

WINTERLIGHT

Predicting Depression Scores using Digital Speech Measures Collected at High-Frequency



Danielle D. DeSouza¹, Melisa Gumus^{1,2}, Mengdan Xu¹, Celia Fidalgo¹, William Simpson^{1,3*}, Jessica Robin¹

¹ Winterlight Labs, Toronto, ON, Canada

² Department of Psychology, University of Toronto, Toronto, ON, Canada

³ Department of Psychiatry and Behavioral Neuroscience, McMaster University, Hamilton, ON, Canada

*Presenting Author; Disclosures: All authors are employees of Winterlight Labs, Inc.

Background

Symptoms of depression are common in the general population, with an estimated one in five American adults experiencing mild, moderate, or severe symptoms [1]. Depressive symptoms are also known to vary over time with greater fluctuation being linked to poor global functional and quality of life outcomes [2]. Day-to-day symptom fluctuation is difficult to measure since repeated clinical assessments are not always feasible and can be burdensome for patients. There has been growing interest in automated speech and language assessments to overcome these challenges and objectively characterize mood symptoms in psychiatric disorders [3, 4]. Speech assessments can be completed remotely, at high-frequency, and are low patient burden.

Study Objective:

To determine if acoustic and linguistic speech properties relate to variations in daily depression symptoms in individuals from the general population.

Methods

16 participants (5M, 11F, age=30.8 ± 9.3) remotely completed daily assessments of speech and depression for 26 days. Audio recordings in response to an open-ended question asking how participants were feeling that day (Fig. 1A) were obtained using the Winterlight app and analyzed using signal and natural language processing (NLP) to derive >500 acoustic and linguistic measures (Fig. 1B). Daily depression symptoms were separately collected using a 9-item electronic questionnaire based on items from the Patient Health Questionnaire-9 with total daily scores ranging from 0 (no symptoms) to 55 (severe symptoms).

We correlated >500 acoustic and linguistic speech features with depression scores. Only associations with a correlation coefficient ≥ 0.3 were included in linear-mixed effects models to predict depression scores. Age, sex, and select speech measures were included as covariates.

Methods

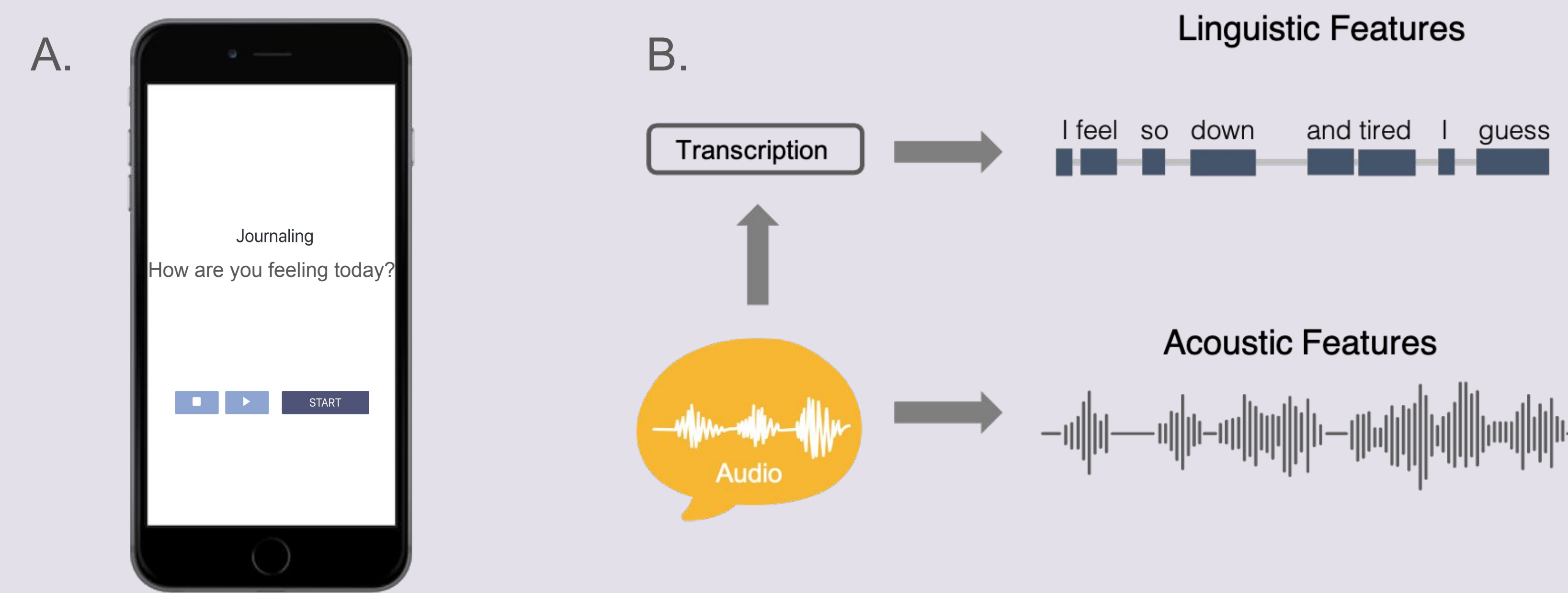


Figure 1. The Winterlight App and speech processing pipeline. **A.** Screenshot of an open-ended question as displayed in the Winterlight speech app. **B.** Schematic representation of how audio samples were used to derive acoustic and linguistic speech features.

