



EEG-Based Spanish Language Proficiency Classification: A Power Spectrum and Cross-Spectrum Analysis

Blaise O'Mara¹, Skyler Baumer¹, Ronald Croce, PhD², Wayne Smith II, PhD¹, Mauricio Pulecio, PhD³
University of New Hampshire Departments of:



¹Electrical and Computer Engineering, ²Kinesiology, and ³Literatures, Languages, & Cultures

Introduction

The Big Questions

- What happens in the brain cortex as someone becomes more proficient in a second language (L2)?
- Can these electrophysiological changes be measured with EEG?

The Neural Efficiency Hypothesis

- Skill/task proficiency increases → brain **power** and **resources** used decreases.

Brain Power

- Event-Related Desynchronization and Synchronization (ERD/ERS): measures of relative power change.

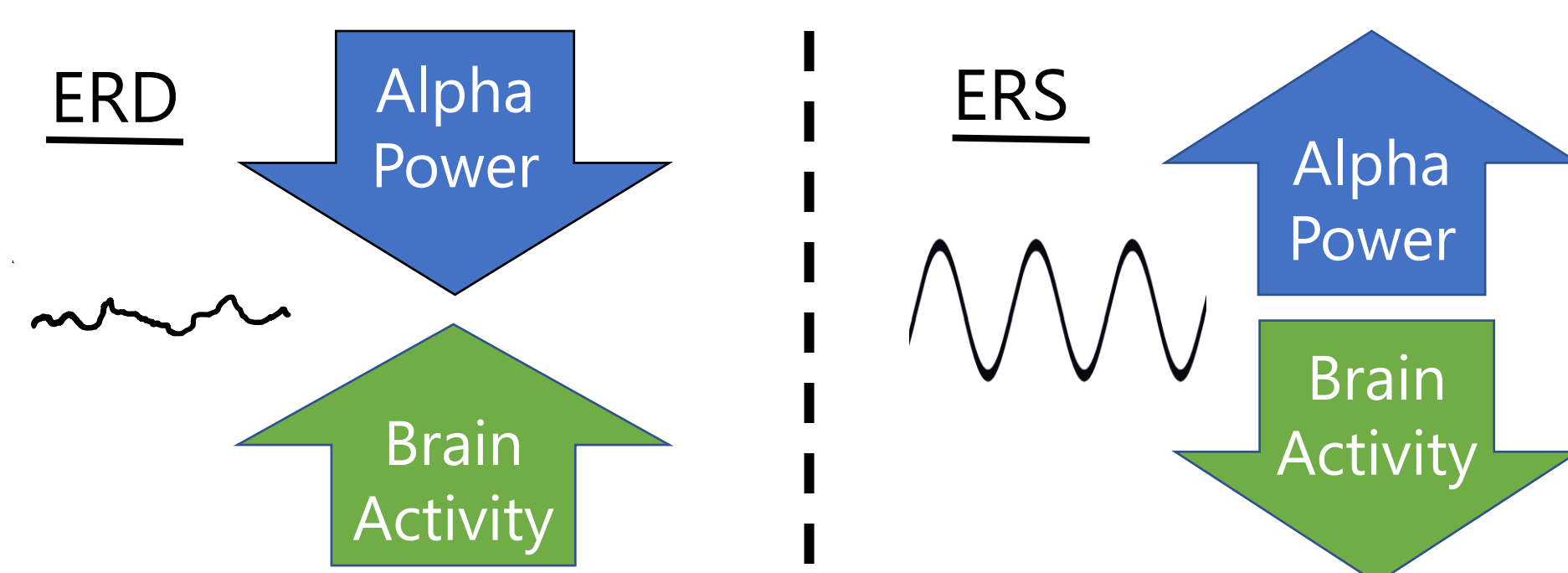


Figure 1: ERD/ERS in reference to alpha "inhibitor" frequency band.

