



**TANG LAB** 

# Predicting Treatment Outcomes with Computational Speech Features in Hospitalized Patients with Schizophrenia



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# Introduction

Speech and language alterations are hallmarks of schizophrenia spectrum disorders (SSD) and contribute to positive and negative symptom dimensions (e.g., pressured speech, poverty of speech). Previous research has shown that gold-standard clinical rating scales are subject to high interrater variability in most clinical contexts. Therefore, objective biomarkers are critically needed to guide personalized, evidence-based treatment decisions for SSD in a quantitative, cost-effective, and scalable way. Our goal was to evaluate the predictive value of computationally-derived speech features on longitudinal treatment outcome to determine if they provide additional insight compared to clinical ratings alone.

### **Objectives:**

To explore the use of computational acoustic and linguistic speech features as longitudinal predictors of:

- 1. Psychotic symptoms in SSD, compared to clinical ratings alone.
- 2. Formal thought disorder symptoms in SSD, compared to clinical ratings alone.

#### Methods

Hospitalized patients with SSD (Table 1) underwent the following:

- Brief Psychiatric Rating Scale (BPRS) to assess psychotic symptoms.
- Scale for Thought, Language and Communication (TLC) to assess formal thought disorder symptoms.
- Winterlight iOS app to collect speech samples

Elastic net regression models with leave-one-out cross validation predicted positive psychotic symptoms and thought disorder at follow-up using baseline measures. (Figure 1)

Linear mixed models evaluated relationships between longitudinal changes in positive psychotic symptoms and individual speech features. (Figure 2)

#### Table 1: Participant Baseline Characteristics

Ν	23
Age - mean (SD)	25.8 (4.3)
Sex - n (%)	
Man	16 (69.6)
Woman	7 (30.4)
Diagnosis n (%)	

#### Figure 1: Obtaining Speech Features



Schizoaffective	4 (17.4)
Schizophrenia	14 (60.9)
Schizophreniform	2 (8)
Unspecified psychotic disorder	3 (13.0)
BPRS Total Score- mean (SD)	45.0 (14.1)
<b>BPRS Positive Subscale</b>	9.5 (3.6)
TLC Summary Score – mean (SD)	21.3 (14.0)
Follow-up Interval - Weeks (SD)	2.0 (0.9)

# Results



Figure 2. Change in Positive Psychotic Symptoms & Individual Speech Features



Screenshot of an open-ended question prompt as displayed in the Winterlight speech app. **B.** Schematic representation showing how audio samples are used to derive acoustic and linguistic speech features. For linguistic measures, samples are manually transcribed and natural language processing methods are applied. Audio waveforms can be directly analyzed to capture acoustic aspects of speech.

# **Key Findings:**

- 1. Adding speech features improved the prediction of positive psychotic symptoms at follow-up ( $R^2$ = 0.58) compared to using clinical ratings alone ( $R^2$ = 0.34).
  - Speech features predicting higher positive symptoms: fewer nodes in strongly connected graph community, fewer prepositions, fewer filled pauses, longer maximum utterance length, greater use of particles.
- 2. Adding speech features improved the prediction of thought disorder symptoms at follow-up (R<sup>2</sup>= 0.41) compared to using clinical ratings alone (R<sup>2</sup>= 0.36).
  - Speech features predicting greater thought disorder: more total words, use of demonstratives, use of particles, decreased age of

# acquisition of nouns, location words, object words, noun to verb ratio, and prepositions.

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