7631L Screen 135 - Speech Biomarkers of Lyme Disease: A First Exploratory Analysis

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Objectives

- Is it feasible to investigate Lyme disease (LD) symptoms with a conversational AI remote monitoring system, as with other diseases [1]?
- Are speech biomarkers able to discriminate between people with and without a diagnosis of LD?

Background

- LD is the most common vector-borne illness in the US.
- Symptoms can include fatigue, brain fog, and joint pain.
- Post-treatment sequelae are not well understood.
- There have been some past non-speech biomarker studies [2,3,4].
- This is the first known exploration of speech biomarkers of LD.

Methods and Materials

- 30 patients diagnosed with LD at the California Center for Functional Medicine, in collaboration with Dr. Sunjya Schweig.
- 135 healthy controls, collected in collaboration with EverythingALS.
- All participants participated in a self-administered speech assessment using a web-based multimodal dialogue system (See Fig 1).
- Structured exercises to elicit different types of speech: read speech (short and long), automatic speech (counting), measure of diadochokinesis (DDK), spontaneous speech, and sustained vowel.
- Speech metrics were automatically extracted (See Table 1).
- Kruskal-Wallis tests were used to plot effect sizes of metric values between the control and patient cohorts.

Domain	Metrics
Energy	Intensity, signal-to-noise ratio, shimmer.
Timing	Speaking and articulation duration, rate; percent pause time (PPT); canonical timing alignment (CTA); syllable rate, count, cycle-to-cycle temporal variation (cTV).
Voice quality	Cepstral peak prominence, harmonics-to-noise ratio.
Frequency	Fundamental frequency mean, min, max, and standard dev.; first three formants; slope of 2nd formant; jitter.

***Table 1**: Automatic speech metrics, depending on task.*

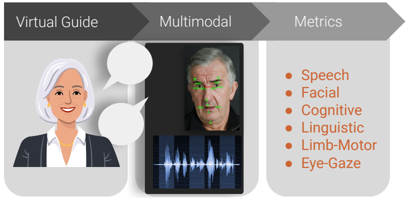

***Fig. 1:** Schematic diagram of the Modality.AI dialogue platform.*

Results

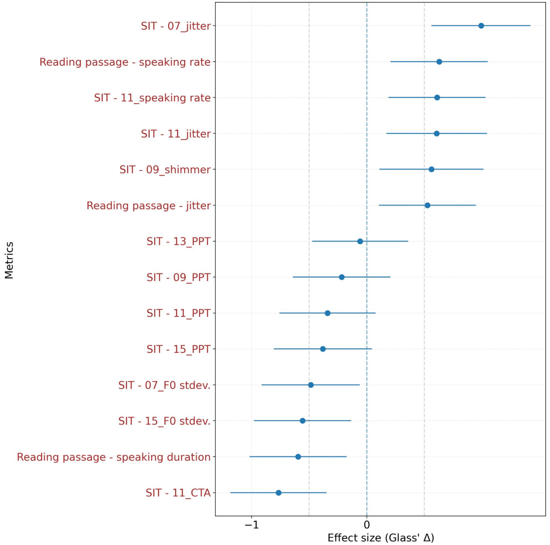

***Fig. 2**: Significant metric effect sizes per task, at $p < 0.01$. "SIT - N" refers to a read sentence of N words in length. The cohorts were not age and sex matched.*

- Significant cohort differences were seen in the read text tasks for jitter, shimmer, speaking duration and rate, percent pause time (PPT), F0 stdev, canonical timing alignment (CTA) (See Fig. 2).
- When age and sex matched, articulation duration and rate showed up and jitter remained significant (See Fig. 3).

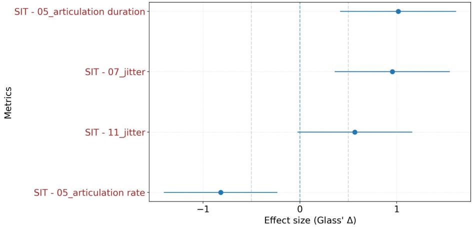

***Fig. 3**: Significant metric effect sizes per task, at $p < 0.05$. The cohorts were age and sex matched. There were 30 subjects in each cohort.*

Discussion

- Objective speech metrics extracted from read speech showed differences between patients and controls.
- Suggestive evidence of timing related differences.
- Stronger evidence of vocal fold behavior differences: LD patients exhibited a smaller range of F0 and a higher rate of jitter.
- Could these be Indications of vocal fold dysfunction? [5]

References

1. V. Ramanarayanan et al., "Speech as a biomarker: opportunities, interpretability, and challenges," Perspectives of the ASHA SIG, 7:1, 2022.
2. A. Badawi, "The potential of omics technologies in lyme disease biomarker discovery and early detection," Infectious diseases and therapy, vol. 6, 2017.
3. A. Pegalajar-Jurado et al., "Identification of urine metabolites as biomarkers of early lyme disease," Scientific reports, vol. 8, no. 1, 2018.
4. X. Li et al., "Digital health: tracking physiomes and activity using wearable biosensors reveals useful health-related information," PLoS biology, 15:1, 2017
5. T. Karosi et al., "Recurrent laryngeal nerve paralysis due to subclinical lyme borreliosis," The Journal of Laryngology & Otology, vol. 124, no. 3, 2010.