Brain Resources

- Coherence: synchronization between two electrodes
- Indicates regions of the brain working together

Objective & Hypotheses

Objectives

1. Observe relationship between Spanish L2 proficiency and Alpha ERD, Alpha and Beta Coherence
2. Identity EEG features for a machine learning system.

Hypotheses

1. Greater alpha ERD in lower proficiency learners, and
2. More widespread coherence in lower proficiency groups

Regions of Interest

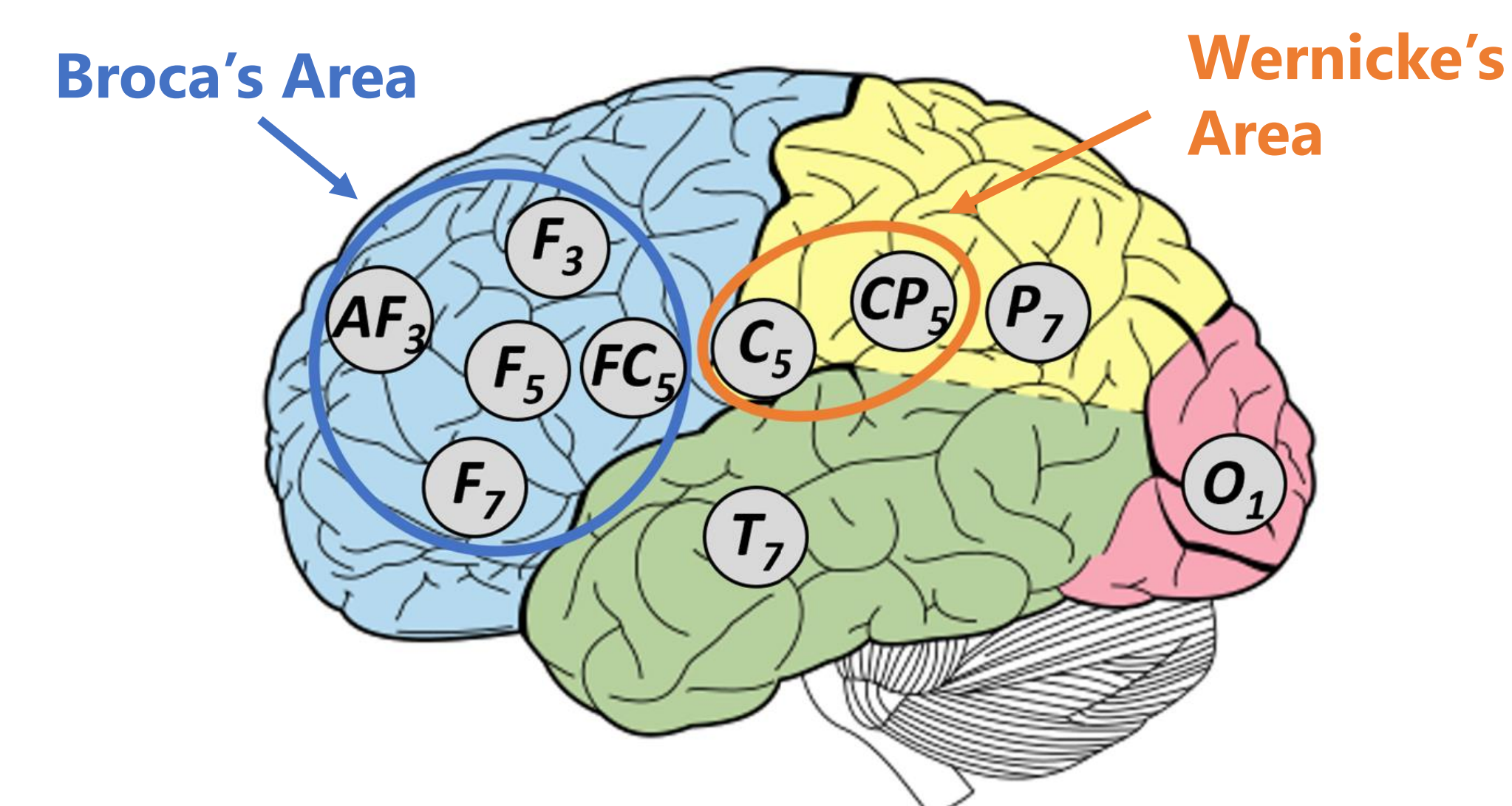


Figure 2: 10 of 20 Electrodes sites of interest.

