Exploring the Absence and Double Peaks of Alpha Activity in Resting-State EEG

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Outline

Introduction

- Resting-state alpha activity (8-12 Hz) is a core neural oscillation tied to cognitive functions such as attention, memory, and self-regulation
- Studies have demonstrated that individuals with higher individual alpha peak frequency (IAPF) tend to perform better on cognitive tasks compared to those with lower IAPF levels *(Bazanova & Aftanas, 2008)*
- Higher levels of alpha activity during resting states have been correlated with improved performance on tasks requiring self-control *(Klimesch et al., 2007)*
- Its absence has been linked to depression and various anxiety disorders

- The phenomenon of double peaks in the alpha range (characterized by the prescence of two distinct peaks within the alpha range) may offer insights into more complex cognitive processes
- Despite the potential significance of double peaks, there remains a notable gap in literature regarding their prevalence and implications, and the mechanisms underlying the emergence of double peaks in alpha activity are not well understood

Key Research Question:

What percentage of individuals lack alpha activity, and how common are double peaks?

Objectives

Quantify the percentage of participants lacking resting-state alpha activity in surface EEG

Explore the prevalence of double peaks in the alpha frequency range

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Research on how these patterns relate to cognitive performance & mental health

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Dataset Description

Source: OpenNeuro database, containing EEG recordings from 111 healthy participants (110 used)

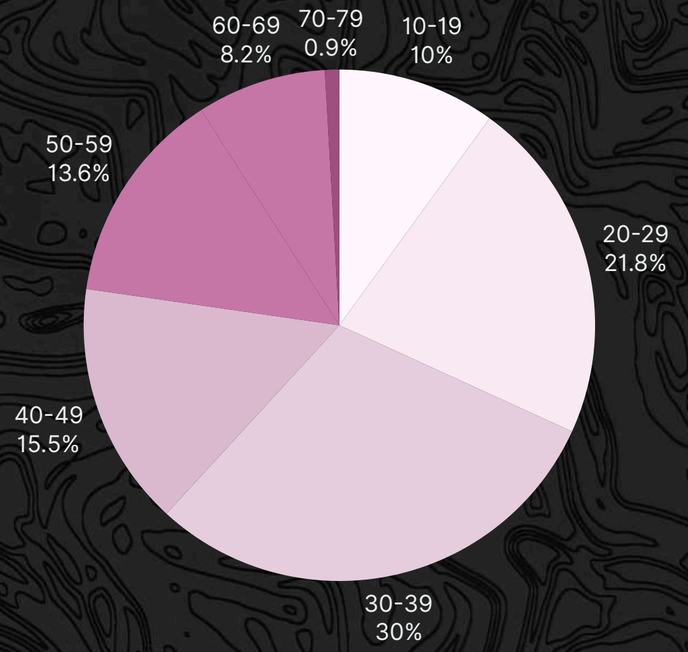
Demographics:

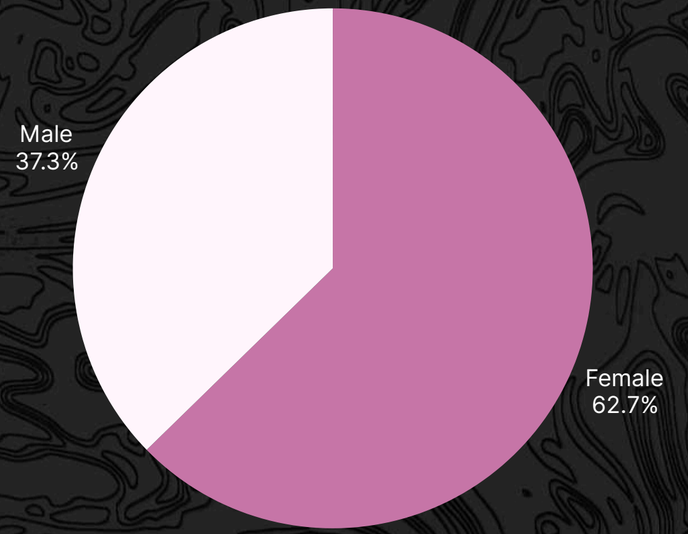
- Mean Age: 37.35 years
- Age Range: 17-71 years
- Gender Distribution: 37.3% male, 62.7% female

