.
- There was a significant interaction of diagnosis and sleep group [*F*(1,35)=4.65, *p*=.038] such that children with TD and sleep problems showed greater theta power than children with TD and typical sleep (*p*=.007) and children with ASD and sleep problems (*p*=.009).
- There was no significant difference in relative theta power between the sleep groups for children with ASD.

**Relative Alpha Power, Relative Beta Power, Relative Gamma Power:**
- There was no significant main effect nor a significant interaction effect on the relative alpha, beta, and gamma powers (*p*'s>.1).
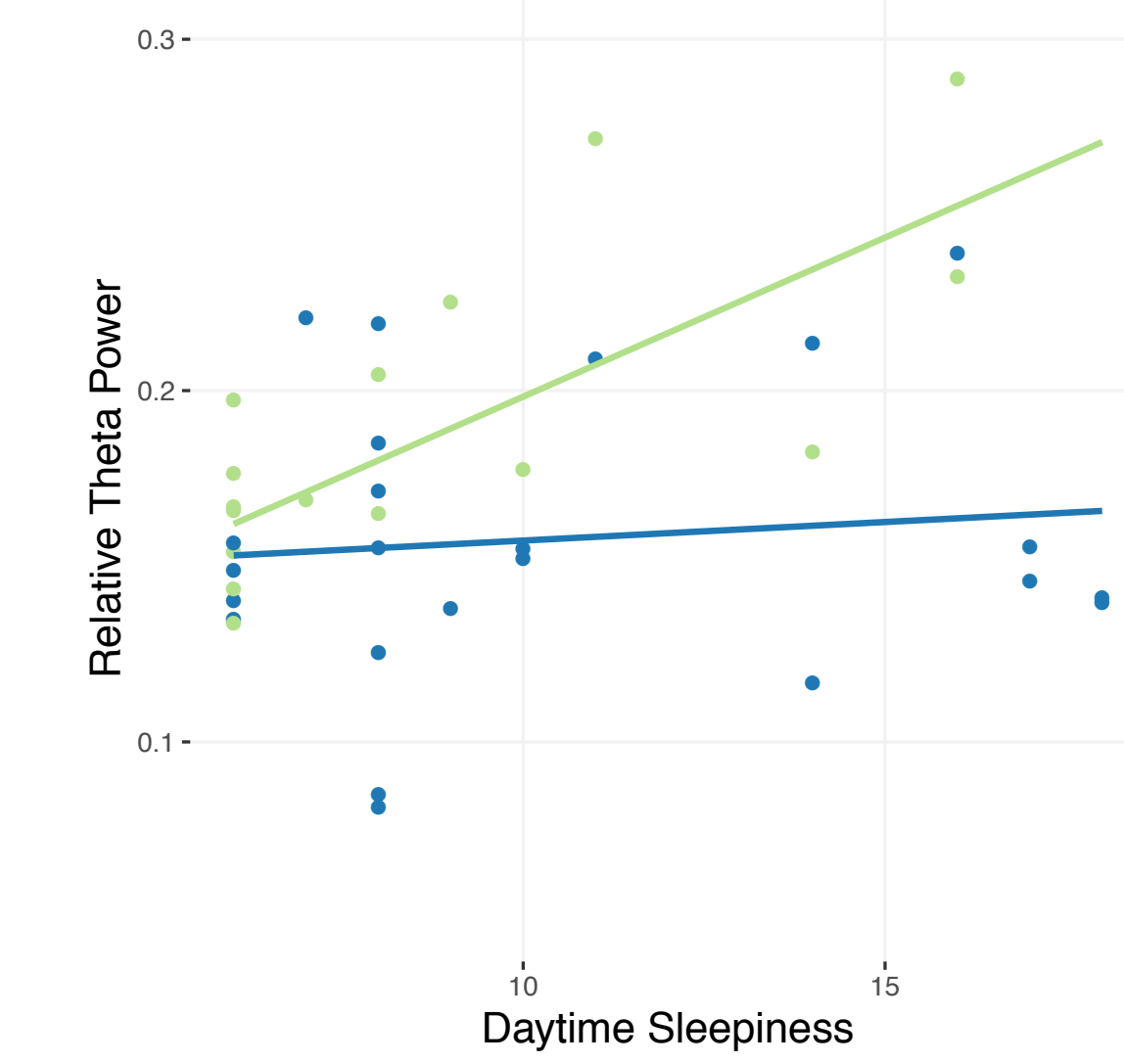
