# An Analysis of Resting EEG Data in Infants at High-Risk for Developing Autism Spectrum Disorder (ASD)

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## BACKGROUND

- The resting EEG paradigm is a well-suited neuroscience tool for individuals with developmental disabilities and infants because it is inexpensive, noninvasive, and does not demand an overt response (Coben, 2009).
- Differences in resting EEG spectral power have successfully discriminated children with ASD from controls and correlate with clinical characteristics (Wang et al., 2013).
- Resting EEG activity may differentiate high- and normal-risk infants (Bosl et al., 2011).
- Alpha asymmetry is associated with mood reactivity and cognitive functioning (Gotlib, 1998).
- Atypical patterns of alpha asymmetry have been observed in school-age children with autism (Stroganova et al., 2007).
- Atypical trajectories of alpha asymmetry have been observed in high-risk infants (Gabbard-Durnam et al., 2007), which demonstrates that alpha asymmetry is a promising potential ASD endophenotype.
- Previous resting EEG studies suggest a U-shaped profile of electrophysiological power alterations in ASD, with excessive power in low-frequency, such as theta, and high-frequency power (Wang et al., 2013).

**Current Study**

- The experiment measured and compared electrophysiological brain activity in infants at high-risk for ASD with activity in infants at normal-risk over the first two years of life using the resting EEG paradigm.
    - High-risk infants (HR): infants with an older sibling diagnosed with ASD
    - Normal-risk infants (NR): infants with no first-degree relatives with ASD
- We evaluated the hypotheses that, relative to NR infants, HR infants would display:
    - Differing patterns of alpha asymmetry.
    - Differentiated resting EEG activity in theta spectral power.

## PARTICIPANTS & METHODS

- EEG recorded continuously at 500 Hz using 128-channel Hydrocel Geodesic Sensor Nets.
- Infants seated on parent's lap, watched bubbles being blown for 2 minutes.
- Using Netstation 4.5.4 software, EEG data were filtered, segmented into 120 overlapping 1s epochs, processed through artifact detection, and hand-edited for artifacts.
- Processed and cleaned data were averaged from lateral electrodes across both hemispheres (Fig. 1).
- Spectral power was estimated using a Multitaper Fast Fourier Transform.
- Theta (θ; 3-5 Hz) spectral power levels for the left and right hemispheres and alpha (α; 6-8 Hz) asymmetry, or the difference in alpha power levels between hemispheres, were examined (Fig. 2-4).
- Participants grouped into two cohorts: infants ≤ 12 months and infants > 12 months.
- Alpha asymmetry and theta power were analyzed using repeated measures analysis of variance (ANOVA) and paired samples t-tests.
    - Within-subject factors:
        - Hemisphere (Left/Right)
    - Between-subject factors:
        - Risk (HR/NR)
        - Sex (Male/Female)
        - Age (≤12m/>12m)

| | NR | | HR | |
|---|---|---|---|---|
| | Male | Female | Male | Female |
| **≤12 m** | 6 | 7 | 16 | 8 |
| **>12 m** | 7 | 10 | 11 | 2 |

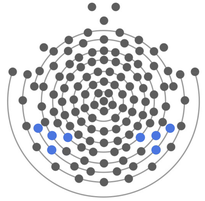
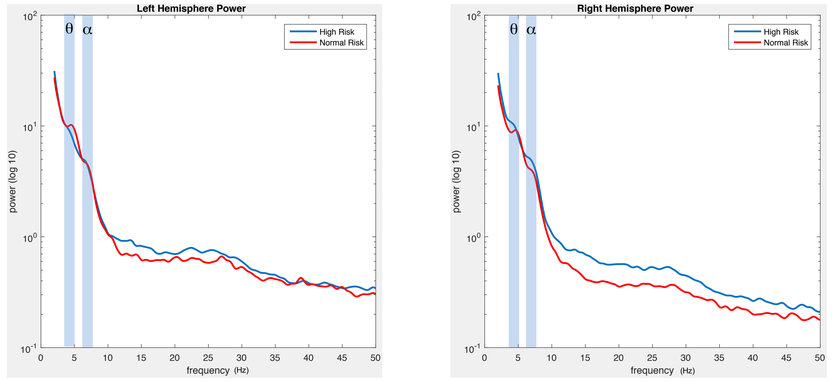


**Figure 1: Resting EEG Electrode Chart.** Data were averaged across 4 lateral electrodes for both **right** (91, 95, 96, 100) and **left hemispheres** (57, 58, 59, 64 ).

