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SPEAKapp: Language as Digital Biomarker for Mental Health

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Abstract. Language has always been a rich source of amnestic information in the context of cognitive and affective disorders. Many of the language tests and metrics that are employed today have been designed when the only available technology was paper and pencil. Here we present a novel digital tool to administer and score a set of tests based on language.

Keywords. Mental Health, Natural Language Processing, mHealth

1. Introduction

Language dysfunctions are common features in many psychopathologies. Part of the reason why is that language requires the simultaneous activation of multiple cognitive systems [1]. The assessment of language is generally carried out relying on the subjective appreciation by the clinician.

Recent advances of Natural Language Processing (NLP) techniques, Voice Analysis, and Automatic Speech Recognition have gained the attention of clinicians working with people with cognitive and affective disturbances [2]. Unfortunately, the practical adoption of the solutions proposed into clinical setting is limited by the need of specific recording equipment and the availability of trained staff. To overcome the barrier between technological advancement and clinical needs, we developed SPEAKapp, a system based on a mobile application to deliver and analyze speech and language data for clinical and research purposes.

2. Methods

SPEAKapp implements five tests: verbal fluency, automatic series, repetition of complex sentences, picture naming, and prose recall. Each test has been chosen to cover a broad range of cognitive functions and systems affected in different psychiatric and neurological conditions. The system collects this verbal production, and it is the starting point of the features extraction process. The text content of each audio is first extracted using a Speech-To-Text module that leverages commercial Google Speech-To-Text APIs (https://cloud.google.com/speech-to-text). Then, both the raw audio and the text

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content are processed to extract acoustic and semantic features. The system's module for the extraction of voice's acoustic signal parameters computes acoustic features commonly used in acoustic analysis applications: fundamental frequency, jitter, shimmer, harmonicity to noise ratio, and phonation duration. The SPEAKapp acoustic analysis stands upon the Open Source Parselmouth Python library for Praat [3], while novel NLP-based scores are based on Distributional Semantic Models of language. The DSMs used in SPEAKapp were created with word2vec [4]. Features extracted by SPEAKapp uses FHIR (Fast Health Interoperability Resources) standard and can be directly integrated with any Electronic Health Record system supporting this standard.

3. Expected Results

Scoring to the neuropsychological tests collected via the mobile phone app will be calculated twice: i) manually, after having manually transcribed the answers, following the gold standard in the literature and ii) via the app software: the system implements the logics needed to compute the scoring as per literature, but based on the automatic transcription. To test the convergent validity of the system, the correlation between the scoring computed manually and the result of the automatic elaboration will be calculated, according to the Cronbach's α.

4. Discussion and Conclusions

Natural language use can be a sensitive and nonintrusive indicator of changes in internal affective states such as stress, depression, or anxiety. The integration of novel indexes based on verbal performance with standardized measures might lead to novel insights into mental health conditions, as well as to the identification of light and reliable indexes of cognitive functioning. In the long term, identifying a valid marker of treatment efficacy would support clinical research and innovation, facilitating the evaluation of new drugs' efficacy and the mental health of the population served.

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