

# Identification of robust speech-based markers of negative symptom severity in schizophrenia spectrum disorders



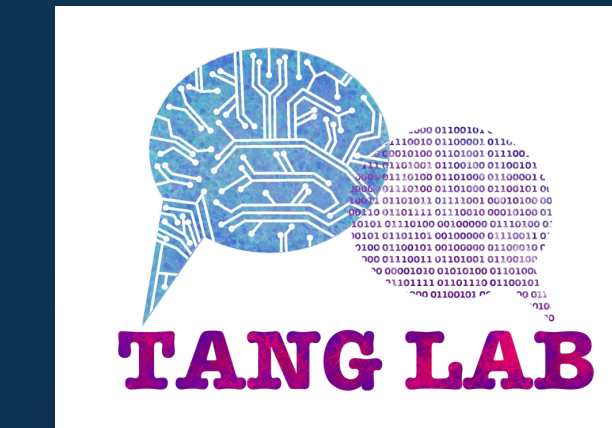
CAMBRIDGE  
COGNITION

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## Background

Digital speech assessment and analysis have the potential to enhance the assessment of negative symptoms in schizophrenia spectrum disorders (SSD).

However, the large number of available speech features and variability in results across studies make it difficult to determine the features with the greatest clinical utility.

**Objective:** to identify the most robust speech-based markers of negative symptom severity by evaluating their reliability and validity in a sample of participants with SSD.

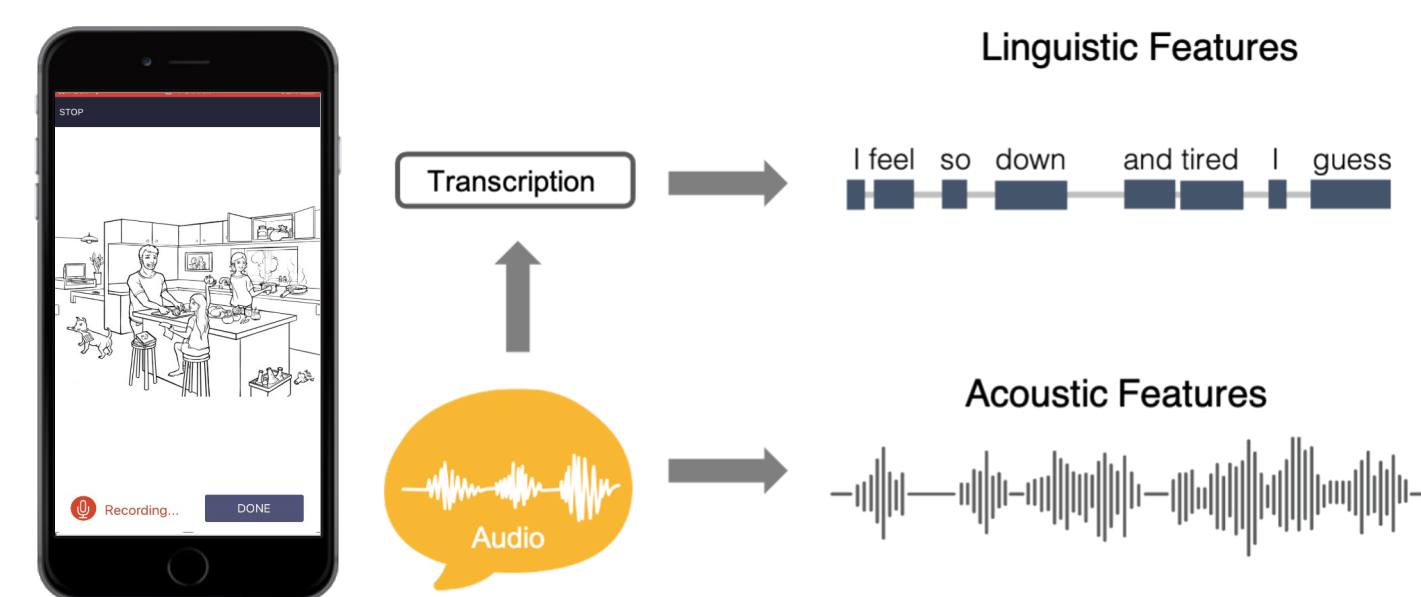
## Methods

**Participants:** 62 inpatients with an SSD diagnosis from a longitudinal study of acute psychosis (baseline visit at inpatient admission and follow-up visit upon discharge ≈1-3 weeks later).

**Clinical assessments:** Scale for the Assessment of Negative Symptoms (SANS), Brief Psychiatric Rating Scale (BPRS).

**Speech assessment:** 2 picture description and 2 journaling tasks at each visit (using the Winterlight iOS app).

**Quantitative speech features:** 38 relevant features (based on prior findings and theory) quantifying acoustic and linguistic properties were extracted for each participant from their speech recordings and accompanying transcripts using acoustic signal processing and Natural Language Processing (NLP) tools.



