Audio Analysis of Acoustic and Linguistic Features in Huntington's disease (Audio-HD)

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BACKGROUND

Motor abnormalities are key symptoms of manifest Huntington's disease and individuals with HD often develop an impairment of speech production known as dysarthria. 78-93% of individuals with HD suffer from speech difficulties such as slurring, slow speech, sometimes due to inappropriate pauses, or unexpected variations in pitch or loudness as well as involuntary breathing or repetitive sounds. Speech is a physical manifestation of motor function but can also be affected by cognitive decline. While language is a cognitive process, it is heavily reliant on cognitive ability and speech production.

Current speech analysis and diagnostics are not well developed in HD – widely used and validated assessments such as the Unified Huntington's Disease Rating Scale (UHDRS^{TM}) simply rate language impairment on a scale from 1-4 (from normal to anarthria). This is because speech analysis is unique to the person listening and cannot be easily standardized; humans are typical insensitive to early changes in speech (Kreiman, Gerratt, & Ito, 2007). If it were possible to identify subtle speech/language impairment early in disease and speech/language impairment correlated with cognitive deficits, it might be possible to monitor cognitive decline before the overt appearance of motor manifest symptoms in HD.

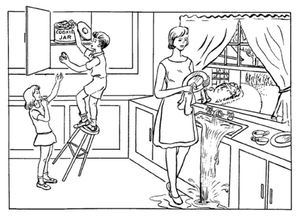
OBJECTIVE

As noted above, UHDRS^{TM} has a single item to grade dysarthria from 0-4 (normal to anarthria); but automated speech feature detection could be a more sensitive biomarker of disease onset or progression. Using a data-driven exploratory approach, we sought to identify the features of speech that differentiated HD from controls using software developed by Canary Speech, a company with patented technology that focuses on analysing digital biomarker data from speech.

METHODS

HD participants (n=26) and healthy controls (n=21) were matched for sex, age, and education. Participants completed an eight minute tablet-based protocol (Audio-HD) that included procedural narrative, passage reading, narrative prompt, picture description, and audio recordings of the Stroop Color and Word Test (SCWT).

- **Duration per word (Stroop Color Naming):** The average gap in time between words.
- **Speech Dynamics (Stroop Interference):** Is a reference to all stages of the human speech communication. This measure is an effective tool to model how humans exploit redundancy and variability to enhance speech output.
- **Words per second (Caterpillar Passage):** Measures the speed of how quickly an individual reads.
- **Minimum of Bandwidth (Caterpillar Passage):** "Bandwidth" is the difference between the upper and lower frequencies in a continuous band of frequencies. Low Bandwidth could potentially impact speech intelligibility.
- **Contrast (Caterpillar Passage):** Decibel difference between spectral peaks and valleys of speech output.



The Caterpillar

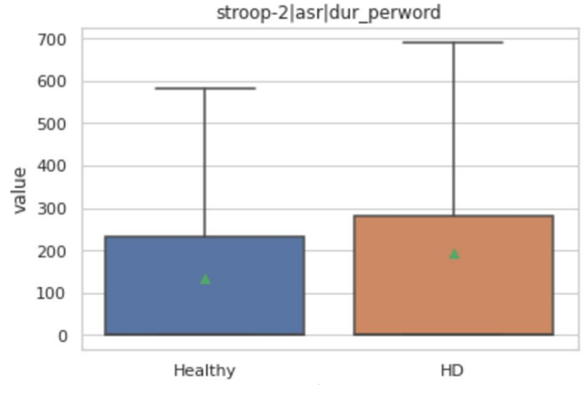
Do you like amusement parks? Well, I sure do. To amuse myself, I went twice last spring. My most MEMORABLE moment was riding on the Caterpillar, which is a gigantic rollercoaster high above the ground. When I saw how high the Caterpillar rose into the bright blue sky I knew it was for me. After waiting in line for thirty minutes, I made it to the front where the man measured my height to see if I was tall enough. I gave the man my coins, asked for change, and jumped on the cart. Tick, tick, tick, the Caterpillar climbed slowly up the tracks. It went SO high I could see the parking lot. Boy was I SCARED! I thought to myself, "There's no turning back now." People were so scared they screamed as we swiftly zoomed fast, fast, and faster along the tracks. As quickly as it started, the Caterpillar came to a stop. Unfortunately, it was time to pack the car and drive home. That night I dreamt of the wild ride on the Caterpillar. Taking a trip to the amusement park and riding on the Caterpillar was my MOST memorable moment ever!

