**Introduction**

**Background:** Dystonia is a neurological movement disorder characterized by sustained muscle contractions that cause twisting and repetitive movements or abnormal postures. Deep brain stimulation (DBS) of the globus pallidus internus (GPI) has been successful in alleviating symptoms for patients who do not respond to medication.

**Objective:** To determine the volume of tissue activated (VTA) within the GPI and the cortical spinal tract (CST) (side-effect pathway) for a subject treated with DBS for dystonia through computational modeling.

**Methods:** A general model of GPI DBS, based off of a human brain atlas, was established by integrating several computational modeling programs to ultimately determine the VTA. The DBS lead electrode configuration was altered to assess how changes affect GPI modulation and CST activation.

**Results:** GPI DBS simulations yielded a combination of cell activation and inhibition. Activation was found to be greatest around the cathode of the DBS lead. Modulated cells were localized relative to the lead and the degree of modulation decreased farther away.

**Conclusion:** Treatment outcome is strongly dependent on the precise placement of the electrodes in the brain and subsequent adjustment of the stimulation settings to fine-tune the therapy. Patient-specific stimulation settings are required in order to provide maximum GPI modulation with minimal side-effects. This modeling approach can provide a framework for neurosurgeons and neurologists to improve current techniques that will optimize treatment outcome.

**Modeling Approach**

- **Rhinoceros**
  - Trace GPI and CST subnuclei, align traces in space, and render three-dimensional lofts

  - MATLAB
  - Populate subnuclei volumes with neuron models

- **COMSOL Multiphysics**
  - FEM to determine electric field around DBS lead

- **NEURON**
  - Determine activation voltage of neurons

**Future Work**

- Determine how sensitive DBS lead placement is to the ratio of GPI modulation vs. CST activation
- Evaluate new lead designs (e.g., segmented, directional) and alternative lead trajectories and orientations through the use of three-dimensional FEMs
- Develop patient-specific models based off of MRI and CT data for subjects who received DBS treatment for dystonia

**References**


**Acknowledgements**

We gratefully thank the University of Minnesota Undergraduate Research Opportunities Program (UROP) and the North Star STEM Alliance for their financial support.