**Figure 3.** Increased daytime sleepiness score on the CSHQ is associated with increased relative theta power in children with TD [*r*(15)=.70, *p*=.002], but not ASD [*r*(21)=.10, *p*>.5]. This correlation stays significant even after controlling for age.
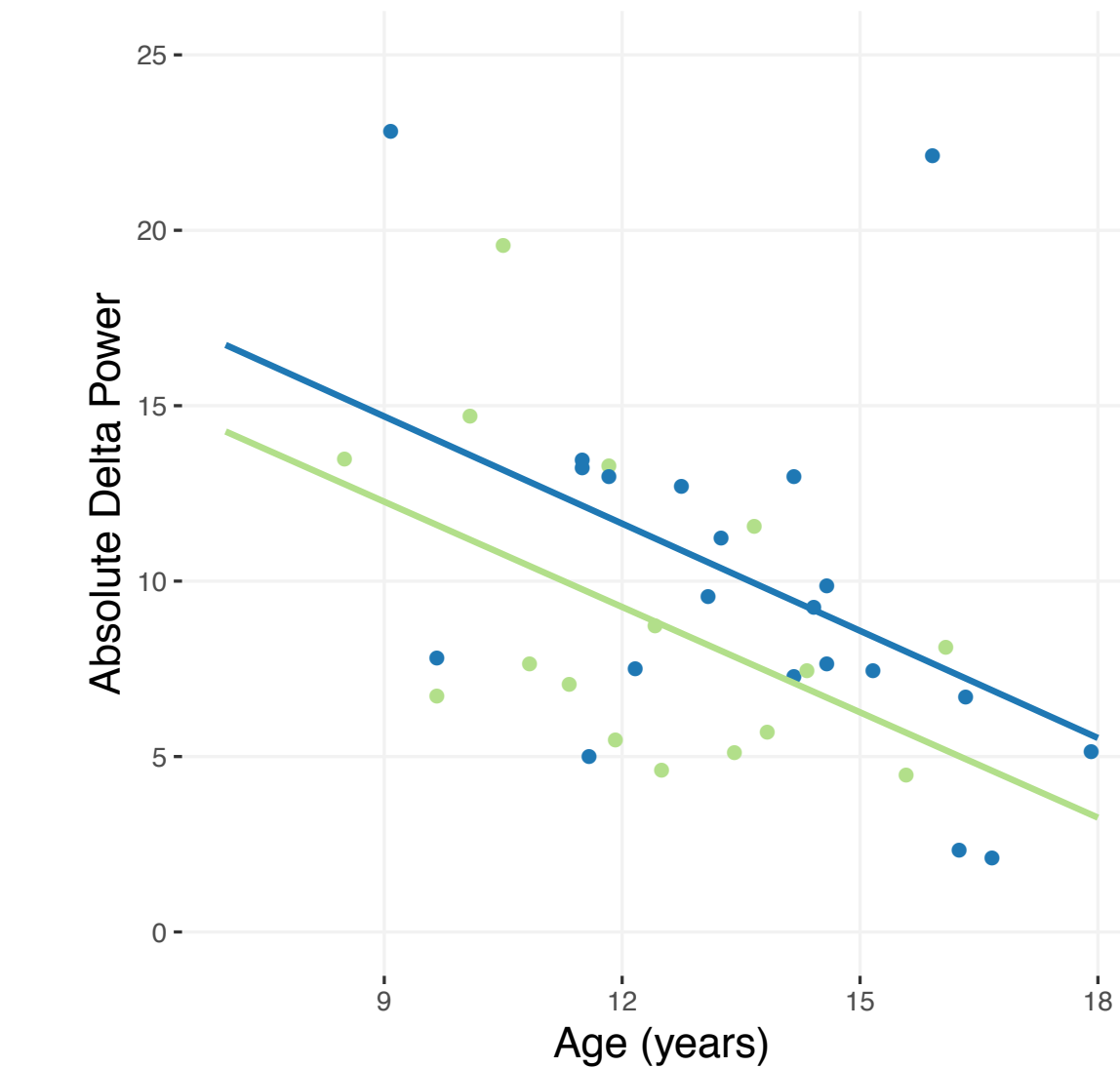
**Figure 4.** Delta power decreases with age in both children with TD [*r*(15)=-.62, *p*=.01] and ASD [*r*(21)=-.44, *p*=.044].
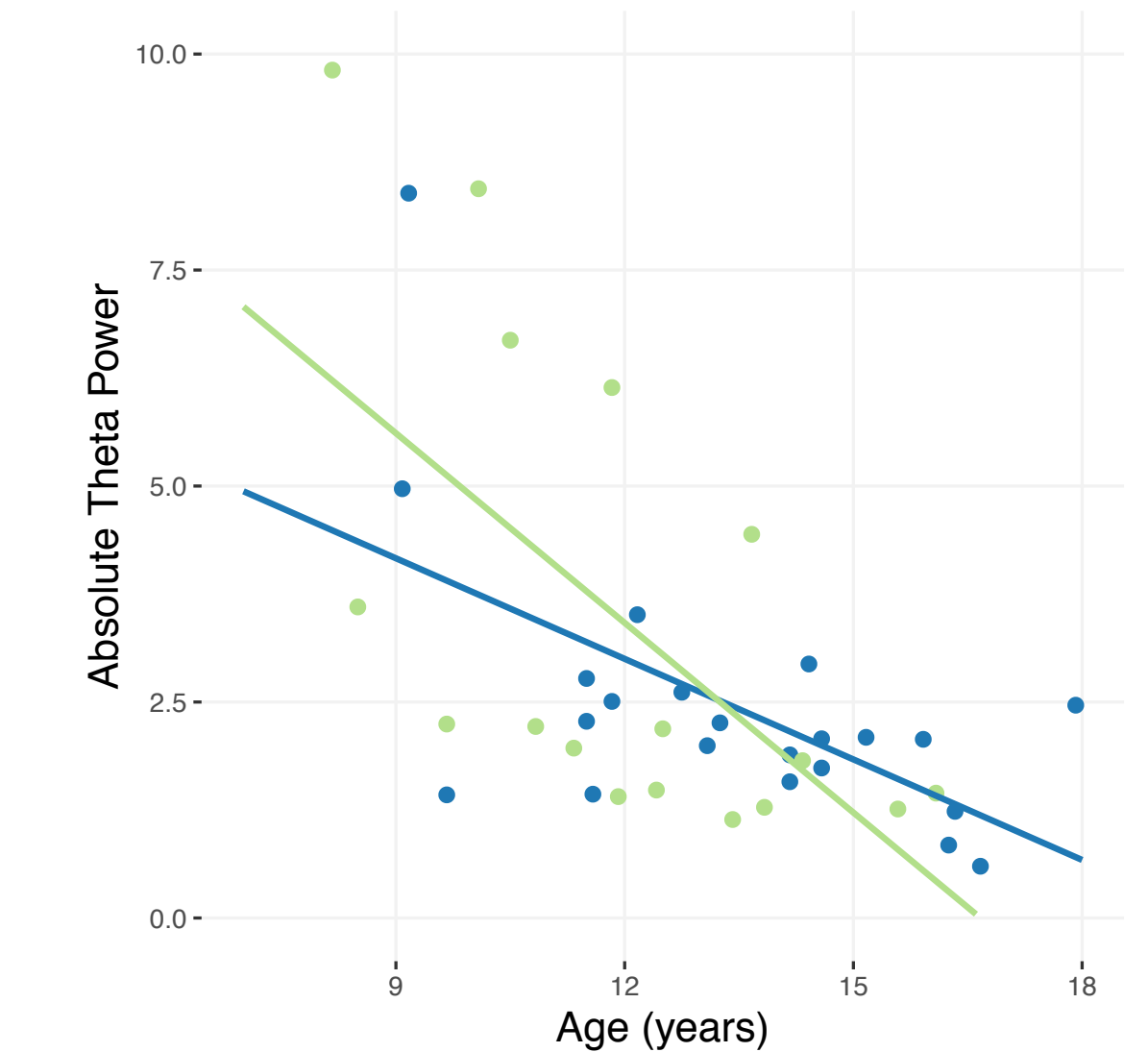
**Figure 5.** Theta power decreases with age in both children with TD [*r*(15)=-.60, *p*=.014] and ASD [*r*(21)=-.52, *p*=.016].

## Conclusions

- Children with ASD showed elevated sleep problems compared to their TD peers, with a prevalence consistent with the current literature.

- Consistent with previous research, children with TD and sleep problems demonstrate increased theta power. In contrast, children with ASD and sleep problems showed no such changes in theta power, suggesting altered homeostatic brain function in children with ASD and sleep disturbances.

- Future analyses will examine EEG spectral power during wake and sleep to better understand how sleep problems affect the baseline brain activity of children with ASD.

### References
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