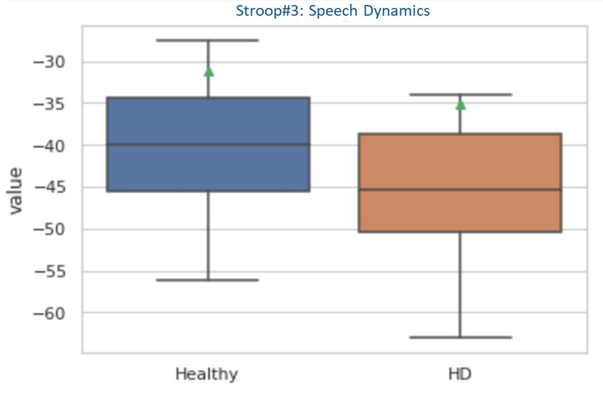
CONCLUSION

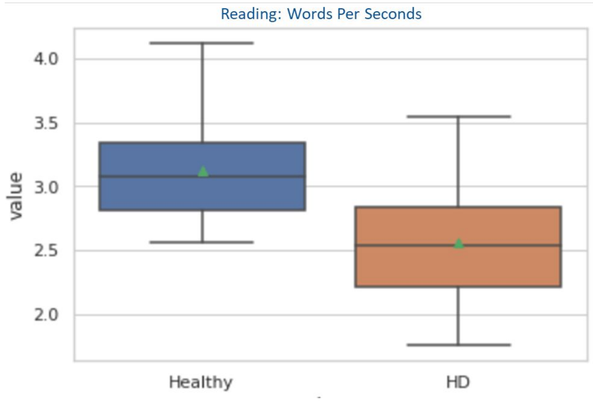
The Audio-HD protocol using Canary Speech is a sensitive assessment for detecting speech changes in HD. Identified features will be integrated into learning models to generate speech biomarkers with the highest sensitivity for early changes in HD.

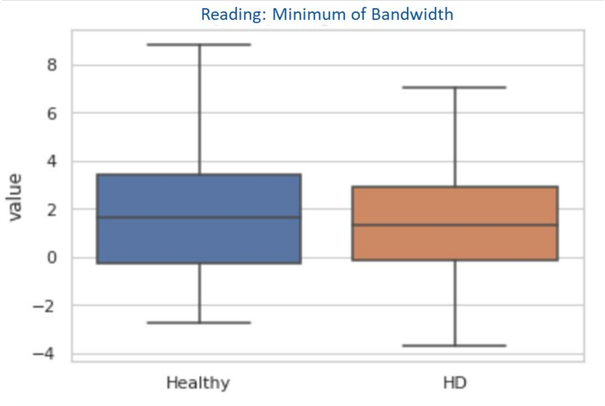
RESULTS

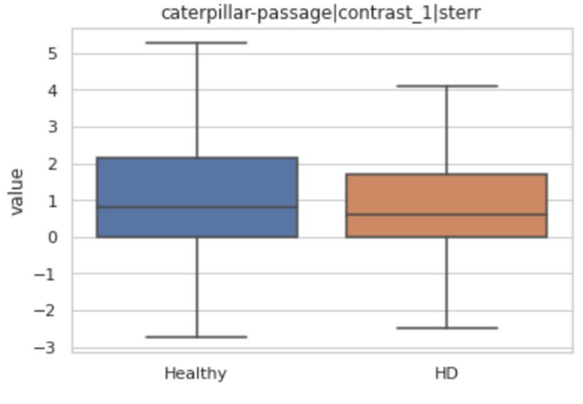
The HD cohort's average UHDRS^{TM} total motor score was 13.5 (SD=13.14) and expanded CAG repeat length 43.2 (SD=3.34). Welch's t-test (95% CI) identified >1000 features of speech that differentiated HD from controls. Features acquired during SCWT and passage reading prompts identified the highest number of significant differences between cohorts. Among many others, speech dynamics (P = 0.033), duration per word ($P < 0.001$), words per second ($P < 0.001$), bandwidth (P = 0.005), and contrast ($P < 0.001$) were significant.











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