TL1 Team Approach to Predicting Pain from EEG: Understanding Chronic Low Back Pain Status from Resting Electroencephalography using Artificial Intelligence

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Introduction

Back pain is the leading cause of pain in the United States. Spinal cord stimulation (SCS) is an intervention for patients with chronic back pain (Fig 1). Beneficial effects of SCS rely on self-reported pain scores as outcome measures. These measures tell us very little about how SCS is altering pain and motor systems over time, therefore mechanisms of action in the brain remain poorly understood. Research utilizing electroencephalography (EEG) has demonstrated that pain is associated with **reductions** in **alpha and beta power** over the **sensorimotor cortex** and **increases** in **theta and gamma power** in the **medial prefrontal cortex** (Fig 2). In addition to this, previous research has used machine learning to classify EEG correlates of high and low pain with 89.58% accuracy.. Our research will use EEG and machine learning to classify resting brain activity of healthy controls and individuals with chronic low back pain.

Hypothesis

At baseline, our machine learning algorithm will separate our groups with high accuracy. However, after one week and six months of SCS our algorithm will have a more difficult time classifying our groups.

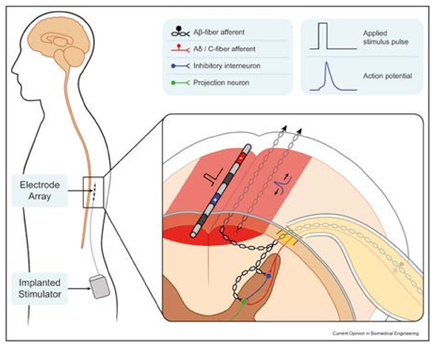


Figure 1. Spinal cord stimulator consists of 3 main parts: pulse generator ("implanted stimulator"), wire leads, and electrode array. Pulse generator and wire leads are placed under the skin while electrode array is implanted in epidural space.

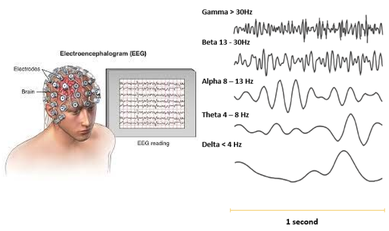
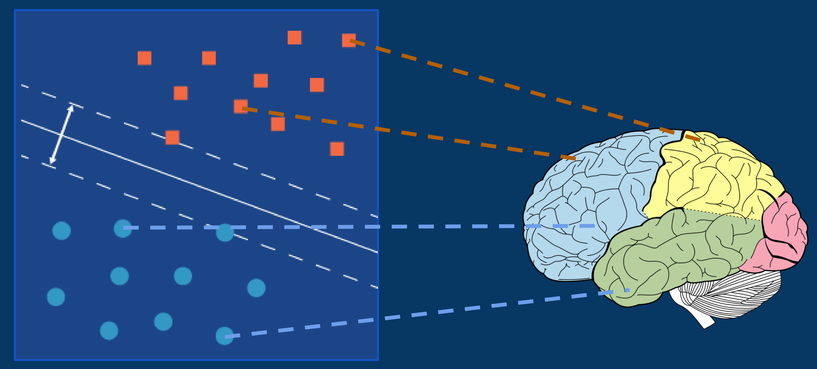


Figure 2. Example of EEG cap measuring cortical activity from populations of neurons.

Artificial intelligence may **differentiate** participants with and without **chronic low back pain** using **resting electroencephalography**



Methods

Healthy sex and age-matched controls will report to the lab for one day of data collection. Participants with chronic low back pain will report to the lab at three time points (Figure 2):

- (1) one month before SCS trial surgery
- (2) seven days after receiving SCS
- (3) six months after SCS permanent implant surgery.

EEG will be analyzed and classified using customized MATLAB scripts. Raw EEG data is preprocessed through high-pass and low-pass filters and a within-trial assessment to locate artifacts. Artifacts are screened and rejected. Independent component analysis is applied to find brain activity characteristics that are connected to our experimental tasks (Fig.2).

EEG will be analyzed with various machine learning methods such as support vector machines (SVM). Feature weights are generated at each electrode at the time points. Data will be split 80/20 using cross-validation on the training set and testing the data without being seen by the model. Results will be compared to current knowledge and literature to evaluate accuracy of the models. .

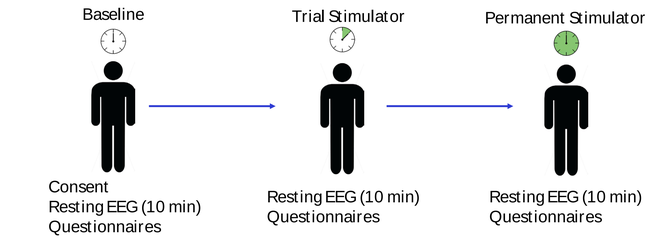


Figure 3. Diagram of participation details and overall timeline.

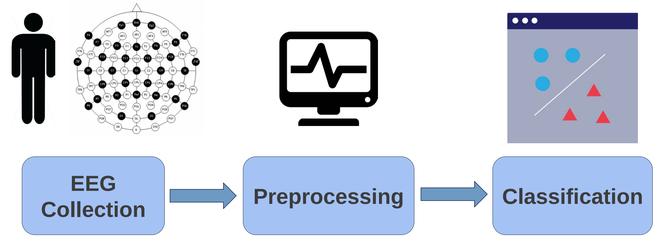


Figure 4. Flowchart of EEG collection to preprocessing. 1) EEG is collected in 128-electrode array. 2) Data is preprocessed through a series of filtering, sampling, and independent component analysis (ICA). Significant components are manually extracted using ICA to linearly unmix signals. 3) Features are organized per electrode and fed into a machine learning algorithm, SVM. A training data set is used to develop a model. A test set is used to assess the performance of the model without being seen beforehand.

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