Methodology

Spanish L2 Proficiency Classification

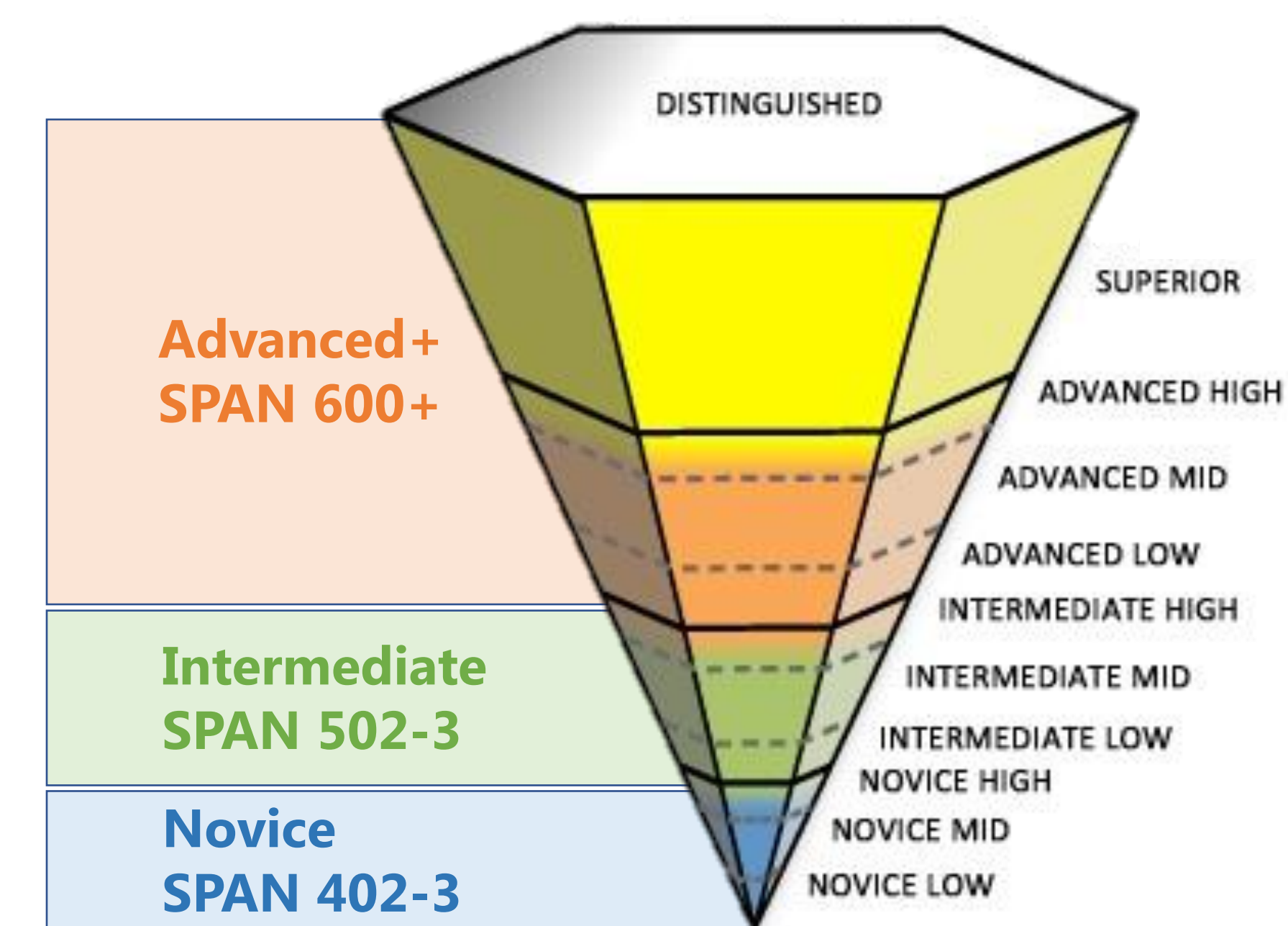


Figure 3: Language proficiency categories procured by the American Council for the Learning of Foreign Languages (ACTFL). Subjects were chosen from the corresponding courses.

Data Collection

- 20 participants
- 3 audio stimuli
- 20 actiCAP electrodes
