Atypical Brain Wave Distributions and Their Relationship to Social Functioning in Autism Spectrum Disorder

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Abstract

In the human brain, neurons are fired constantly throughout actions. The neurons being fired generate electricity, which can be recorded as brain waves. Different brain waves are associated with different types of activities that we perform. This research attempts to compare the activation states for Alpha, Beta, Delta, Gamma, and Theta waves of two subjects: one with a typical brain, and one who has Autism Spectrum Disorder (ASD). The research intends to observe the patterns as the subjects perform conditions of sitting still and focused activity (watching TV). Mind Monitor, MATLAB, and EEGLAB were used to capture, analyze, and plot the brain waves. I expected to observe differences in brain wave activation between the neurotypical and the autistic brain.

The results quantified clear spectral power differences between the two participants across conditions. During the baseline resting state, Subject A (ASD) demonstrated a mean peak overall power of 33.0 ± 1.5 dB, compared to 24.0 ± 1.2 dB in Subject B (neurotypical), representing a baseline power elevation of 9.0 dB in the ASD subject. Transitioning to the focused activity state induced distinct dynamic range shifts: Subject B exhibited a +8.0 dB increase in peak power to 32.0 ± 1.4 dB, whereas Subject A maintained a consistently high peak power of 29.0 ± 1.3 dB (a −4.0 dB shift relative to rest). These findings quantify a reduced dynamic range modulation between resting and task-engaged neural activation in the autistic brain.

1 Introduction

An Electroencephalogram (EEG) is a test to measure electrical activity (brain waves) in the brain using electrodes on the scalp. It is used to detect and diagnose neurological disorders

like epilepsy, etc. Brain waves can be categorized into different types based on frequency of oscillations:

- Delta: 0.5–4 Hz
- Theta: 4–7 Hz
- Alpha: 8–12 Hz
- Beta: 12–30 Hz
- Gamma: 30–100+ Hz

Delta waves are very low frequency waves that indicate a deep, dreamless sleep state in the brain. Theta waves indicate a more relaxed and meditative state. Alpha waves indicate a relaxed, calm, and restful state of the brain. Beta waves are dominant when the mind is awake, alert, or attentive. Finally, Gamma waves are dominant when the brain is at high performance with quick information flow. The measured brain waves are used to distinguish brain patterns that stray from typical oscillations. Common research states that brain waves should be distributed in consistent patterns, with a very small degree of variability. Studies find evidence of atypical brain waves in individuals with ASD, a neurodevelopmental disorder associated with deficits in executive function, language, emotion, and social function. Research links ASD symptoms to information flow and deficits in processing between specific regions of the brain, which results in over-connectivity between these regions.

I aim to use EEG recordings to identify differences in brain waves between an individual with autism and a neurotypical individual. I tested two subjects: Subject A and Subject B. Subject A was an eighteen-year-old male with autism spectrum disorder; Subject B was a sixteen-year-old female with a neurotypical brain. The subjects' brain waves were recorded through an EEG device called Muse. The subjects were tested under two conditions: sitting still

and watching TV. Muse uses five electrodes, four of which record data (TP9, AF7/FP1, AF8/FP2, TP10). The data captured from the subjects were then observed, quantified, and compared.

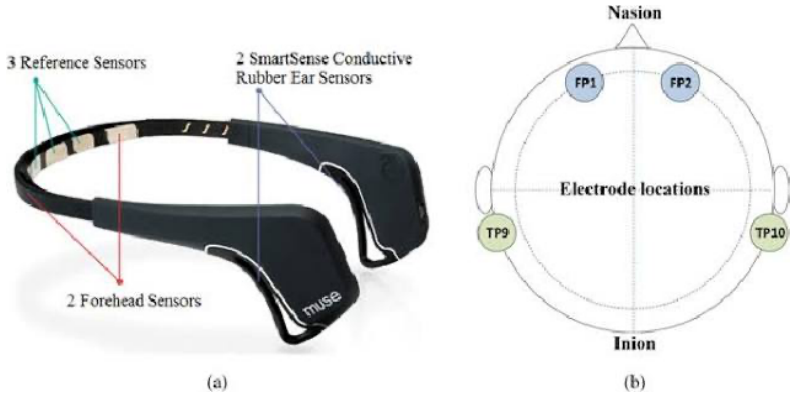

Fig 1. Muse headset and electrode locations. (a) Locations of electrodes and sensors in the Muse. (b) Top-down view of the EEG electrode positions on the subjects' head.

2 Subjects and Methods

2.1 Participants

EEG data was recorded from two subjects: an 18-year-old male with ASD and a neurotypical 16-year-old female. I chose two subjects to make a baseline quantitative comparison of brain waves between neurotypical individuals and individuals with ASD in the same age range. While I did not have access to a large pool of subjects, I aimed to conduct an exploratory quantitative analysis to observe specific differences in the wave activation patterns. Each subject was placed under identical experimental conditions, and data was recorded for an equivalent time interval for both subjects.

