Remote assessment of speech and language changes in Primary Progressive Aphasia (PPA) and behavioral variant Frontotemporal Dementia (bvFTD)

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Background

Changes to speech and language occur across frontotemporal dementia (FTD) subtypes, including impairments in naming, agrammatism and increased word finding difficulty.[1–5] Assessing language abilities may help to characterize disease severity and progression in FTD, and detect effects of treatment. Mobile devices and advances in natural language processing (NLP) enable objective, detailed, remote assessment of language, offering potential advantages over current clinical tools. In order to determine the feasibility of remote language assessment and the aspects of speech affected in behavioral variant FTD (bvFTD) and primary progressive aphasia (PPA), we collected speech samples over a one year period using a remote, digital speech assessment tool.

Objectives:

1) Test the feasibility of remote speech assessments in individuals with FTD variants.
2) Use natural language processing to characterize the aspects of speech that change over one year.

Methods

- Thirty-six individuals (20 M, 16 F; mean age at baseline = 61.3 years) with variants of FTD were recruited from the community.
- FTD subtypes included behavioral (n = 21), semantic (n = 6), non-fluent (n = 1), logopenic (n = 4) and unspecified (n = 4) variants.
- In this observational study, participants completed a tablet-based speech assessment (including picture description, phonemic and semantic fluency tests, and object naming) at months 1, 2, 3, 6, 9 and 12 (Figure 1).
- Verbal responses were recorded, transcribed and analyzed using NLP, producing >500 speech variables.
- Scores on standard language tests at baseline were compared to healthy controls using t-tests (Figure 2).
- Change over time was tested in selected speech variables (pauses, total words) and exploratory speech composites (information units, global coherence) using linear mixed effects models controlling for age and sex (Figure 3).

Figure 1: Remote assessment adherence over 1 yr

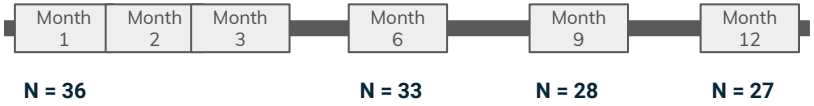


Figure 2: Language impairments in FTD on standard tasks

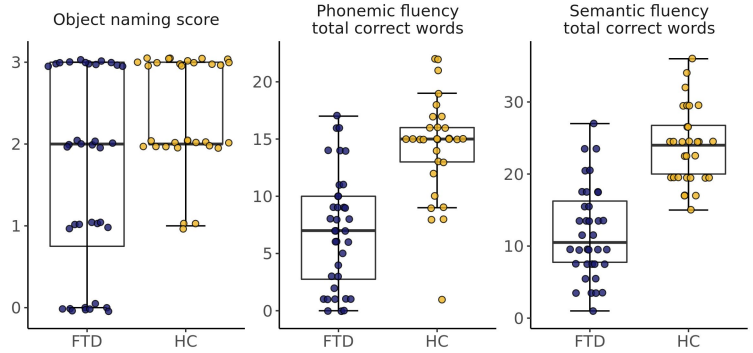
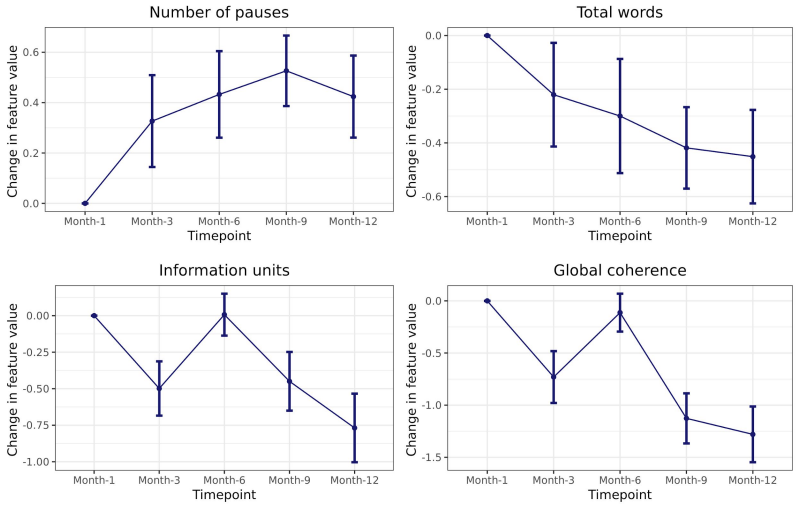


Figure 3: Speech variables show increasing impairment over 1 yr



Results

- Study adherence was good (92% at 6 months, 75% at 12 months). The lower adherence at 12 months was partly due to complications from the COVID-19 pandemic.
- At baseline, individuals with FTD variants showed impairments compared to a control sample on object naming, phonemic and semantic fluency (p's < 0.01).
- Over one year, individuals with FTD showed increases in the number of pauses, decreases in the number of words used, and decreases in the information content and global coherence of picture description (p's < 0.05).
- Information content reflects the number of items correctly identified in the picture, and global coherence measures the semantic relatedness of words used to the items in the picture. These content-based exploratory composites may be more sensitive to differences between picture stimuli.

Conclusions

This study demonstrates that remote language assessments are feasible, with caregiver assistance, in FTD populations. Remote assessments allow for frequent patient monitoring without the need for clinical visits, reducing the burden on patients and their caregivers. Our results replicate standard findings of reduced naming and fluency in FTD, and indicate that language features reflecting the amount, rate and information content of speech are affected in FTD and decline over a 12-month period. Remote language assessments represent an innovative tool for characterizing language changes and disease progression in FTD.