## RESULTS

**≤ 12 months**




**> 12 months**

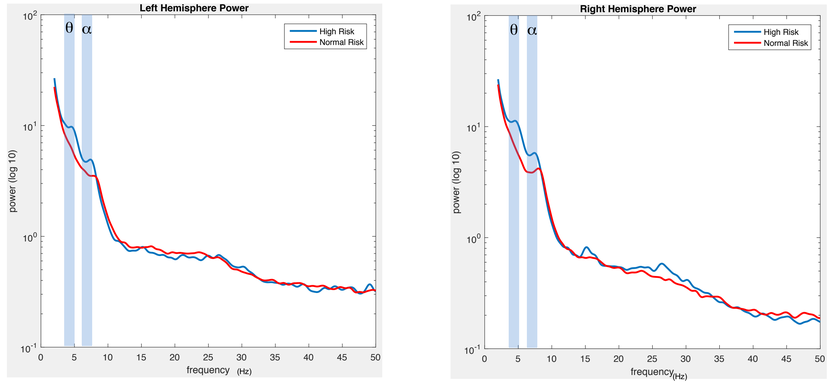



**Figure 2: Spectral power maps for HR and NR infants at ≤ 12 and > 12 month time points.**

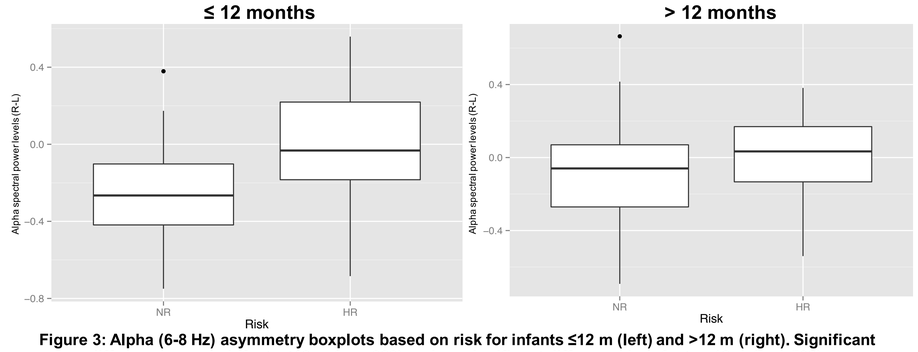



**Figure 3: Alpha (6-8 Hz) asymmetry boxplots based on risk for infants ≤12 m (left) and >12 m (right). Significant difference seen in infants ≤12 m ($p$ = .023) and no significant difference in infants >12 m ($p$ = .508).**

**REFERENCES**

Bosl, W., Tierney, A., Tager-Flusberg, H., & Nelson, C. (2011). EEG complexity as a biomarker for autism spectrum disorder risk. *BMC medicine*, *9*(1), 1.
Coben, R. (2009). The importance of electroencephalogram assessment for autistic disorders. *Biofeedback*, *37*(2), 71-80.
Gabard-Durnam, L., Tierney, A. L., Vogel-Farley, V., Tager-Flusberg, H., & Nelson, C. A. (2015). Alpha asymmetry in infants at risk for autism spectrum disorders. *Journal of autism and developmental disorders*, *45*(2), 473-480.
Gotlib, I. H. (1998). EEG alpha asymmetry, depression, and cognitive functioning. *Cognition & Emotion*, *12*(3), 449-478.
Stroganova, T. A., Nygren, G., Tsetlin, M. M., Posikera, I. N., Gillberg, C., Elam, M., & Orekhova, E. V. (2007). Abnormal EEG lateralization in boys with autism. *Clinical Neurophysiology*, *118*(8), 1842-1854.
Tau, G. Z., & Peterson, B. S. (2010). Normal development of brain circuits. *Neuropsychopharmacology*, *35*(1), 147-168.
Wang, J., Barstein, J., Ethridge, L. E., Mosconi, M. W., Takarae, Y., & Sweeney, J. A. (2013). Resting state EEG abnormalities in autism spectrum disorders. *Journal of neurodevelopmental disorders*, *5*(1), 1.