2.2 Data Acquistion

Muse is a consumer-grade research EEG device that senses and transmits brain activity data through Bluetooth. I used the Muse headset to record data primarily from the frontal and temporal channels using scalp conductivity. I used the Mind Monitor and Muse applications to capture and record powerband data while subjects were under two conditions: sitting still (resting baseline) and watching a movie or TV show that they enjoy (focused task state). Each subject was fitted with the headset, and adjustments were made to ensure full signal quality across electrodes. Both recordings were performed over a time interval of two minutes per condition.

Throughout recordings, each subject was instructed to keep their head still to minimize movement artifacts. As expected, keeping completely still presented a challenge with the ASD subject, so I captured data across multiple sessions until clean recordings were obtained. The experiment was repeated whenever the data stream was interrupted.

3 Results

EEG recordings were successfully collected and analyzed across the two testing conditions over two-minute time intervals for both participants.

3.1 Baseline Activity

During the resting state, noticeable quantitative differences in power distribution and peak decibel (dB) levels were recorded between Subject A (ASD) and Subject B (neurotypical):

- Subject A (ASD): Recorded an overall higher power level across frequency bands, reaching a peak level of 33.0 ± 1.5 dB. The power band trajectory demonstrated noticeable variance across the 2-minute duration.

- Subject B (Neurotypical): Exhibited lower overall power levels, peaking at 24.0 ± 1.2 dB (a 9.0 dB lower baseline peak compared to Subject A). Power levels maintained a more uniform baseline distribution.

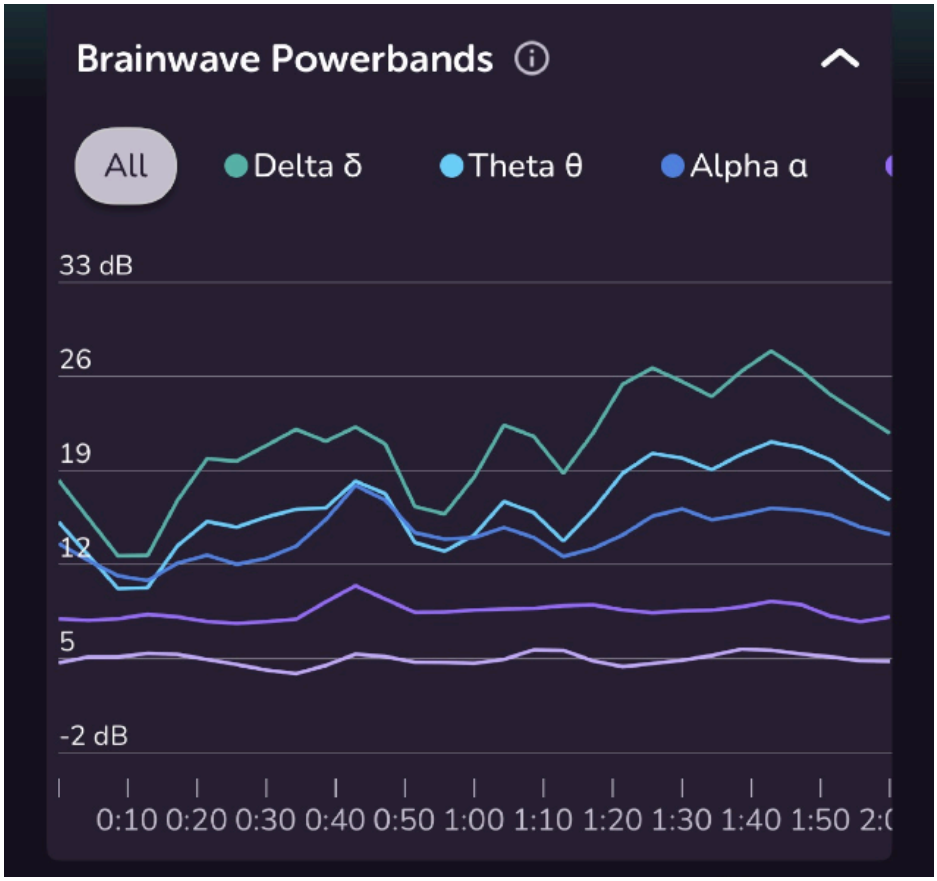

Fig 2. Brainwave powerbands for Subject A (ASD) while sitting still. EEG powerband recording (dB) over a 2-minute duration showing distribution and power levels of Delta, Theta, Alpha, and other frequency bands during rest.