EEG Recording Setup:

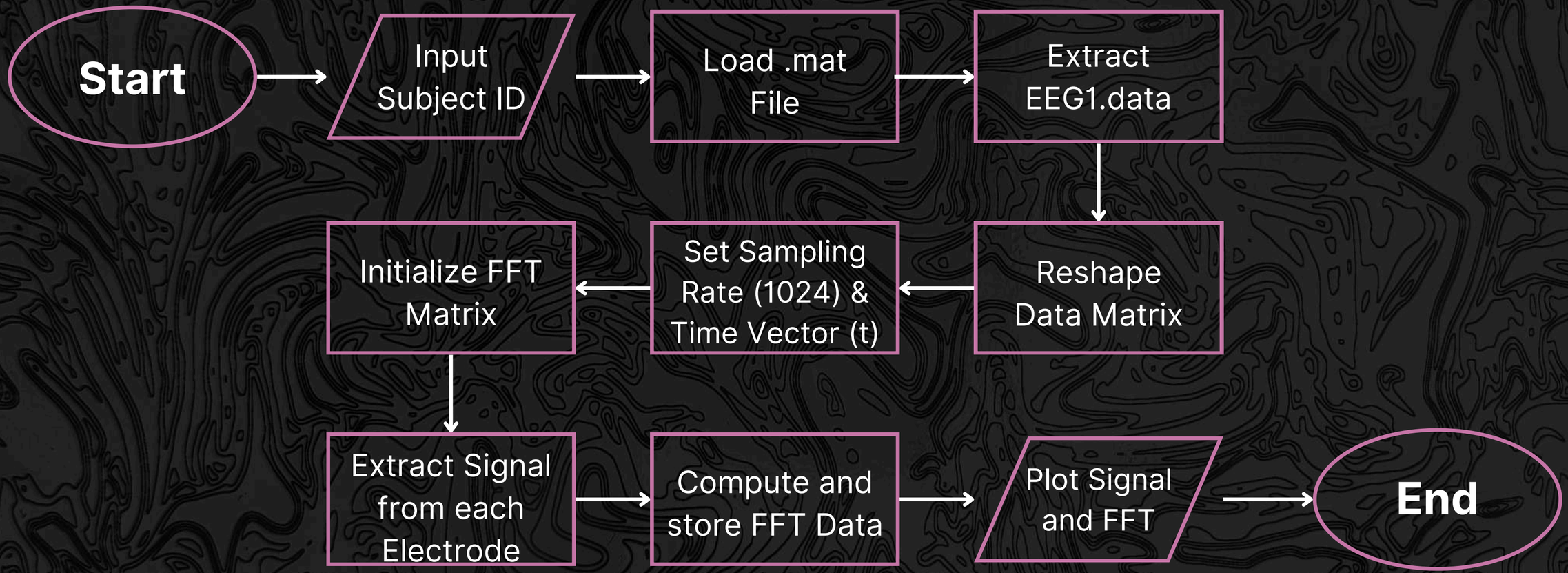
- Conducted using a 64-channel BioSemi ActiveTwo system
- Followed the extended 10-20 electrode placement system
- Resting-state EEG; 4 minutes; eyes closed; no task involved

Original Study Purpose: EEG data was initially collected to investigate long-term potentiation modulation of sensory-evoked potentials