- 1kHz sampling rate

b – baseline measurement
Q – comprehension & engagement assessment

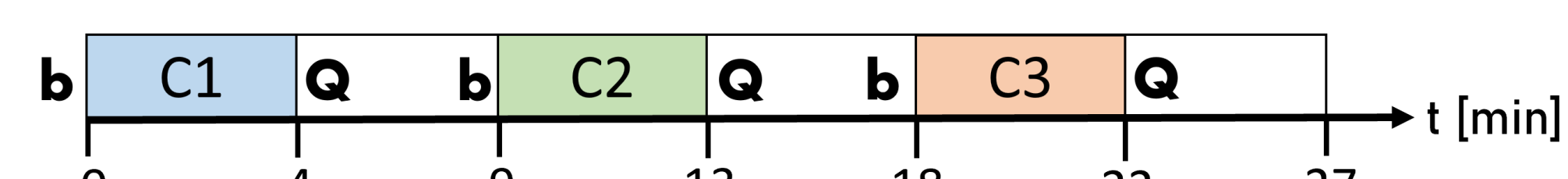


Figure 4: Timeline of audio condition stimuli during data recording.

Data Processing

- Brain Vision Analyzer Software
- Bandpass filtering
- Artifact Rejection
- FFT, ERD, Coherence
- 5s epochs with 50% overlap