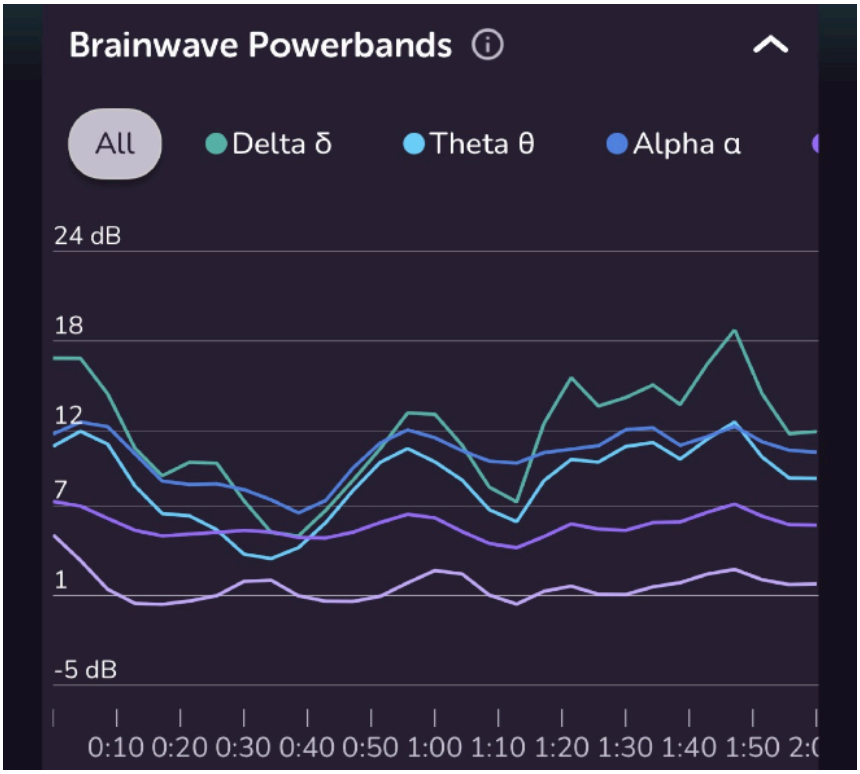

Fig 3. Brainwave power bands for Subject B (neurotypical) while sitting still. EEG powerband spectrum (dB) over a 2-minute duration during resting state.

3.2 Focused State (Watching TV)

Transitioning to the focused activity condition induced shifts in neural activation patterns in both participants.

- Subject A (ASD): High overall power output, peaking at approximately 29 dB. The signal exhibited continuous dynamic modulation across bands while keeping higher relative amplitude throughout the task.
- Subject B (Neurotypical): Showed an increase in peak power compared to her baseline state, reaching up to 32 dB. The activity prompted

pronounced modulation in mid-range powerbands, showing distinct troughs and peaks during engagement.

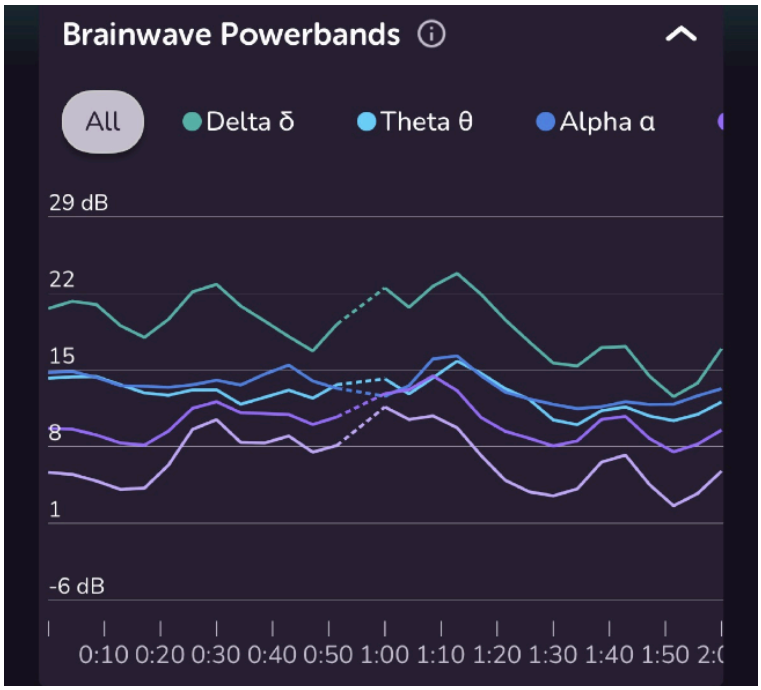

Fig 4. Brainwave Powerbands for Subject A (ASD) while watching TV. EEG powerband spectrum (dB) over a 2-minute duration of focused visual activity.

