Children with autism and sleep problems show abnormal regulation of resting EEG

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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 electroencephalography (EEG) provides a measure of baseline brain activity, which changes as a function of age and mental state.
  - Frontal theta (4-8 Hz) is associated with sleep deprivation and sleepiness: theta power is expected to increase with sleepiness in TD children (Fattinger, 2017).
- Previous studies have shown a positive relationship between sleep deprivation and power in the 7, 8, and 9 Hz range (Cajochen, 1994).
- However, the relationship of theta power (4-8 Hz) and sleepiness in children with ASD has not been determined.

Specific Aims:

1. Determine resting EEG power features associated with sleep problems in children with TD and ASD.
2. Examine resting EEG structure between diagnostic and sleep groups using conventional frequency bands (theta and alpha) as well as 1-Hz wide bins.

Method

		Mean (SD)			
	N (*n* male)	Age	IQ *	ADOS CSS	CSHQ total score
ASD	22 (14)	13.4 (2.5)	97 (19)	7.1 (1.7)	31.5 (6.7)
TD	14 (7)	12.3 (2.2)	113 (9.3)	---	28.6 (4.1)

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 according to Katz et. al (2018) modified scoring.
  - Subscales were calculated such that increased scores represent greater impairment in an area: Sleep Initiation, Sleep Anxiety, Daytime Sleepiness, and Parasomnias.
- Diagnostic groups differ significantly in IQ (* indicates p=.001).

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 filtered from 0.1 to 100 Hz, segmented into 2 second epochs of eyes open data and 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 1 Hz wide bands from 4 to 12 Hz, as well as the theta (4-8 Hz) and alpha (8-12 Hz) bands.

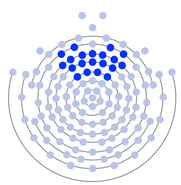

Figure 1. Selection of frontal electrodes

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
- Absolute power at each 1 Hz bin was analyzed with diagnosis and sleep group as between group factors.
- Pearson correlations were run to asses relationship of CSHQ sleep impairment scores and EEG power.

Results

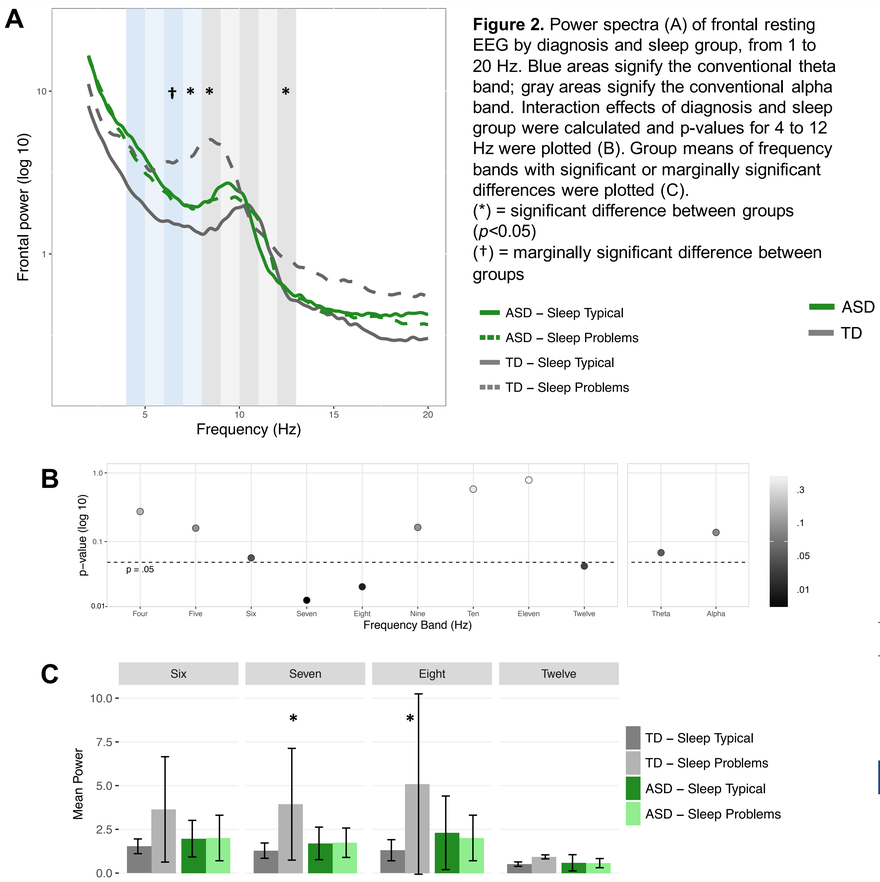

Figure 2. Power spectra (A) of frontal resting EEG by diagnosis and sleep group, from 1 to 20 Hz. Blue areas signify the conventional theta band; gray areas signify the conventional alpha band. Interaction effects of diagnosis and sleep group were calculated and p-values for 4 to 12 Hz were plotted (B). Group means of frequency bands with significant or marginally significant differences were plotted (C).
(*) = significant difference between groups (p<0.05)
(†) = marginally significant difference between groups

