**Human ECoG Data Analysis**

**Introduction:**

I was curious about the strength of the signal in the brain corresponding to the fingers on the hand. The homunculus depictions are always shown with the thumb being represented in the brain larger than the other fingers. This observation leads me to hypothesize that because the thumb is so important to our dexterity and is represented within a larger portion of the brain, it's signal would likewise be stronger than the other fingers. I intend on answering this question by analyzing a study where participants were asked to move a finger according to a cue displayed on screen. The signals corresponding to the fingers were recorded from the dorsal primary motor cortex. In order to process the signal, several techniques were used including; Fourier analysis, filtering, and ERP (averaging).

**Research Question and Hypothesis:**

Does signal strength increase with finger dominance? I believe that the index finger will create the largest response as it is used most often. The thumb will create the next largest response and the middle, ring, and pinky finger will create the least response of roughly similar amplitude.

**Data:**

The dataset is comprised of recordings from the human sensorimotor region. Data was collected using ECoG and was sampled at 1000Hz from Miller et al., JNeuro, 2007. For the study, patients were told to sit in a chair and observe a monitor. The monitor would present a cue for 2 seconds which would indicate to them which finger to move.

**Background Research:**

In the paper *Decoding Individual Finger Movements from One Hand Using Human EEG Signals,* Ke Liao and his researches were looking into determining how to classify brain signals with the intended application for brain computer interfaces (BCI’s). This is very closely related to my research because they used their study to classify brain patterns based on EEG recordings. In mine, I instead used ECoG recordings which is more invasive than an EEG. However, both studies shared in their intent to determine intended finger movement based on brain recordings. Ke Liao’s study and mine both used filtering in order to get a cleaner signal. However, they used a high pass filter because of the noise with an EEG while I used a low pass filter because I was studying an ECoG signal. Both studies analyzed the power associated with the finger movement to get a better understand of the data.

**Methods and Parameter Decisions:**

My analysis consisted of using a combination of Fourier analysis, Filtering, Event Related Potential (ERP) analysis, and Power Spectrum analysis. The Fourier analysis was performed in order to determine how much noise was in the signal. Because ECoG studies are performed directly on the brain as opposed to EEG, not much noise or interference was expected as there was no concern for of muscle movement interfering A screenshot of a cell phone

Description automatically generatedwith the signal. However, just to confirm, the Fourier analysis was performed and confirmed the expectation. The analysis did show a 60hz signal was interfering. This was to be expected as the study was performed indoors near electricity, and power lines will create a 60hz distortion in the signal as seen in **Figure 1**. In order to remove the noise identified at the 60hz frequency, a low pass filter was used to remove everything above 10hz as A screenshot of a cell phone

Description automatically generatedthe signals we would be interested in were all less than that. As you can see in **Figure 2**, even though Fourier analysis did not show much interference above 10hz, upon filtering, the signal appears much cleaner.

**Figure 1.** Plot showing the existence of noise at 60hz as the result of electrical interference.

**Figure 2**. Plot showing that the filtered signal is much cleaner than the original

After analyzing the signal for noise and filtering that noise out, the signal was finally ready for analysis. Because each finger was moved 20 times during the experiment, I thought it would be best to perform an ERP analysis of the signal and find the various intervals in the signal that represented each finger and combine them and average them to create and average signal for each finger. By doing so I can eliminate any confounds that may have arisen during any such trial. This would eliminate the signal growing weaker due to fatigue or practice. Each signal’s onset was decided to mimic the onset of the cue. This was decided because during analysis, each finger did not have a consistent window of activation and sometimes the finger activation was shorter or longer. This erratic behavior was eliminated by analyzing only for the consistent cue duration. This had no effect on analysis because I was not concerned with the entire signal, only with the peak which happened shortly after cue onset. **Figure 3** shows a comparison of the strength of each A picture containing text, map

Description automatically generatedA close up of a map

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**Figure 3**. Plot showing signal strength after cue onset with horizontal lines indicating minima and the corresponding power analysis of each signal.

**Conclusion:**

My analysis contradicts my hypothesis and shows that rather than the primary digits creating the strongest signal, they create the weakest. Rather it is the pinky and middle finger that creates the largest signal in the brain. Further studies to determine confirm my analysis should be performed. However, to create a better analysis than the one performed each individual section on the brain that corresponds to a finger should be analyzed instead of just two points. This will be more accurate as the signals will not be averaged with other fingers. Additional studies should also compare differences in left versus right hand fingers to determine if hand dominance also plays a factor in signal strength.

**References and Contribtuions:**