Results

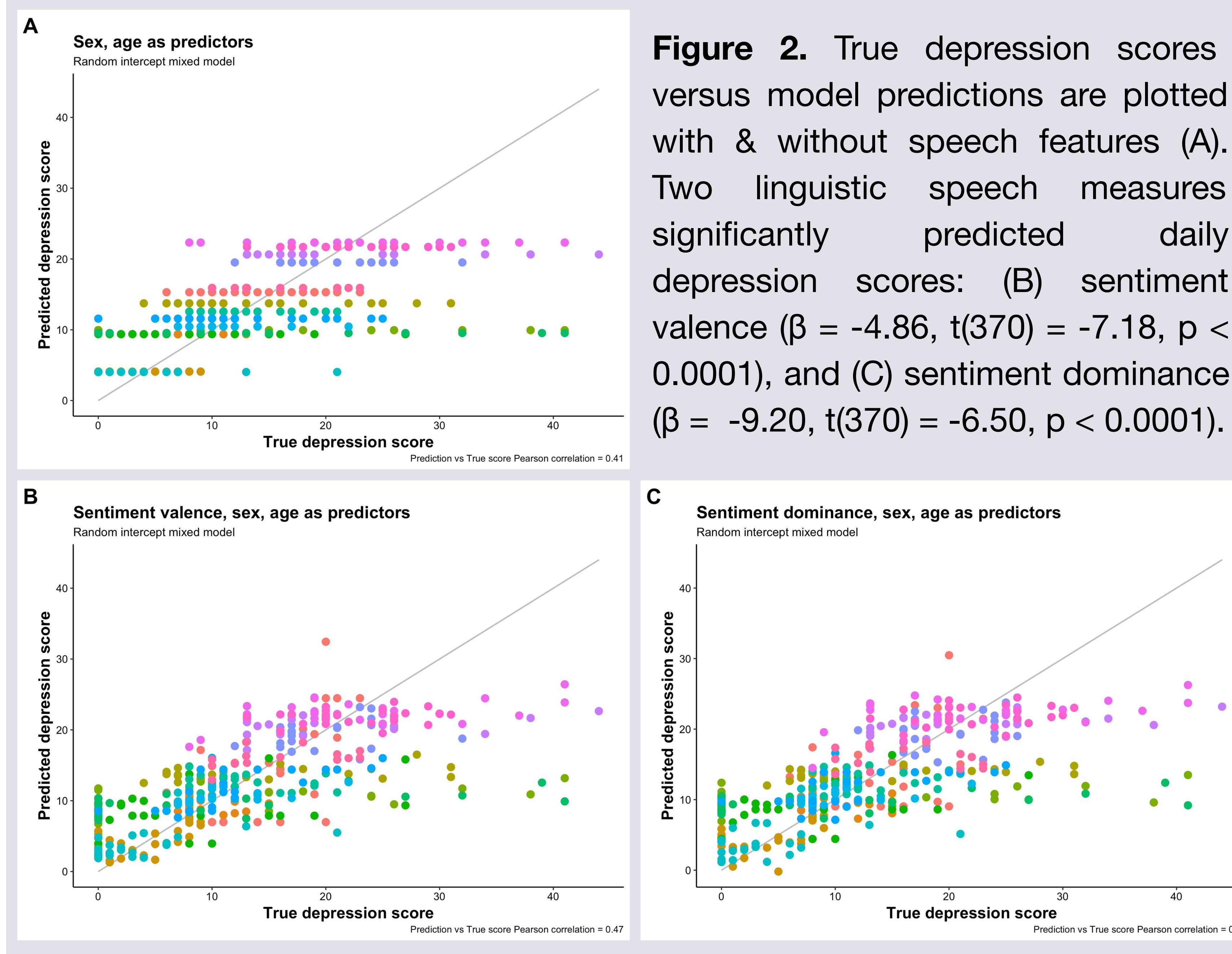


Figure 2. True depression scores versus model predictions are plotted with & without speech features (A). Two linguistic speech measures significantly predicted daily depression scores: (B) sentiment valence ($\beta = -4.86$, $t(370) = -7.18$, $p < 0.0001$), and (C) sentiment dominance ($\beta = -9.20$, $t(370) = -6.50$, $p < 0.0001$).

Discussion

Our research suggests that remote speech and language assessment are useful tools to assess fluctuating depression symptoms. Sentiment analysis, which uses NLP to identify and quantify affective states through linguistic analysis, may be of particular interest. Sentiment valence informs the use of positive, negative, or neutral words with lower scores indicating the use of more negative words (e.g., unhappy). Sentiment dominance describes feelings of power, with lower scores indicating words that denote feeling less power (e.g., controlled). The objective assessment of these measures may have clinical utility particularly with growing interest in telehealth and digital health interventions. However, future studies with larger clinical samples are warranted to determine specifically how speech may inform symptom fluctuations in the context of symptom remission and/or relapse.

Key Findings:

1. Linguistic speech measures map on to daily fluctuations in depression symptoms.
2. Lower sentiment valence values relate to worse depression scores.
3. Lower sentiment dominance scores relate to worse depression scores.

References

[1] Villarroel MA, Terlizzi EP. Symptoms of Depression Among Adults: United States, 2019. *NCHS Data Brief*, No. 379 (2020).
[2] Vergunst FK et al. Longitudinal course of symptom severity and fluctuation in patients with treatment-resistant unipolar and bipolar depression. *Psychiatry Research* 207: 143-149 (2013).
[3] Low DM et al. Automated assessment of psychiatric disorders using speech: a systematic review. *Laryngoscope Investigative Otolaryngology* 5, 96-116 (2020).
[4] DeSouza et al. Natural language processing as an emerging tool to detect late-life depression. *Frontiers in Psychiatry* 12, (2021).