Exploring Low-Cost Detection of EEG-Based Error-Related Potentials

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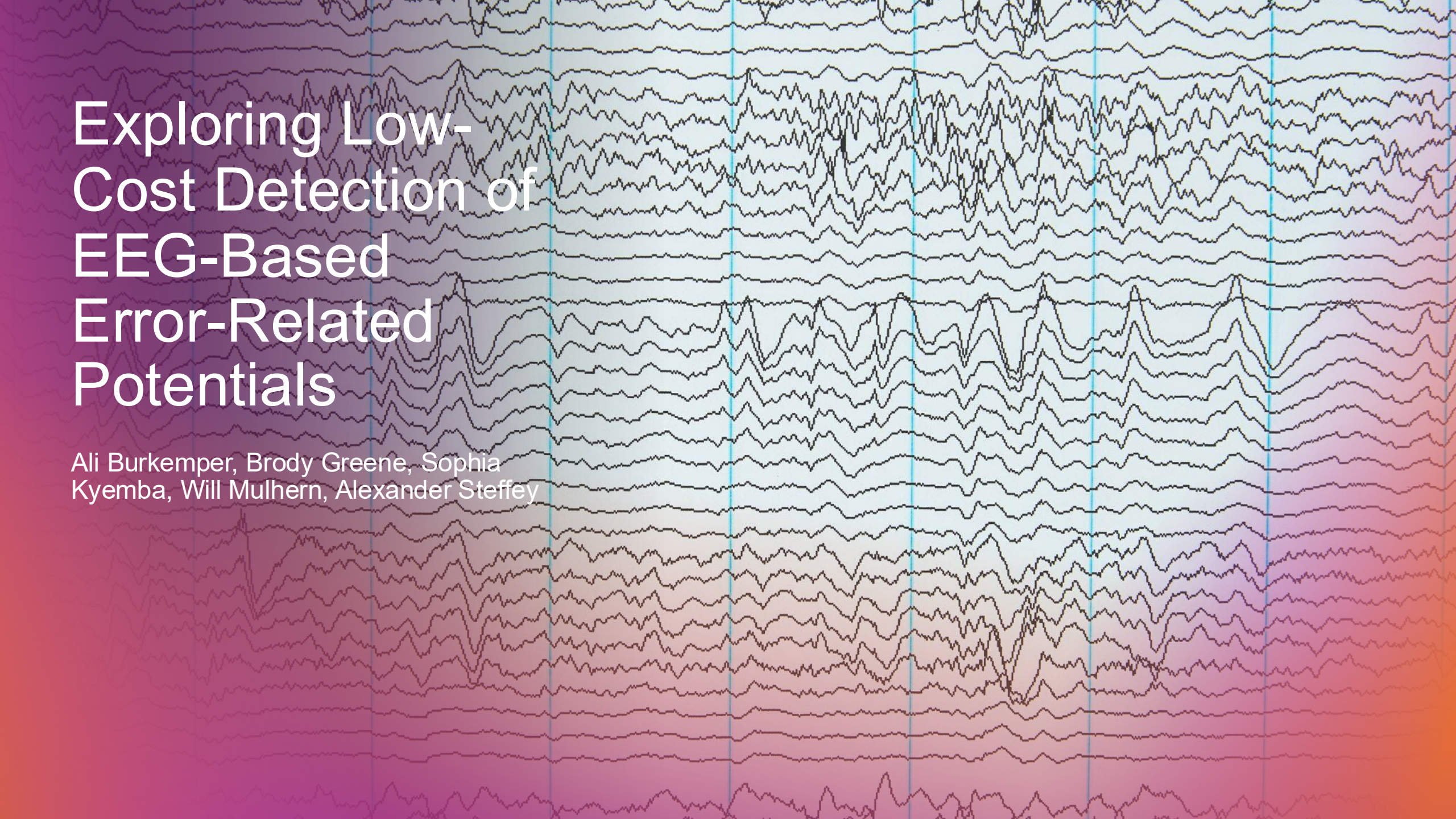