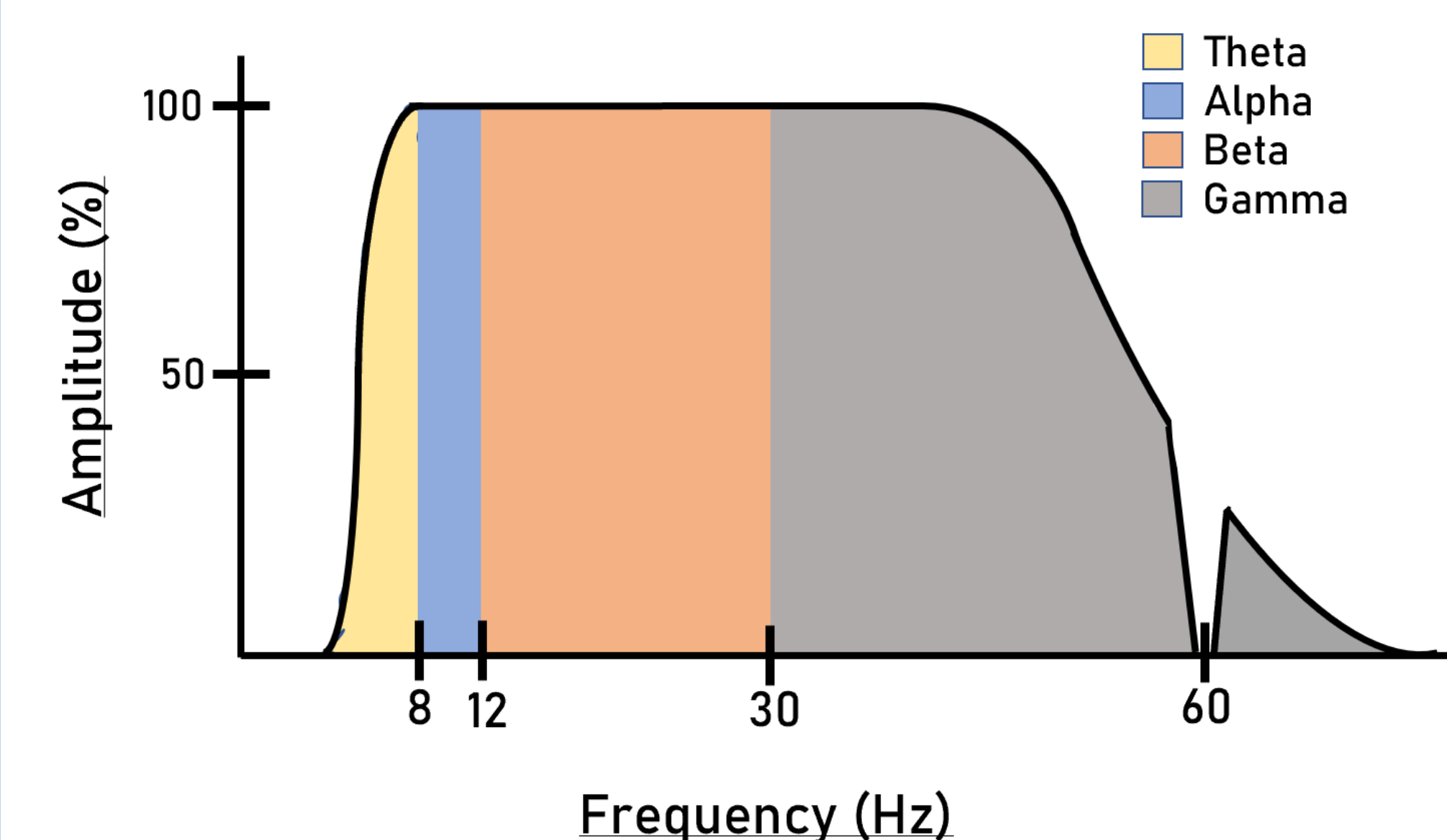


Figure 5: Digital 8th-order Butterworth bandpass filter with brain frequency bands of interest.

Data Analysis

- Parsed and organized using Python DataFrames
- Git, JIRA/Bitbucket
- Visualization
- 3X3 ANOVA
- Proficiency, Condition, Proficiency x Condition

ERD Results

Alpha ERD

- Two electrodes with significance
- AF3 (P < .05 across Proficiency groups)
- T8 (P < .05 across Conditions)
- Rejected due to noise in Novice data

Discussion

Limitations & Challenges

- Data collection timeline
- Small sample size
- Eligibility requirements decreased subject pool
- Uneven groups
- Faulty electrodes

Future Work

- Larger sample sizes should be examined
- Examine correlation of metrics
- Machine Learning model
- Examine trends in Alpha ERD as function of time

Conclusion

- EEG data could be used to classify L2 Spanish proficiency
- Alpha & Beta Coherence provide significant distinctions between proficiency groups

