Recording Cognition through Voice

UDSv4

INTRODUCTION

The implementation of digitally recording participant responses to neuropsychological tests is a cost-effective way to detect early changes in cognition. As our cognitive capabilities shift, we express them through vocal responses in subtle ways, such as changing word choices or sentence structures because of word finding problems, pausing, hesitating, and shifting as memory, attention, and executive functions are compromised.

Currently, there are no gold standards in methods for analyzing voice recordings in relation to cognition. However, just as with blood-based biomarkers, there is a growing, albeit still limited, set of literature suggesting that analysis of digital voice recordings as a method for differentiating those with and without cognitive impairment is promising.

UDSv4 will initially give centers the option to collect digital audio recording of the cognition section of the UDS but it is highly encouraged. More information and resources will be provided in the coming months detailing the protocol.

BENEFITS

1. Non-Diluting Resource

Digital data can be repurposed for different purposes as algorithms and analysis techniques improve.

2. Minimize Participant Burden

NP tests are already being conducted, digital voice collection allows for scientific enablement at no additional burden to participants.

3. Low Cost and Inclusive

Penetration of recording devices allows for easy, low cost collection of voice data that can be done in the person's native language.

4. Novel Analytics

Natural Language Processing (NLP) and other advanced machine-learning methods offer opportunities to explore acoustic and semantic features in novel forms.

5. QC Tool

Digitally recorded voice tasks can act as a QC tool to determine natural drift in standardization in any longitudinal study.

POTENTIAL QUESTIONS

1. Can features from audio recordings provide early indicators of cognitive impairment in preclinical or prodromal AD?
2. Are these features salient across different languages and accents?
3. Can voice phenotypes help track disease progression and predict converters?
4. With the emergence of blood-based biomarkers, can digital voice be paired as a easy-to-scale clinical indicator of neurodegeneration?

EARLY SUCCESSES

- **LEADS program** - 13 ADRCs are already collecting a subset of NP tests through leads and 19 ADRCs are recording the NP testing.
- **Framingham Heart Study** - FHS has been recording the NP testing of their participants since 2005 and is now developing de-identification methods for data-sharing and using deep machine learning methods to differentiate those who are and are not cognitively impaired.

STATE OF THE SCIENCE

- Beyond cognitive assessments, unscripted dialogue with participants is being analyzed by **Hiroko Dodge et al.** to identify early signs of MCI
- Validating digital voice as a digital biomarker of Alzheimer's disease through imaging and blood-based biomarkers through **Rhoda Au's work.**
- Exploring the potential of human voice as a language, culture, and educationally unbiased biomarker of cognitive impairment and dementia with **Vijaya Kolachalama's team.**
- **Jeff Kaye and Jason Hassenstab** have written extensively on the promise of digital technologies to measure cognition, including digital voice as well as additional digital tools.

See "dVoice - The State of the Science" 1-pager for more details on the exciting work being done!

HOW TO COLLECT & STORE VOICE DATA

Step 1: Turn on Zoom Recorder

Power the Zoom H4N recorder on by sliding a button down and holding it until the device powers on (located on left side, not pictured).

Step 2: Record staff, participant, and visit information

Ensure there is limited background noise. Press the red recording button to create a new recording. Press Play button to record a statement including staff ID (staff initials and number), participant ID, study visit date, study visit number, and what you are recording (UDS 4.0 Cognitive Tests - C2 form). Press pause.

Zoom H4N recorder

Step 3: Record participant reponse

Inform the participant that they will be recorded as they agreed to in the consent form. Press the play button again on the Zoom H4N recorder and administer the UDS 4.0 cognitive tests as the research administrator would normally. Press pause once testing is completed and end the recording after the participant has finished.

Step 4: End the recording

Press the square symbol to end the recording. Download the audio file (See Step 5 for details). Turn off the device by sliding the left side button down and holding it until the device powers off. Repeat the steps for the next annual visit.

Step 5: Store and Upload the Data to NACC

Download the audio file to local storage using prescribed NACC naming conventions: NACCID_DATE_TESTNAME. Store recordings in WAV format. Avoid data compression as that can degrade quality, potentially impacting the analysis. Enter meta-data of the test in UDS4 dVoice form, including, 1) NACC ID 2) Tester ID 3) Recording Date 4) Name of file with full path 5) Recording device details 6) QC details .

dVoice - The State of the Science
UDSv4

BEYOND NP TESTING

The realm of digital voice research extends far beyond cognitive assessments. It's conceivable that brief, unscripted dialogues with patients could yield enough data to identify early signs of Mild Cognitive Impairment (MCI) or individuals predisposed to cognitive decline. **Hiroko Dodge and team** engage participants in unscripted conversations via internet/webcam, resulting in the accumulation of over 3000 hours of dialogue. Analysis of the audio and video recordings from this trial has shown promising results in MCI detection and has also paved the way for utilizing digital voice features as sensitive indicators of intervention effectiveness in clinical trials.

RELEVANT PUBLICATIONS

- Older people with mild cognitive impairment exhibit lower semantic noise after six months of frequent social conversations. https://doi.org/10.1002/alz.080436
- The Joint Effects of Acoustic and Linguistic Markers for Early Identification of Mild Cognitive Impairment. doi: 10.3389/fdgth.2021.702772.
- Scalable diagnostic screening of mild cognitive impairment using AI dialogue agent. doi: 10.1038/s41598-020-61994-0

VOICE AS A BIOMARKER

Digital voice recordings are given additional power by leveraging the data of the SCAN initiative and prospective plasma biomarkers characterization through NCRAD. Acoustic and lexical-semantic features of the voice can be used to identify cognitive impairment in preclinical and prodromal AD as well as an indicator of disease progression. **Felicia Goldstein, Ihab Hajjar, Jeff Kaye, Jason Hassenstab, Hiroko Dodge, Rhoda Au, and Sudeshna Das** have begun conceptualizing and working on what it might take to validate digital voice as a biomarker of AD and ADRD pathology.

RELEVANT PUBLICATIONS

- Development of digital voice biomarkers and associations with cognition, cerebrospinal biomarkers, and neural representation in early Alzheimer's disease. doi: 10.1002/dad2.12393
- Assessment of cognition in early dementia. https://doi.org/10.1016/j.jalz.2011.05.001
- Current advances in digital cognitive assessment for preclinical Alzheimer's disease. https://doi.org/10.1002/dad2.12217

DEMENTIA SCREENING THROUGH VOICE

Digital voice is a scalable data modality that is flexible, non-invasive, and cheap to collect. It could serve as an affordable and accessible way to characterize individuals at-scale and potentially serve as a dementia screening tool. **Ioannis Paschalidis, Rhoda Au, and Vijaya Kolachalama** have begun to explore the utility of digital voice as a tool to evaluate the presence of dementia.

RELEVANT PUBLICATIONS

- Fusion of Low-Level Descriptors of Digital Voice Recordings for Dementia Assessment. doi: 10.3233/JAD-230560.
- Automated detection of mild cognitive impairment and dementia from voice recordings: A natural language processing approach. doi: 10.1002/alz.12721.
- Detection of dementia on voice recordings using deep learning: a Framingham Heart Study. doi: 10.1186/s13195-021-00888-3.

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