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Evaluation of speech-based digital biomarkers for Alzheimer's disease

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Background

Non-invasive, low-cost digital biomarkers for Alzheimer's disease (AD) would represent a major advance for dementia research. Digital biomarkers could facilitate more efficient screening and treatment of disease, and provide more sensitive endpoints for research studies and clinical trials. Speech changes in AD have emerged as an exciting area of research and a promising potential digital biomarker.[1-6] Rigorous validation is needed to better understand what speech features are affected by disease, the time course of speech changes, and how these novel measures compare to current clinical standards.

Objectives:

- Outline a framework for clinical validation of digital biomarkers.
- With reference to this framework, provide evidence on the development of speech-based biomarkers for detecting and monitoring AD.
- Demonstrate what aspects of speech are useful for AD screening and symptom tracking, and present directions for future research and further validation.

Methods

Winterlight uses an automated, natural language processing pipeline to extract >500 acoustic and linguistic variables from speech samples. We developed recommendations for clinical validation and apply them to our novel speech-based digital measures.[7,8] We provide evidence from a series of studies examining the relationship between features extracted from automated speech processing and the presence and severity of cognitive impairment in mild cognitive impairment (MCI) and AD.

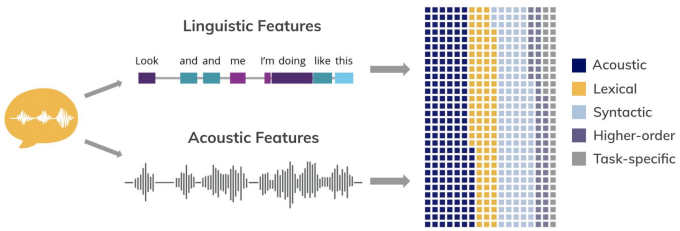


Figure 1: Clinical validation framework for digital biomarkers

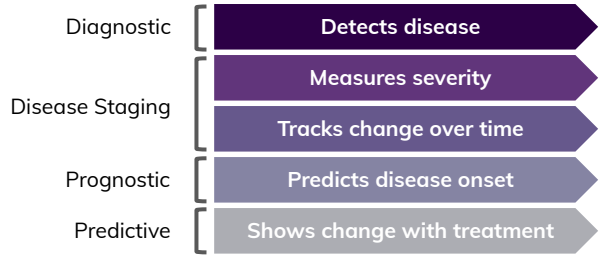
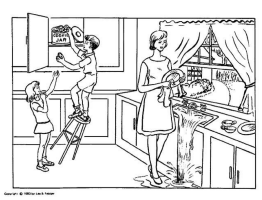


Figure 2: Classification of Alzheimer's Disease based on speech

Detects disease



Picture description task

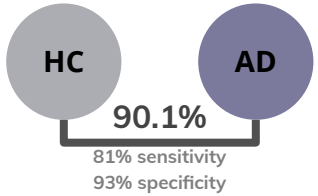


Figure 3: Prediction of MoCA scores based on speech variables

Measures severity

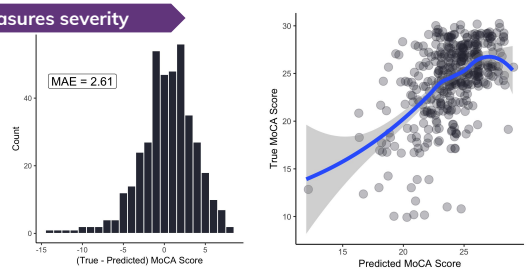
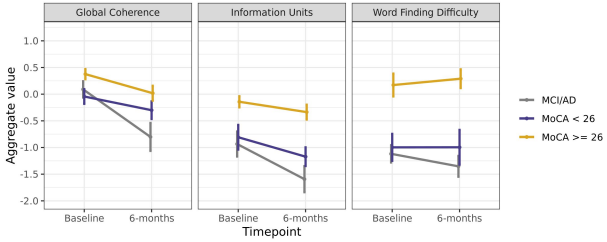


Figure 4: Longitudinal changes in speech in controls & MCI/AD

Tracks change over time



Results

We present a framework for clinical validation for novel digital measures relevant to MCI and AD (Figure 1). Our research shows evidence for speech measures in three aspects of clinical validation:

- **Disease detection**: Our machine-learning models based on picture description speech samples have 90% accuracy when differentiating healthy controls from cases of AD, with high sensitivity (82%) and specificity (91%). (Figure 2)
- **Measuring severity**: We show that speech features can be used to predict scores on clinical measures. In this study, we used speech variables to predict scores on the Montreal Cognitive Assessment (MoCA), within an average of 2.6 points of true values. (Figure 3)
- **Tracking change over time**: We assessed speech in a longitudinal study of community-dwelling older adults, grouped according to MoCA scores, and those with diagnoses of MCI or early MCI. We identified measures that differ between groups and show declines over time, including exploratory composite scores relating to the information content and coherence of speech. (Figure 4)

Conclusions

Together, these studies show how speech represents a promising potential biomarker for AD by demonstrating diagnostic specificity, change with disease progression and correlation with current clinical tools. Collection of speech is naturalistic, low-cost and requires little training, making it a flexible tool for clinicians and researchers. Future work will continue to develop and refine speech-based biomarkers for identifying and tracking AD onset and progression. In addition, more work is needed to demonstrate how speech measures can be used to predict disease before onset and measure response to effective treatment.

References

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