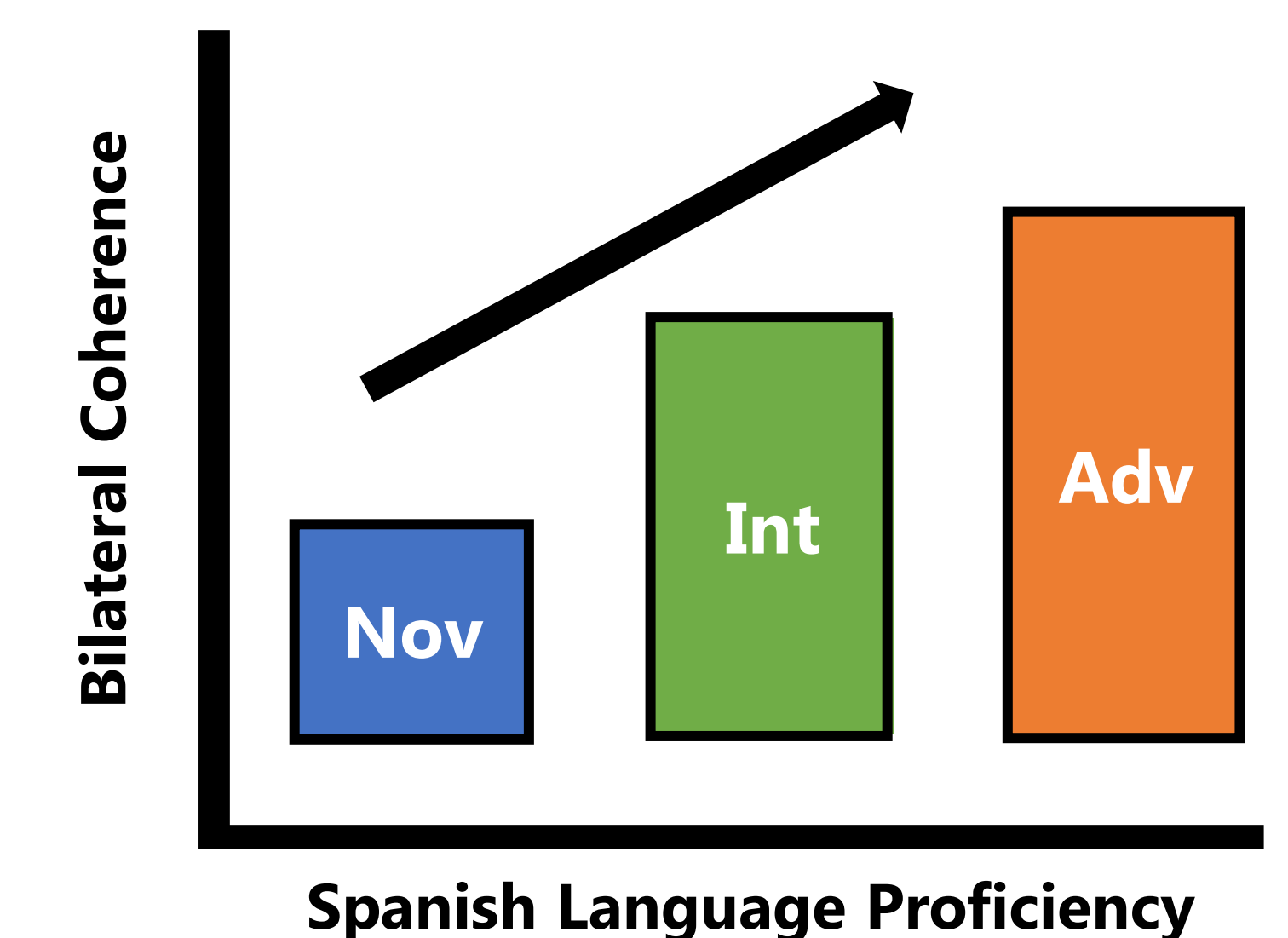


Figure 8: Positive trend between bilateral coherence and proficiency level.

Coherence Results

LEGEND	
...	0.01 < p ≤ 0.05
—	p ≤ 0.01

KEY FINDINGS

- Significant pairs: 31 (Alpha), 41 (Beta)
- Significant between Proficiency groups
- Novice shows greater unilateral coherence
- Advanced+ shows greater bilateral coherence