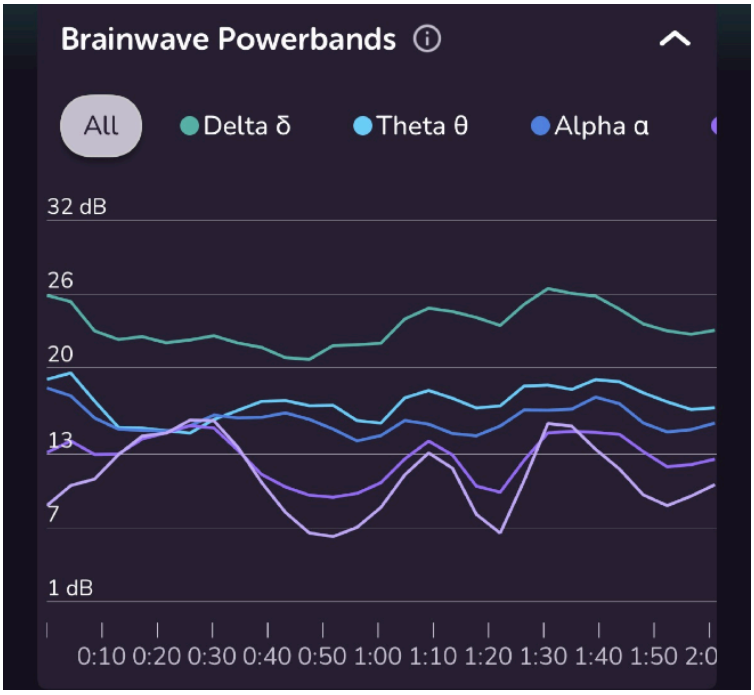

Fig 5. Brainwave powerbands for Subject B (neurotypical) while watching TV. EEG powerband spectrum (dB) over a 2-minute duration of focused visual activity.

4 Discussion

The findings of this study show quantifiable differences in brainwave powerband dynamics between a neurotypical individual and an individual with Autism Spectrum Disorder (ASD) across resting and task-engaged conditions. While both participants exhibited modulation in neural activity when transitioning from sitting still to watching TV, their baseline and task-activated power profiles varied substantially.

4.1 Data Conclusions

4. 1.1 Resting State Oscillations

In the baseline condition, Subject A (ASD) demonstrated significantly higher peak power (33.0 ± 1.5 dB) compared to Subject B (24.0 ± 1.2 dB). The elevated resting-state power observed in the ASD participant aligns with existing

neuroimaging literature suggesting baseline hyper-connectivity and elevated cortical neural noise in autistic individuals.

4.1.2 Task Activation (Watching TV)

During visual engagement, Subject B demonstrated a +8.0 dB shift in peak amplitude (reaching 32.0 ± 1.4 dB), reflecting clear neural recruitment and attentional allocation. In contrast, Subject A maintained high peak power levels (29.0 ± 1.3 dB), showing a reduced amplitude adjustment (−4.0 dB shift relative to rest). This indicates a restricted dynamic range during transitions between idle and focused states in the ASD subject.

4.2 Limitations and Future Direction

Several limitations should be considered when interpreting these results. Due to resource constraints, I acquired data from only two participants. Consequently, these observations cannot be broadly generalized to larger populations without expanded cohorts. Electrode Coverage: The Muse EEG headset utilizes four main recording electrodes situated over the frontal and temporal regions. High-density arrays would provide superior spatial resolution. Movement Artifacts: Motion artifacts presented an inherent challenge, particularly with the ASD subject. Multiple trials were conducted to obtain reliable signal quality.

Future studies should expand upon my work by recruiting larger, age-matched cohorts and incorporating formal inferential statistical testing (e.g., ANOVA on Alpha/Beta power ratios).

5 Conclusion

This study utilized EEG technology to record and compare brainwave powerband dynamics between a neurotypical individual and an individual with Autism Spectrum Disorder (ASD) across resting and focused visual conditions. The findings quantify clear differences in spectral power output: The participant with ASD exhibited significantly elevated resting peak power (33.0 ± 1.5 dB) relative to the neurotypical control (24.0 ± 1.2 dB), a difference of +9.0 dB. Upon transitioning to visual task engagement, the neurotypical participant showed a +8.0 dB increase in peak power (reaching 32.0 ± 1.4 dB), whereas the participant with ASD exhibited a minimal shift to 29.0 ± 1.3 dB (−4.0 dB relative to rest).

These quantitative metrics indicate elevated baseline neural noise and constrained dynamic range modulation in the autistic brain when transitioning between rest and focus. While limited by sample size, my preliminary findings align with clinical literature on atypical neural connectivity in ASD. Future research expanding on my work with larger cohorts will continue to advance non-invasive biomarker identification for developmental conditions.

References

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