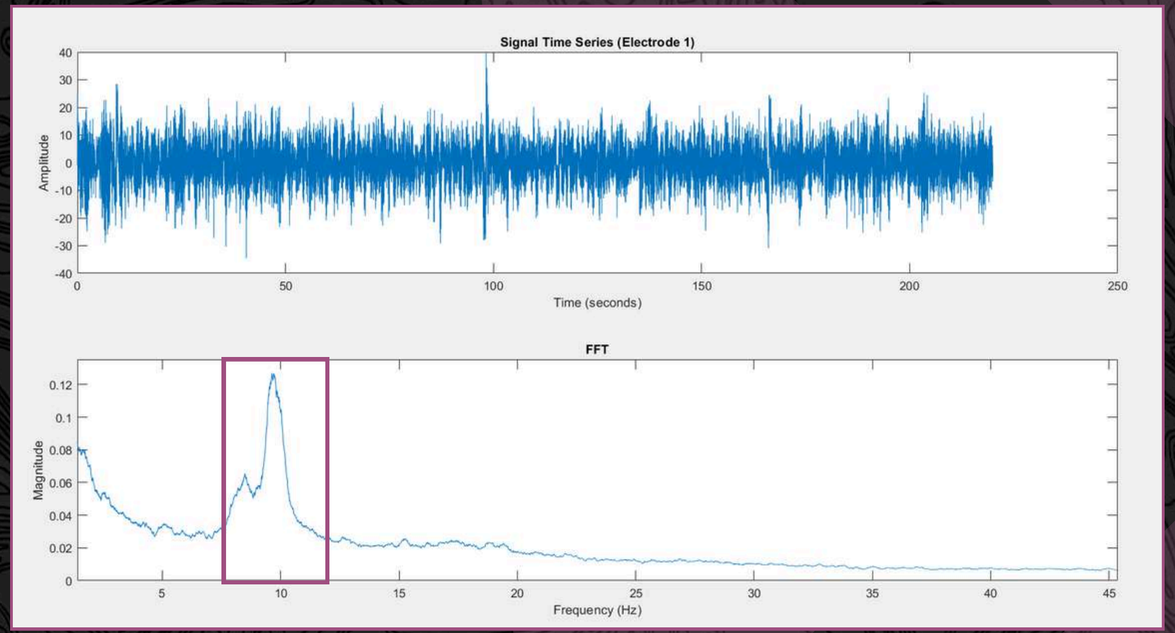
Methodology - Code



Methodology

Time-Domain Plot:

- Displays the raw EEG signal from one electrode, plotted against time
- Helps identify signal anomalies & artifacts, allowing for an inspection of the signal quality