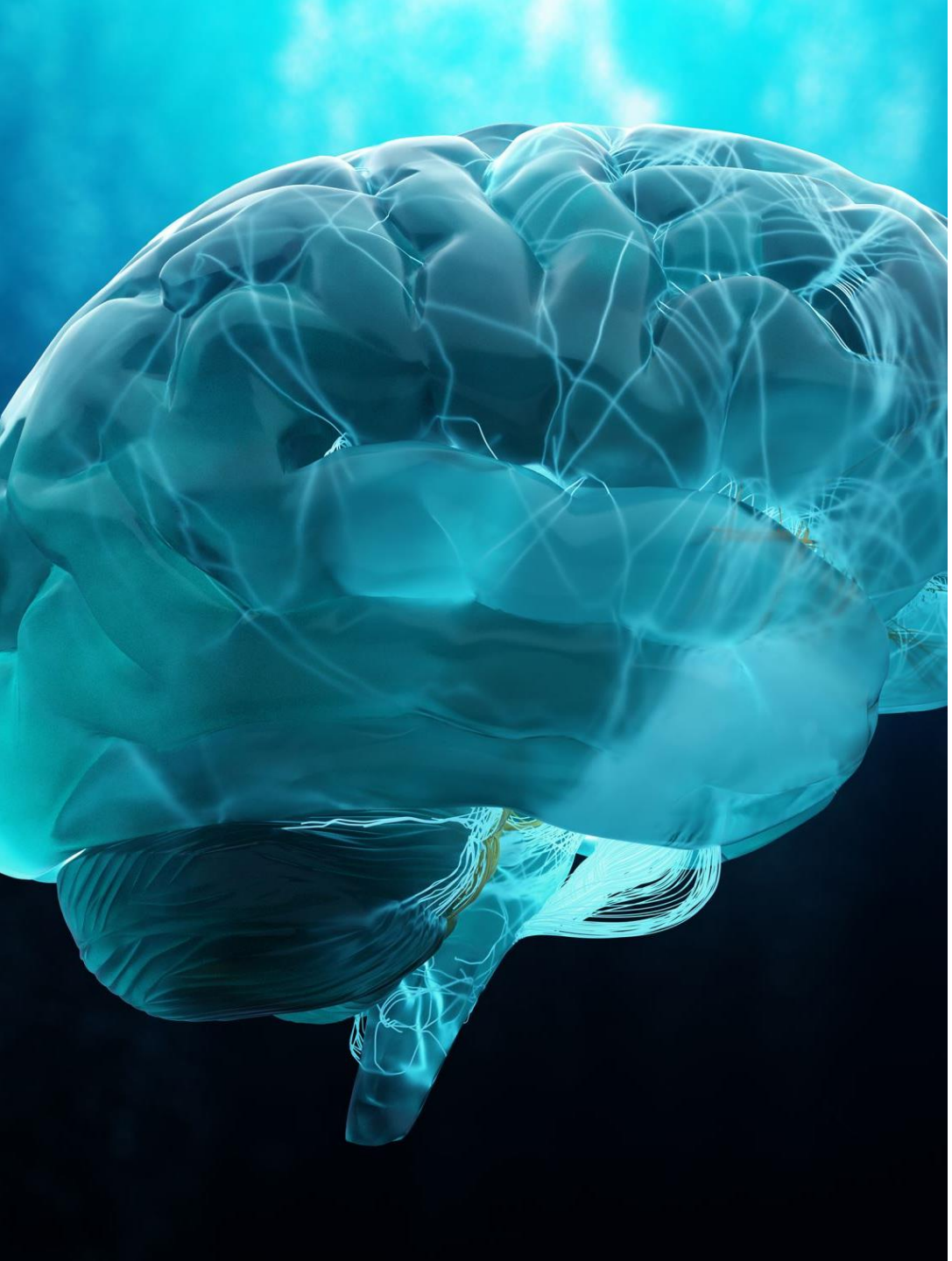
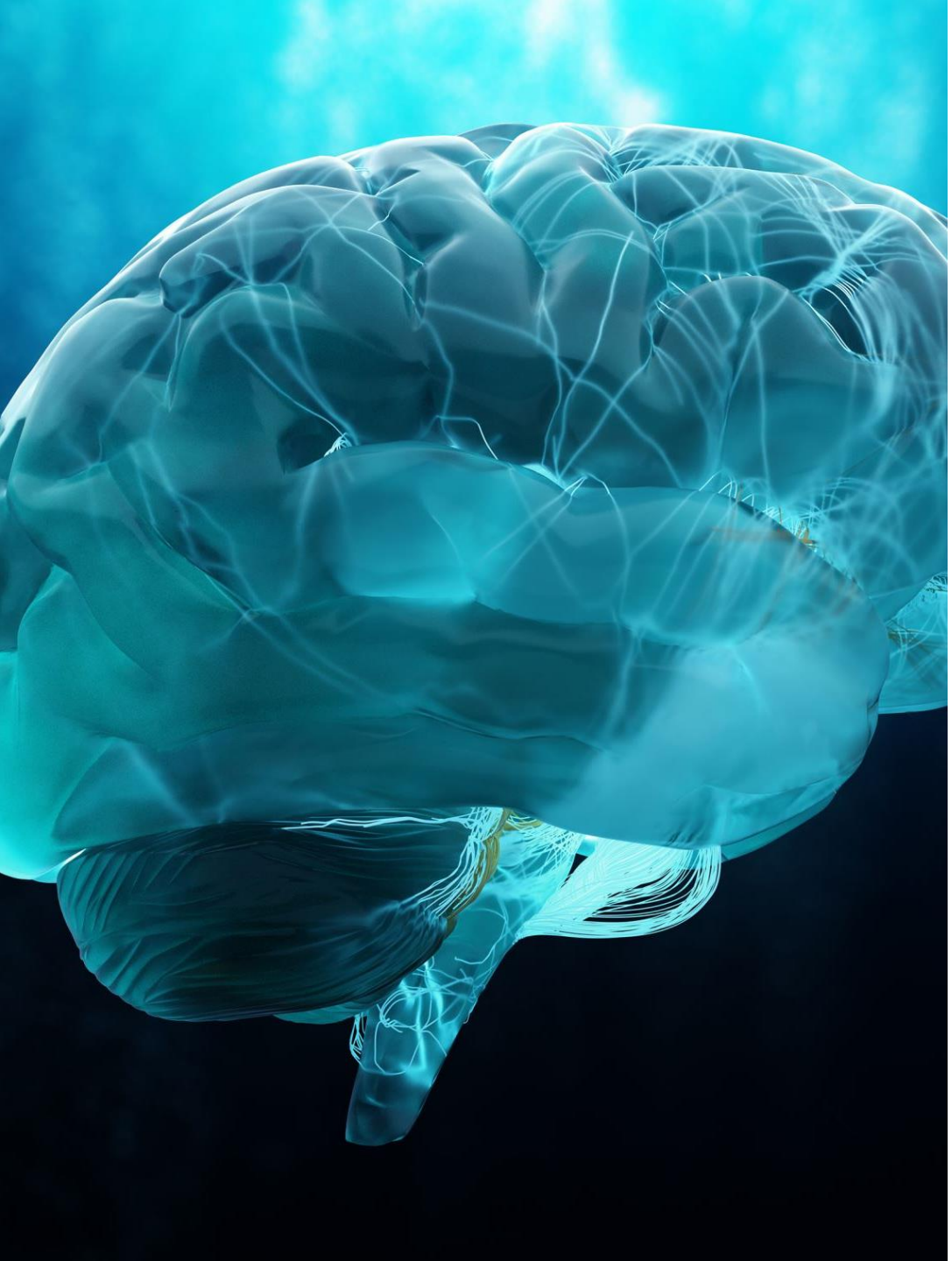




