Identifying Effects of Deep-Brain Stimulation on Parkinson's Disease Using Voice

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Background

- Parkinson's Disease (PD) affects fundamental frequency, jitter, harshness and tremor of voice [1]
- Deep-Brain Stimulation (DBS) is used to alleviate PD symptoms, but is tedious for both patients & clinicians
- DBS on/off, motor scores, and motor cortex ECoG have been explored for closed-loop DBS [2]

Prevalence

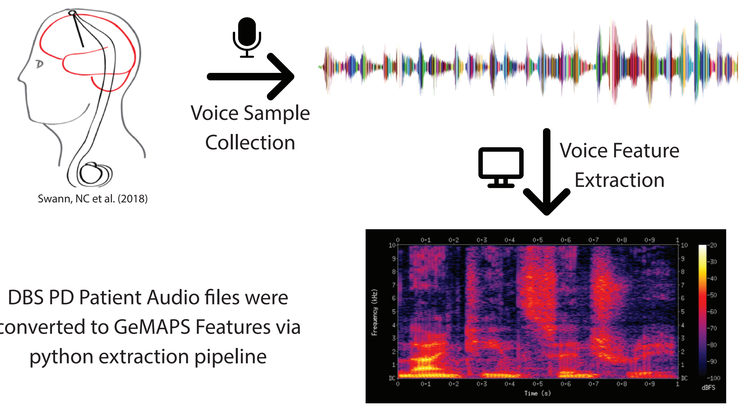
- PD is expected to affect over 930,000 people in the US by 2020, projecting to 1.2 million people by 2030 [3]
- Diagnosed via history/physical exam, and treated with levadopa or other dopamine agonists [4]
- DBS has aided an estimated 150,000 patients with movement disorders in the US [5]
- Good DBS PD candidates include patients with clear responses to levadopa, and few co-morbidities [6]

Hypothesis

- Voice feature analysis can be used to detect DBS stimulation state
- Voice feature analysis can be used as feedback for tracking motor symptoms to aid in programming DBS

Methods

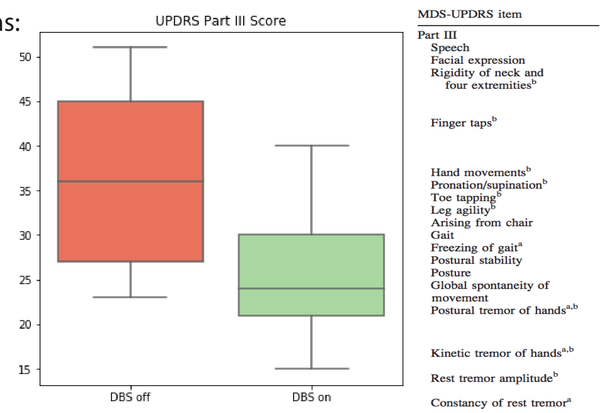
- 5 DBS PD Patients were seen during initial programming visit post DBS Neurosurgery at UW Medicine
- Patient survey generated on REDCap and included
  - Patient demographic and medical history
  - Motor/non-motor symptom scores via the Unified Parkinson's Disease Rating Scale (UPDRS)
- Voice samples were collected for DBS on/off
  - Via smartphone/laptop microphone
  - Tasks included saying "ahh", free speech, sentence reading, counting backwards, and animal naming
- Voice samples analyzed for specific features
  - Via Geneva Minimalistic Acoustic Parameter Set (GeMAPS) [7]
  - 88 acoustic features including fundamental frequency (F_0), Mel-frequency cepstral coefficients (MFCC's), power, etc



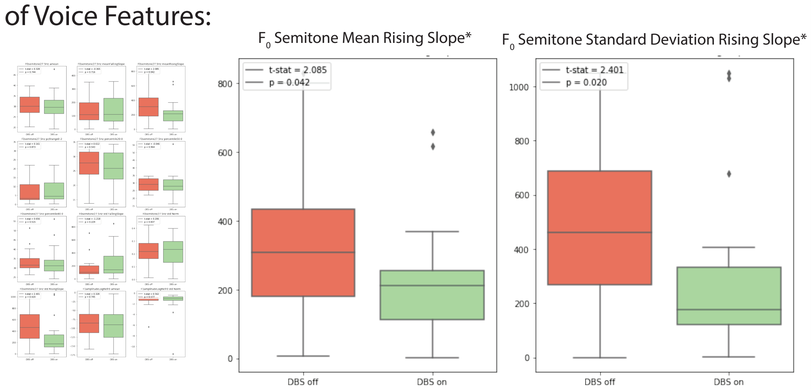
DBS PD Patient Audio files were converted to GeMAPS Features via python extraction pipeline

DBS Effect on Motor Symptoms:

Motor scores improved with DBS on amongst our patient population (n = 5, p = 0.02)



Statistical Analysis of Voice Features:



T-test were performed for all 88 features, 14 of which are featured above

F_0 Semitone Mean and Standard Deviation of Rising Slope differences gave $p < 0.05$

Results

Features (n=5)	DBS OFF	DBS ON	*T*	*p*
MDS-UPDRS Motor Scores*	36.4 ± 11.8	26 ± 9.51	-3.71	0.02
F_0 Semitone Mean Rising Slope (Hz)*	330.8 ± 208.8	223.2 ± 151.9	2.085	0.042
F_0 Semitone std dev Rising Slope (Hz)*	470.1 ± 297.2	277.1 ± 270.1	2.401	0.020

- Motor scores improved with DBS on
- Of the 88 GeMAPS features, changes in F_0 Semitone Rising Slope were detectable for DBS on/off

Conclusion

- Our voice feature extraction was able to identify significant GeMAPS features for DBS on/off
- We want to continue further studies, conducting more uniform sampling to strengthen our dataset, and identify other significant voice features
- Future research aims:
  - Exploring other audio feature sets
  - Developing a predictive model for DBS on/off using voice
  - Closed-loop DBS, using voice as feedback indicator
- Benefits:
  - Accessibility and potability of voice sample collection
  - Inexpensive, non-invasive, and time efficient
- Limitations:
  - Patient recruitment and follow-up
  - Physician required to capture UPDRS motor scores

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References

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