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Basal Ganglia activity during directional hand reaching task in human dystonic subject

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Introduction

- Neural activity and its relationship with movement parameters have been studied extensively over the years in motor cortex. Georgopoulos's paper [1] is a well-known study which shed light on how neural firing rates in cortex relates to direction of movement
- In this preliminary study we had the opportunity to examine how spiking activity in Basal Ganglia relate to direction of hand movement in a center-out reaching task.

Results (spiking raster plot)

- Almost half of Spiking units extracted in GPi and STN showed varied response (discharge rate) with direction. (Figure 1-3)
- The detected changes were mostly after movement initiation although there were some pre movement pattern changes as well.
- The firing rate patterns were not highly consistent or repeatable between repetitions

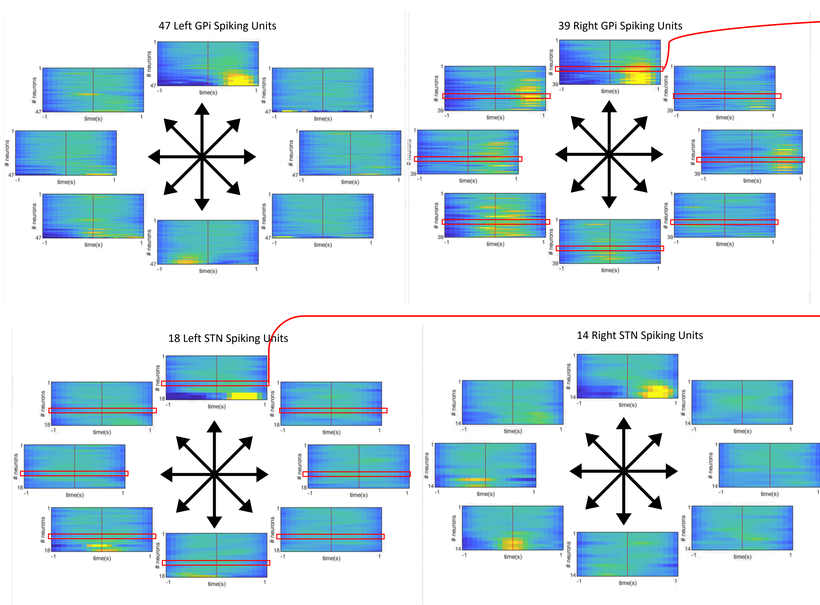

Figure 1. Population Spiking activity of all detected spiking units during the **right-hand** reaching task in both left and right hemispheres. Each row in the heatmap corresponds to average spiking activity of that neuron between all repetitions. Red vertical line is movement onset

Figure 2. Spiking activity of a single spiking unit in GPi during right-hand center out reaching task. Each row corresponds to a single repetition of movement. Notice the post movement rate changes with direction

Figure 3. Spiking activity of a single spiking unit in STN during right-hand center out reaching task. Each row corresponds to a single repetition of movement. Notice the pre movement firing rate changes with direction

Results (predictive power)

- For prediction analysis 8 directions were reduced to 4 main direction (chance level 25%) combining adjacent directions. A simple MLP was able to predict the direction looking at firing rates of recorded spiking units. Table 1 quantifies the predictive power of firing rates based on the **location** and **timings** of considered spiking unit firing rates.

Validation accuracy	GPi	STN	Combined
Pre movement	**39.28%**	**39.29%**	**40.47%**
Post movement	**47.62%**	**45.24%**	**46.43%**
Both	**55.95%**	**48.81%**	**57.14%**

Actuals / Predictions

Table 1. prediction accuracy of firing rates grouped by their region and timings relative to movement initiation and their respective confusion matrices

Limitations and Conclusions

Limitations: 1- Number of monitored units were limited, since we had close to 15 micro electrodes in Gpi and 5 micro electrodes in STN (per hemisphere). 2- Electrodes were not high impedance (90KΩ) thus spiking units are not well isolated neurons. 3-Number of repetitions were limited to 40. 4-repetitions were not consistent in terms of path and speed.

Conclusions: 1-Firing patterns in BG circuitry are partially predictive of hand reaching direction. 2-The changes in firing rates are distributed in time and mostly happen after onset of movement. 3- Ipsilateral and contralateral hemispheres display similar spiking behaviors.

Materials and Methods

- The use of Deep Brain Stimulation (DBS) as a treatment for movement disorders such as childhood dystonia provides us with the rare opportunity to study the modulation of BG and thalamic neurons during movement. [2]
- 12 stereoelectroencephalography (sEEG) depth stimulation/recording electrodes were implanted in various BG and thalamic nuclei including GPi 1 , GPi2, GPi3, nucleus, Ventralis Oralis (VO), Subthalamic nucleus (STN).
- The reported case was a 23-year-old male diagnosed with PKAN (Pantothenate kinase-associated neurodegeneration), with hypertonic dystonia
- The experiment was a center out reaching task with 8 light cued directions and 40 repetitions per direction

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