General Motivation

- In the field of **Brain-Computer Interfacing** (BCI) there is minimal research that has been done into the development and application of **passive BCI** (pBCI) systems
  - **pBCI**: systems that monitor spontaneous brain activity without the user's explicit command
  - **Error related potentials** (ErrPs): Involuntary EEG responses that occur when a subject perceives an unexpected sense



General Motivation

- Development and research towards pBCIs require expensive **EEG equipment and frameworks**
  - There are limited frameworks for low-cost ErrP validation
  - Most existing solutions require MATLAB packages

We need a better framework for ErrP detection and visualization

Core Features

EEG-based error-related potential **Definition**

- Ability to run a **flanker task**, a cognitive test measuring selective attention and response inhibition, that reliably elicits ErrPs
- Automatically label EEG data
- Support for visual and auditory feedback

ErrP **Detection**

- Ability to differentiate between error and non-error trials
- Ability to detect in real-time

ErrP **Visualization**

- Ability to update graph as task runs

Accessible interface

- Scratch-like modular workflow

Technical Details

Language:

- Python

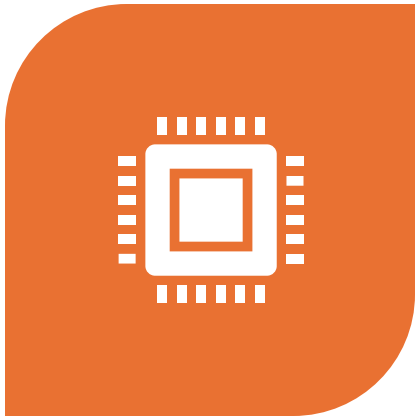
Packages/Libraries:

- MNE - a library used to examine and display EEG data
- NumPy
- SciPy
- Matplotlib/Plotly
- PyTorch/TensorFlow
- Beautiful Soup/Selenium - used to extract data from a web based flanker task

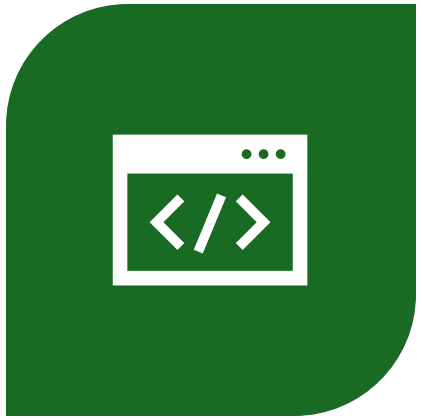
Development Environment

- We will likely be working in **PyCharm** or Google **Colab** since our work will be python based
- An **EEG device** to record our EEG data
- **OpenViBE** for working with our BCI

Related Apps



EEGLAB IS AN INTERACTIVE MATLAB TOOL FOR EEG/MEG PROCESSING. NOT LOW COST AND ONLY BASIC ML ASPECTS



OPENVIBE IS A GUI FOR WORKING WITH BCI'S. MAINLY FOCUSED ON BCI'S, NOT ML OR ERP'S.

MNE IS A LIBRARY FOR PREPROCESSING/ ANALYSING EEG AND MEG DATA. THIS IS A TOOL FOR US TO THEN BUILD OUR ML PIPELINE WITH.

High Priority Challenges or Obstacles

Data Synchronization: Aligning web-based Selenium events with EEG timestamps

Signal Quality: Low signal-to-noise ratio from consumer-grade hardware

Real-Time Latency: Processing lag while updating the graph during tasks

Class Imbalance: Few "error" trials compared to "correct" trials for ML training

Subject Variability: Differences in brain wave patterns between individuals