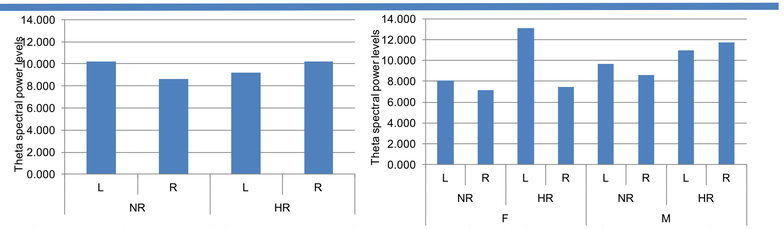



**Figure 4: Theta (3-5 Hz) power levels for infants ≤12 m (left) and infants >12 m (right).**

- In infants ≤ 12 months, there was not a significant difference in the number of bad trials between males (M = 59.93, SD = 23.140) and females (M = 52.62, SD = 23.905; $p$ = .882) as well as NR (M = 56.36, SD = 20.190) and HR (M = 56.97, SD = 24.985; $p$ = .218) (Fig. 5).
- In infants > 12 months, there was not a significant difference in the number of bad trials between males (M = 56.21, SD = 20.602) and females (M = 52.75, SD = 28.429; $p$ = .136) as well as NR (M = 54.43, SD = 21.110) and HR (M = 56.07, SD = 26.470; $p$ = .194).
    - Indicates that spectral power results were not due to the number of trials excluded.
- In infants ≤ 12 months, there was a significant difference in alpha asymmetry between HR than NR infants ($p$ = .023). However, in infants > 12 months, there was no significant difference ($p$ = .508).
    - Alpha symmetry was greater in the younger cohort of infants. While the effect was not significant in the older cohort, the pattern of results was in the same direction.
- In infants ≤ 12 months, there were significant interactions in hemisphere*risk for theta ($p$ = .022) but in infants > 12 months, there were significant interactions in hemisphere*sex*risk for theta ($p$ = .015).
    - For infants ≤ 12 m, NR infants demonstrated left-lateralized theta asymmetry and HR infants demonstrated right-lateralized theta asymmetry.
    - For infants > 12 m, theta power was greater in HR infants. Across groups, theta power was greater in the left hemisphere.
    - In HR infants, theta power was greater in females than in males. Theta power was not significantly different or in the opposite direction in males.

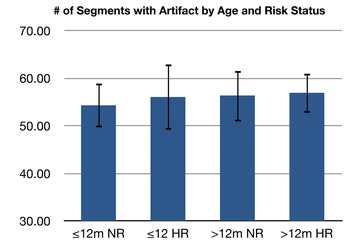



**Figure 5: Sum of bad trials for participants grouped by age and risk.** No significant differences in sums.

## CONCLUSIONS & FUTURE DIRECTIONS

- Different patterns of alpha asymmetry were observed in the two risk groups
    - HR infants exhibited trends towards right lateralization across age groups.
    - May indicate differences in emotional reactivity, which is part of the clinical phenotype of ASD and may allow for earlier detection of ASD.
    - The larger effect of alpha asymmetry in the younger age group may indicate a relationship between early neural pruning and alpha asymmetry differences through either excessive or insufficient neural pruning that leads to hyper-connective and hypo-connective neural circuits.
- Excessive low-frequency theta power in HR infants correspond to findings that link excessive theta levels to ASD.

**Future Directions**

- Compare EEG results in HR infants who develop ASD versus HR infants who do not develop ASD.
- Investigate relationships among EEG and the behavioral phenotype.
- Examine EEG power differences in other frequency bands (gamma and beta).
- Examine the continuous relationship between age and brain activity.
- Explore alternative analytic approaches to resting EEG data, such as coherence and multiscale entropy.

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