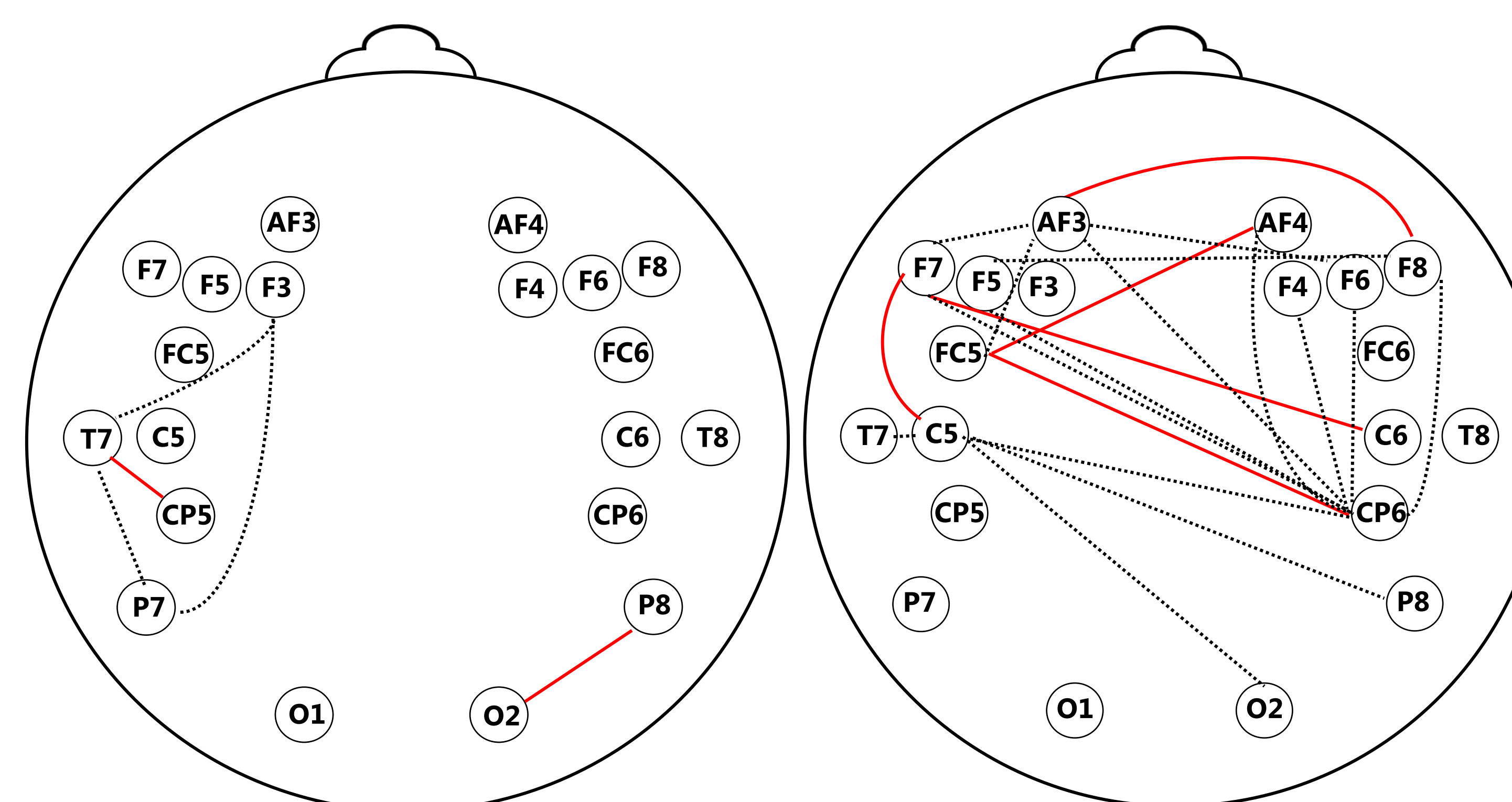


Figure 6: Electrode pairs with significance and Novice Coherence Dominance

Figure 7: Electrode pairs with significance and Advanced+ Coherence Dominance

Acknowledgements

Special thanks to:

- UNH ECE Dept.
- UNH Kinesiology Dept.
- UNH Literatures, Languages, & Cultures Dept.
- UNH McNair Scholars Program