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Deep Brain Stimulation Improves Speed-Accuracy Tradeoff in Children with Dystonia During a Continuous Motor Task

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Introduction

- Childhood dystonia is defined as "a movement disorder in which involuntary sustained or intermittent muscle contractions cause twisting and repetitive movements, abnormal postures, or both" [1].
- Deep brain stimulation (DBS) is a neuromodulatory intervention that has profound impact on treatment of children with movement disorders such as dystonia and tremor [2].
- Understanding how DBS alters movement accuracy in pediatrics diagnosed with dystonia is not well understood [2 - 4].

Aim

Our goal is to study and compare task performance in a group of pediatric patients performing a continuous figure-eight drawing task in three conditions: **1-without stimulation**, 2- with **non-optimized clinical stimulation setting**, and 3- with **optimized clinical stimulation setting**.

Materials and Methods

Patient: We collected kinematics and electromyography (EMG) data from four pediatric patients who underwent DBS surgery. The data was recorded five days post-surgery. Table 1 provides the patient demographics.

Data: Kinematics and EMG recordings were taken using an iPad and 16 EMG sensors placed on the biceps, triceps, flexor, extensor, anterior/lateral/posterior deltoid, and supraspinatus muscles of both hands.

Stimulation: As part of the clinical evaluation, stimulation was applied using a combination of 10 stereoelectroencephalography (SEEG) electrodes placed bilaterally in the globus pallidus internus (GPi), subthalamic nucleus (STN) in the basal ganglia, ventral oralis (VO), ventral anterior (VA), ventralis intermediate nucleus (VIM) in the thalamus, and the pedunculopontine nucleus (PPN) in the brainstem.

Subject	Symptoms	Sex	Age	Stim. Location
P1	Tremor, Ataxia	M	24	STN, VA
P2	Tremor, Dystonia	M	14	STN
P3	Dystonia	M	23	GPi, PPN
P4	Dystonia	M	17	GPi, STN

Figure 1. The schematic of temporary SEEG electrode implanted in target regions. Black squares represent stimulation contacts.

Results

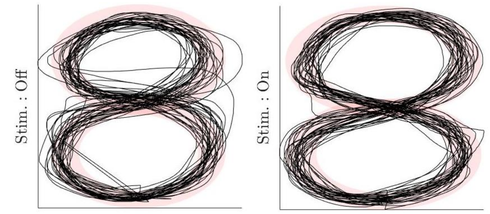

Figure 3. P3 Results. A comparison of the figure-eight trajectories of the left hand during off-stimulation and on-stimulation conditions.

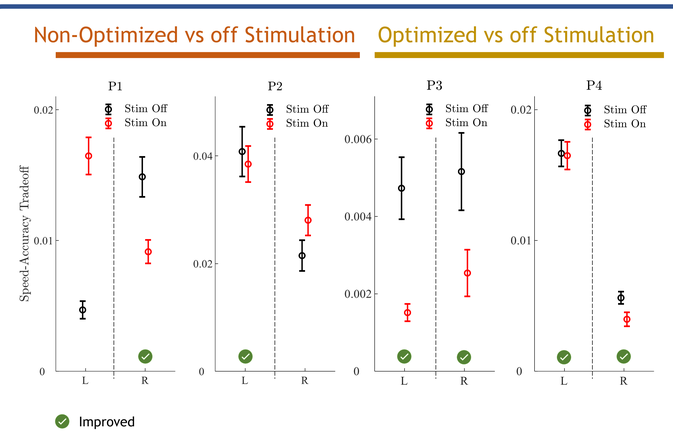

Figure 4. Results show a consistent improvement in the speed-accuracy tradeoff in the patient with optimized stimulation settings compared to the off-stimulation condition.

Materials and Methods

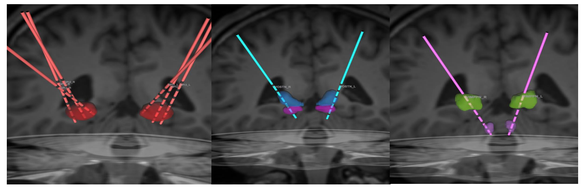

Figure 2. View of SSEG electrodes in bilateral GPi (left), Vo and STN (middle), VIM and PPN (right); normalized scans visualized onto the MNI space. All pairs of DBS electrodes correspond to patient P3, represented with different colors (red, blue, and pink).

Conclusion

- This study provides evidence that deep brain stimulation improves movement execution in pediatric patients with dystonia.
- This study provides evidence of a significant presence of task-uncorrelated muscle components associated with dystonia. The results also suggest that deep brain stimulation alters muscle activation patterns.

Results

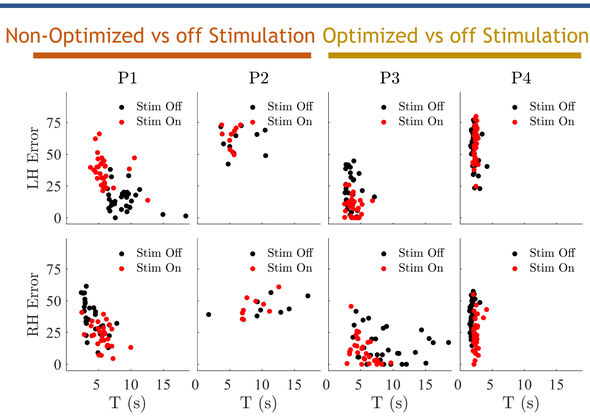

Figure 5. Movement Time (T) vs. Error for Left Hand (LH) and Right Hand (RH): The results indicate that optimized stimulation generally improves movement time and reduces error.

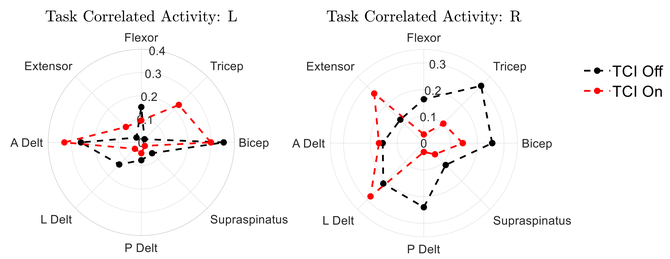

Figure 6. Task-Correlation Index (TCI) for P3: The results demonstrate that muscle activation patterns change when the subject performs the task with stimulation.

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References:

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