Mean Power for 1-Hz bands

Six Hz:

- There was a significant main effect of sleep group [F(1, 32)=4.14, p=.050], and a marginally significant interaction effect of diagnosis and sleep group [F(1, 32)=3.853, p=.058]. Post-hoc t-tests controlling for multiple comparisons revealed no significant differences between groups.

Seven Hz:

- There was a significant main effect of sleep group [F(1, 32)=7.18, p=.012] such that children with sleep problems had greater 7 Hz power than children with typical sleep.
- There was a significant interaction effect of diagnosis and sleep problems [F(1, 32)=14.4, p=0.014]; children with TD and sleep problems show greater 7 Hz power than children with TD and typical sleep (p=.010), children with ASD and typical sleep (p=.027), and children with ASD and sleep problems (p=.024).

Eight Hz:

- There was a significant main effect of sleep group [F(1, 32)=4.24, p=.048] such that children with sleep problems had greater 8 Hz power than children with typical sleep.
- There was a significant interaction effect of diagnosis and sleep problems [F(1, 32)=5.784, p=0.022]. Children with TD and sleep problems showed significantly greater 8 Hz power than children with TD and typical sleep (p=.036).

Twelve Hz:

- There was a significant interaction of diagnosis and sleep problems [F(1, 32)=4.39, p=.044]. Post-hoc t-tests controlling for multiple comparisons revealed no significant differences between groups.

Mean Power for conventional EEG bands

Theta, Alpha:

- There were no significant main effects or interaction effects for the theta or alpha bands.

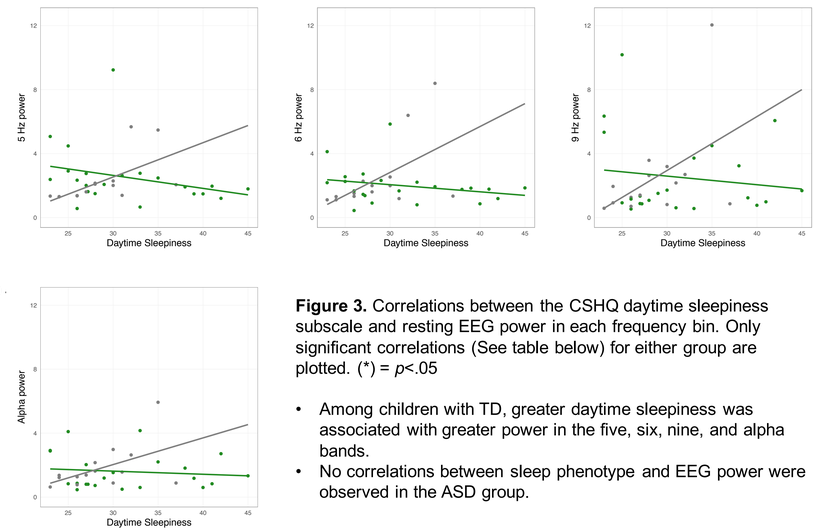

Figure 3. Correlations between the CSHQ daytime sleepiness subscale and resting EEG power in each frequency bin. Only significant correlations (See table below) for either group are plotted. (*) = p<.05

- Among children with TD, greater daytime sleepiness was associated with greater power in the five, six, nine, and alpha bands.
- No correlations between sleep phenotype and EEG power were observed in the ASD group.

Pearson Correlation *r* for CSHQ scores and EEG power

Group	Five	Six	Seven	Eight	Nine	Ten	Eleven	Twelve	Theta	Alpha
ASD	-.327	-.336	-.214	-.037	.004	-.131	-.214	-.267	-.329	-.104
TD	**.605***	**.578***	.288	.489	**.634***	-.008	-.108	.468	.496	**.545***

Conclusions

- Children with ASD showed elevated sleep problems compared to their TD peers, at a prevalence consistent with extant literature.
- Children with TD and sleep problems demonstrated increased power specific to the 7- and 8-Hz range but not when considered across the theta (4-8 Hz) band. In contrast, children with ASD and sleep problems showed no such changes in resting EEG power, suggesting atypical regulation of resting EEG power in response to decreased sleep and sleep disturbances.
- These results demonstrate the importance of exploring resting EEG data outside of conventional frequency bands, especially when examining clinical populations.
- 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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