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### Neurodegenerative <u>Disease</u>s

#### Examples include:

- Alzheimer's disease (AD)
- Parkinson's disease (PD)
- Parkinson's disease mimics (PDM)
- Generally chronic and progressive<sup>1</sup>
- NDs are hard to diagnosis and distinguish
- Potential biomarkers may come from patients' speech patterns



# Speech as a biomarker

- Numerous studies have shown that speech shows strong potential as a biomarker for NDs
- Fundamental Frequency variation is diminished in PD<sup>2</sup>
- Have been used to differentiate mild cognitive impairment (MCI), dementias, and healthy controls<sup>3,4</sup>





### Our Project

- To gather speech data three tests were used:
  - A modified Stroop test (MST)
  - A verb naming test (VNT)
  - A noun naming test (NNT)
- Data was analyzed to quantify dozens of features
- Features were compared across groups using statistical analysis



 Create an automated pipeline to help with diagnosis

- Improve precision in the evaluation of NDs
- Provide a greater understanding in how an ND affects speech patterns



### Participant Selection

- Patients seen within the Johns Hopkins medical system with a clinical diagnosis:
  - AD:11
  - PD:21
  - PDM: 12
- Volunteers and patients with no diagnosed ND
  - CN: 44
- All participants signed consent forms







### One word appears at a time on the computer screen

MST

- Participants were instructed to name the color of the word
- Word was displayed for five seconds







- Cartoon object was displayed on screen
- Participants were asked to name the object
- Displayed for four seconds

NNT







## VNT

- Cartoon action was displayed
- Participants were asked to name the verb
- Action was displayed for four seconds





### Analysis

- Automatic transcription was performed by an Automatic Speech Recognition pretrained model
- Audio and transcriptions were supervised manually
- Automatic processes written in Python were used to analyze each feature
- Statistical Analysis was performed using a Kruskal-Wallis test





### Features

#### Cognitive

- Reaction Time
- Confidence
- Number of Words

#### Acoustic

- F0 variability
- Speech Time



### Reaction Time



### Reaction Time









Transcription: Red oh I'm sorry blue



#### Cognitive

- All three ND groups had low confidence compared to controls in the Modified Stroop Test
- AD patients were slower to react and less accurate compared to the other groups in almost every task
- People with a PDM also exhibited slower RTs and accuracy

#### Acoustic

- PDM patients took longer to complete tasks in the NNT and MST
- AD patients also showed significant differences in F0 variability in the NNT and speech time in the VNT



### Significant Features

























### More Research is Needed

- More participants will help expand results
- More tasks must be evaluated
- Comparison across tasks





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### References

- [1] World Health Organization et al., "Global action plan on the public health response to dementia 2017–2025," 2017.
- [2] Brian T Harel, Michael S Cannizzaro, Henr'i Cohen, Nicole Reilly, and Peter J Snyder, "Acoustic characteristics of parkinsonian speech: a potential biomarker of early disease progression and treatment," Journal of Neurolinguistics, vol. 17, no. 6, pp. 439–453, 2004.
- [3] Daniela Beltrami, Gloria Gagliardi, Rema Rossini Favretti, Enrico Ghidoni, Fabio Tamburini, and Laura Calz `a, "Speech analysis by natural language processing techniques: a possible tool for very early detection of cognitive decline?," Frontiers in aging neuroscience, vol. 10, pp. 369, 2018.
- [4] Honghuang Lin, Cody Karjadi, Ting FA Ang, Joshi Prajakta, Chelsea McManus, Tuka W Alhanai, James Glass, and Rhoda Au, "Identification of digital voice biomarkers for cognitive health," Exploration of medicine, vol. 1, pp. 406, 2020.