Correlations Between Deep Brain Stimulation of the Subthalamic Nucleus, Blood Flow, Oxygenation, and Neural Activity

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Introduction

Deep brain stimulation (DBS) is a method of neuromodulation in which implanted electrodes produce electrical impulses for treatment of neurological disorders like Parkinson's disease. DBS of the subthalamic nucleus (STN) is the method of interest for this research due to its success in human subjects. This research will analyze three cortical measurements **- blood flow, oxygenation, and neural activity** – on a single platform to analyze the correlation between **STN-DBS stimulation** and **metabolic changes in the cortex.**

Research Questions

Do **unipolar and bipolar stimulation** result in different metabolic responses?

Do **mice and rat models** exhibit different metabolic responses?

Methods

A platform containing four ECoG electrodes and an access point for the oxygenation probe has been fabricated and **tested in pilot mouse experiments**. In vivo impedance tests of the electrodes, ECoG measurements in response to STN-DBS stimulation, and blood flow measurements in response to external stimulation provide proof of concept for collecting and analyzing the neural activity and metabolic changes in the cortex.

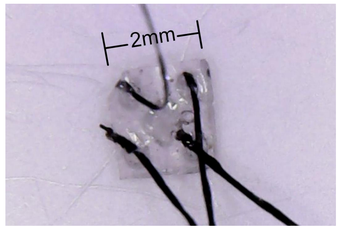


Figure 1. Four-electrode ECoG array with center access point for oxygenation probe

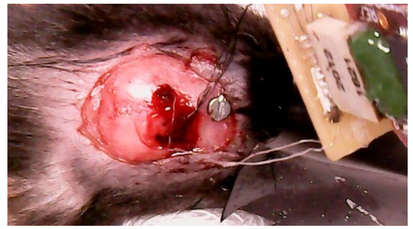
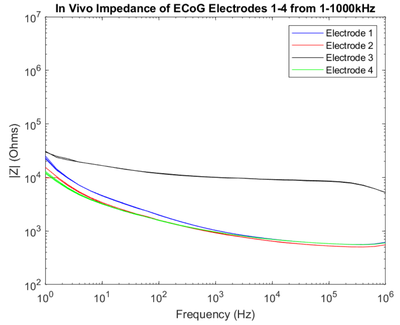


Figure 2. Implanted ECoG array in the cortex with ground screw, reference electrode, and entry point for STN-DBS

Results



In Vivo Impedance Values (kΩ)			
Electrode	10Hz	100Hz	1kHz
1	4.476	2.404	1.577
2	5.338	3.264	2.297
3	5.877	3.695	2.562
4	3.963	2.416	1.787

Table 1. (above) Average impedance values of three trials for each implanted ECoG electrode at 10, 100, and1kHz frequencies

Figure 3. (left) Bode Plot of impedance values (three trials) for each implanted ECoG electrode

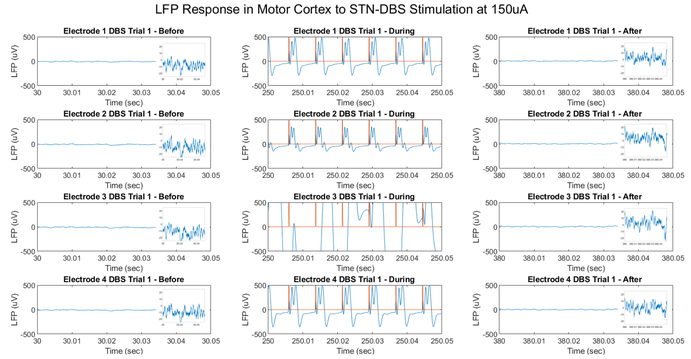


Figure 4. LFP response before, during, and after 150uA STN-DBS stimulation. Orange lines indicate DBS pulses, small scale insets are shown on before and after graphs

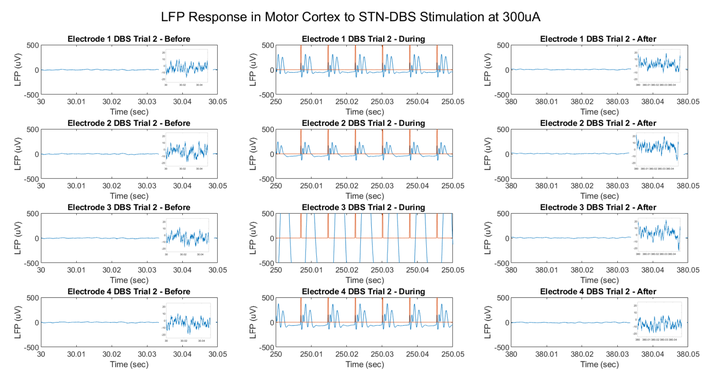


Figure 5. LFP response before, during, and after 300uA STN-DBS stimulation. Orange lines indicate DBS pulses, small scale insets are shown on before and after graphs.

Results

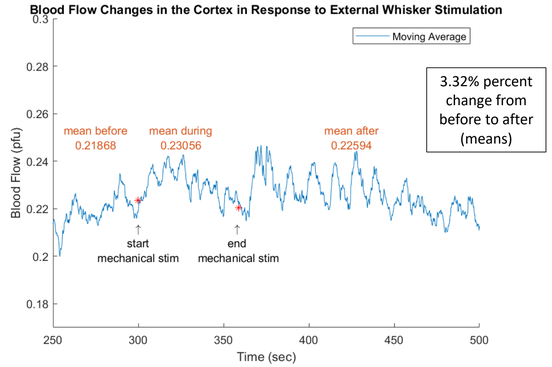


Figure 6. Moving average of blood flow (pfu) collected using a laser doppler system at a sampling rate of 500samples/sec. The beginning and end of mechanical whisker stimulation are marked, and the means before, during, and after stimulation are shown.

Discussion and Future Work

The impedance values recorded are ideal for DBS experiments, suggesting that the fabrication process is successful and will be applied in future platform designs. The recorded change in blood flow after external stimulation verifies the functionality and placement of the probe. The pilot DBS experiments exhibited a change in LFP in response to STN pulses at various amplitudes, providing proof of experimental setup and instrumentation. Future work includes incorporating the metabolic measurements onto a single platform and conducting further STN-DBS stimulation experiments.

Collect oxygenation and ECoG data in mice/rats in response to unipolar and bipolar DBS stimulation → Incorporate blood flow probe into platform design → Collect oxygenation, blood flow, and ECoG data in mice/rats in response to unipolar and bipolar DBS stimulation

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References

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