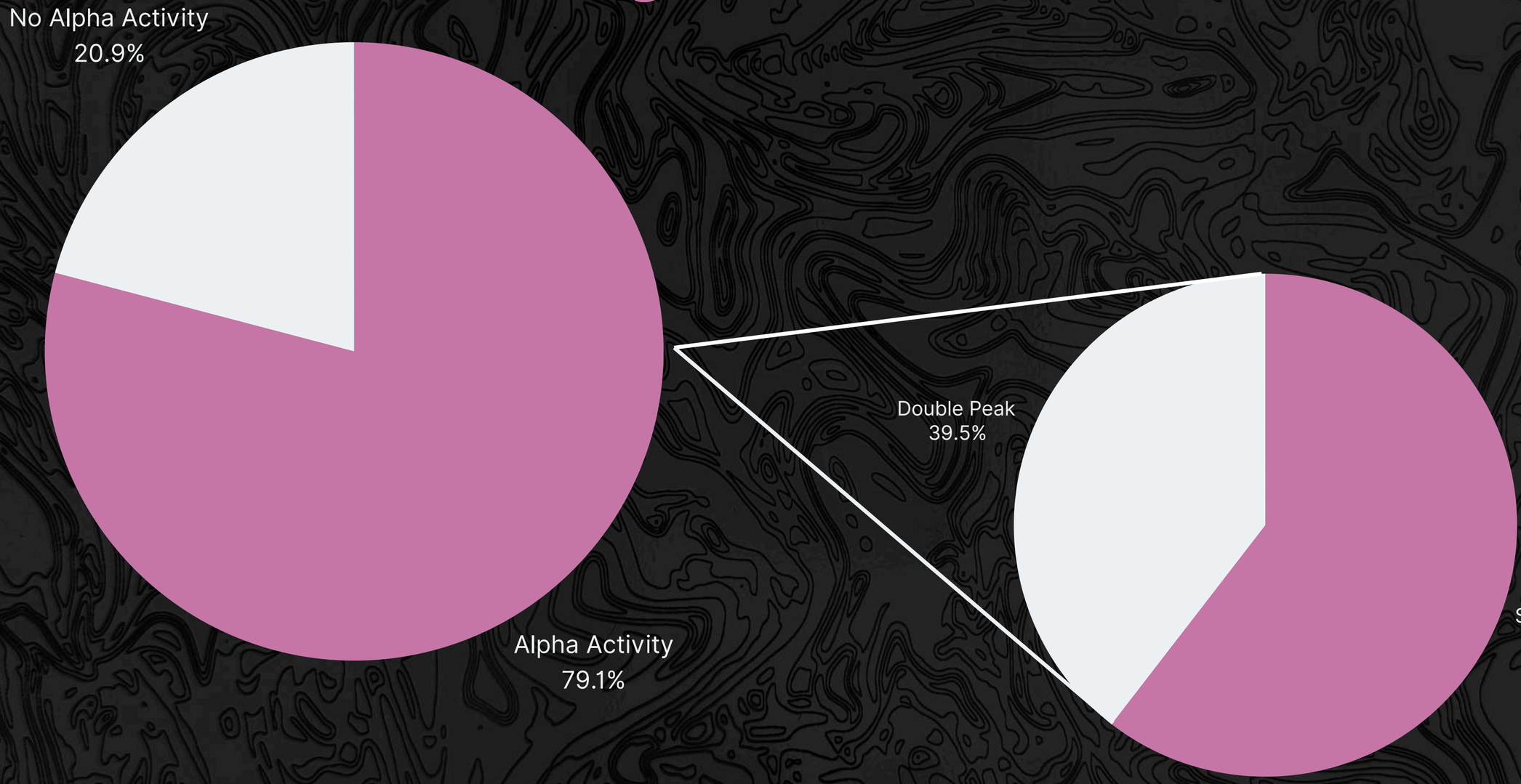
Frequency-Domain Plot:

- Result of the FFT analysis
- Plots signal amplitude vs frequency (Hz)
- Allows observation of the alpha frequency range
- Smoothened to reduce noise and highlight key oscillatory components

Evaluation Criteria:

- **Alpha Activity:** Detect if at least one peak is observed in the 7.5-12.5 Hz range
- **Double Peaks:** Defined as two or more distinct peaks within the alpha range

Key Results


No Alpha Activity
20.9%
Alpha Activity
79.1%
Double Peak
39.5%
Single Peak
60.5%

Insights & Implications

- 20.9% of participants lacked resting-state alpha activity, suggesting a potential gap in using alpha waves as reliable biomarkers for cognitive or psychiatric disorders
- This raises concerns about the exclusivity of existing neurodiagnostic systems that rely solely on alpha activity as an indicator
- Examples: Alpha activity is used as a primary marker for conditions like:
  - ADHD diagnosis
  - Depression assessments
  - Anxiety disorders

- To ensure more comprehensive diagnostics, we need to develop systems that include multiple biomarkers, making neurodiagnostic tools more inclusive for individuals who do not exhibit alpha activity

Insights & Implications

- 39.5% of participants with alpha activity exhibited double peaks, suggesting more complex neural oscillations
- The presence of double peaks could also suggest distinct neural pathways or interactions between different brain regions, offering a new dimension to understanding brain function during resting states
- Future research could explore whether double peaks can serve as biomarkers for advanced cognitive abilities or unique cognitive strategies, potentially offering new insights into how the brain optimally processes information during rest

Conclusions & Future Work

Key Findings:

- 20.9% of participants lacked alpha activity
  - 39.5% of participants with alpha activity exhibited double peaks

Implications:

- It also suggests the need for more inclusive biomarker systems to allow for better medical care.

Future Work:

- Investigate the cognitive relevance of double peaks in larger and more diverse populations
- Explore the therapeutic potential of enhancing alpha activity through neurofeedback, especially for individualized care
- Study the impact of individual differences in alpha activity on cognitive performance

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Thank You!

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