A Novel, Web App-Based Assessment of cognition in ALS using Speech

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Introduction

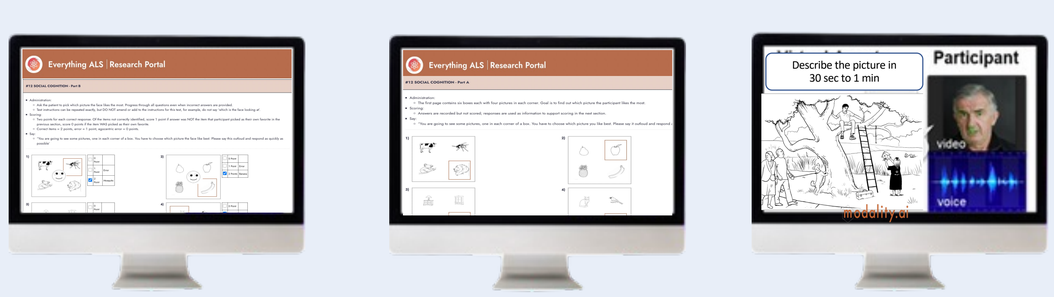
- Amyotrophic Lateral Sclerosis(ALS) impacts motor and cognitive functions, affecting a person's quality of life.
- Researchers have found that 35-50% of people with ALS develop cognitive impairment, with 10-15% meeting the criteria for Frontotemporal Dementia (FTD). Early identification of these changes is crucial to tailor interventions and provide support for individuals and their families.
- Traditional cognitive assessments face challenges with accessibility and mobility, and are often time-consuming to conduct in clinics, leading to them frequently being overlooked.
- EverythingALS created a Web App-based Assessment of Edinburgh Cognitive and Behavioral ALS Screen (ECAS) to enhance accessibility for diverse ethnic and geographic populations, particularly those in rural areas and individuals with severe mobility limitations, while also reducing manual errors associated with traditional paper-based assessments.

Objective:

- #1. Validate the accuracy of online assessment of cognition against in-clinic assessments.
- #2. Infer cognitive scores based on speech analysis from picture description tasks.
- #3. Explore correlation of cognitive scores with the progression metrics; ALS Functional Rating Scale-Revised (ALSFRS-R), Rasch-Built Overall ALS Disability Scale (ROADS) and King's staging.

Methods

- The Web App-Based Assessment of cognition, based on the Edinburgh Cognitive and Behavioral ALS Screen (ECAS), was used to score language, memory, verbal fluency, executive function, and visuospatial.
- Data was collected from 108 people, including individuals with ALS and controls. Of these, 18 people completed at least two ECAS sessions spaced six months apart, totaling to 126 sessions.
- As part of the speech study, individuals described one image weekly from a pool of pictures depicting complex scenes. Speech samples from a subset of 56 people, out of the total 108, were analyzed within ±60 days of the ECAS evaluation.



- Individual's speech recordings of the picture descriptions were analyzed for acoustic features to capture elements such as prosody, voice quality, and noise measurements.
- Recordings were transcribed using Whisper Open AI, and the linguistic features extracted such as Psycholinguistic metrics, Intelligibility metrics, Action words proportions and Graph-based metrics were fed to linear regression models to infer ECAS sub- and total scores.

Results to Date

- Modeling: Linear regression models on NLP-based features were used to infer five ECAS sub-scores and the total score on the 56 people. The model performance was evaluated using 10-fold cross-validation, achieving **Spearman correlation values between 0.32 and 0.51**[1]**.**
- Existing ALSFRS-R scores are being mapped to Rasch-ALSFRS-R and King's stage to explore correlations between ROADS, ECAS, and NLP scores to understand their relationships as ALS progresses.

Discussion

- The study shows that digitized cognitive assessments using speech can be effective for evaluating cognitive health and can serve as an alternative or supplemental approach to traditional tests, broadening access to cognitive assessments for people with limited access to clinical settings due to mobility or location constraints.
- The combination of linguistic and acoustic features with machine learning models proved useful for capturing and predicting cognitive performance.
- While the models showed promise with correlation values (between 0.32 and 0.51) for the small dataset, future efforts will focus on refining feature extraction and expanding research cohorts to improve generalizability.
- **Conclusion:** the digitized ECAS evaluation and NLP of speech are promising tools for remote cognitive assessment in ALS. Next step is to expand research leading to scalable solutions for monitoring cognitive health.

References:

1. Agurto C, Cecchi GA, Wen B, Fraenkel E, Berry J, Navar I, Norel R. Remote Inference of Cognitive Scores in ALS Patients Using a Picture Description. *In 2023 IEEE International Conference on Digital Health (ICDH) 2023 Jul 2 (pp. 50-56). IEEE.*