- Feature categories:**
- Lexical
  - Syntactic
  - Semantic coherence
  - Graph
  - Sentiment
  - Information content
  - Acoustic
  - Timing

**Analyses:** Speech features were evaluated for:

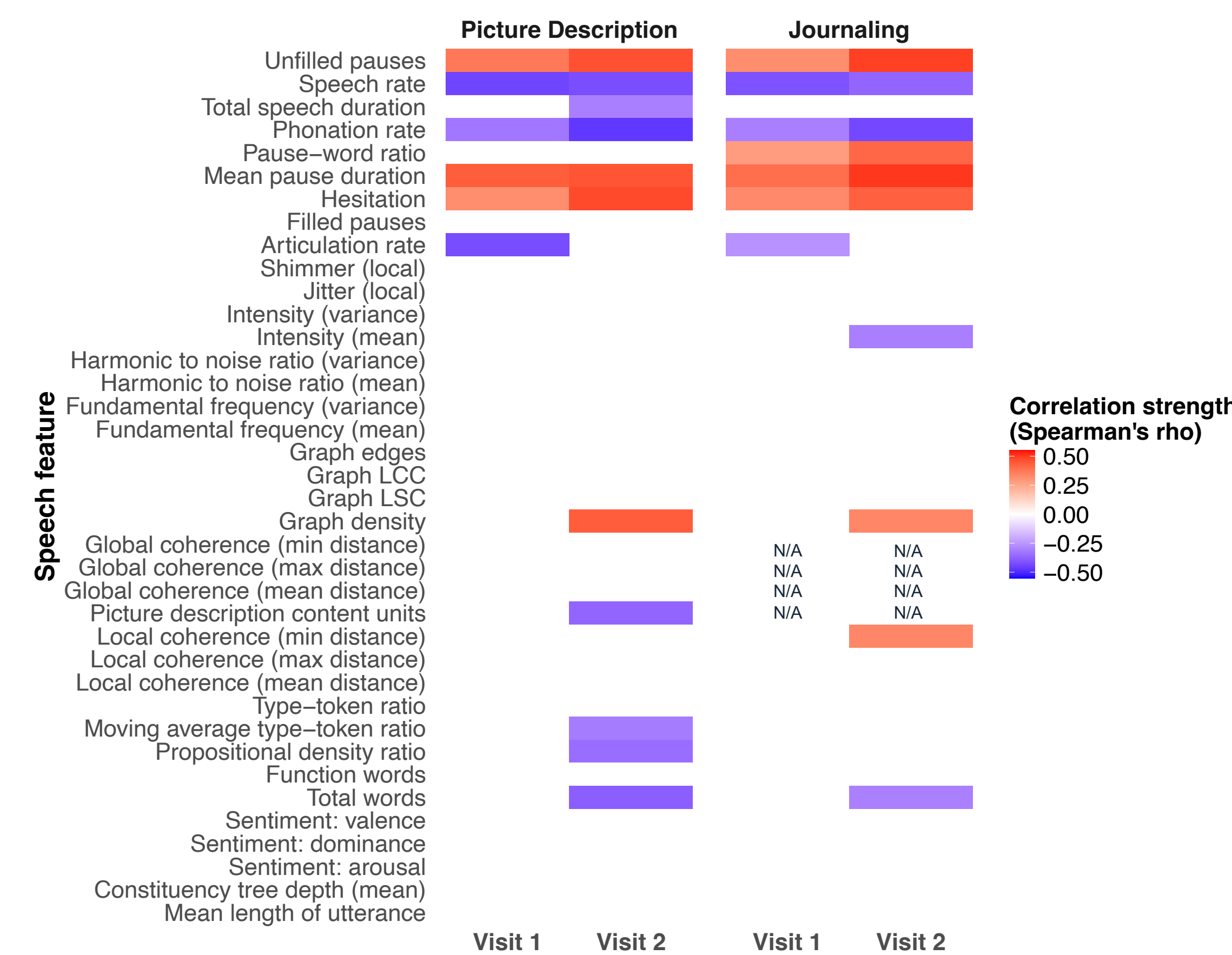
- 1) Associations with negative symptom severity (SANS Total) at baseline (Spearman partial correlations adjusting for age and biological sex).
- 2) Test-retest reliability when comparing stimuli within tasks (intraclass correlations: mean-rating consistency ICC).
- 3) Replicability of significant negative symptom correlations and between-stimulus test-retest reliability at the follow-up visit.
- 4) Convergent validity (associations with BPRS Negative symptom score), discriminant validity (no association with BPRS Positive), and specificity for negative symptom severity (no association with BPRS Total).
- 5) Interrelationships among identified speech features.

## Participant characteristics

	Visit 1 (Baseline) n = 62	Visit 2 (Discharge) n = 48
Age (M, SD)	26.4 (5.3)	26.2 (4.6)
Biological sex (n)	female = 20, male = 42	female = 15, male = 33
BPRS Total (M, SD)	48.2 (10.9)	43.1 (13.1)
BPRS Positive (M, SD)	15.9 (4.4)	13.3 (5.5)
BPRS Negative (M, SD)	5.6 (3.0)	6.4 (3.3)
SANS Total (M, SD)	28.2 (12.2)	26.1 (13.3)

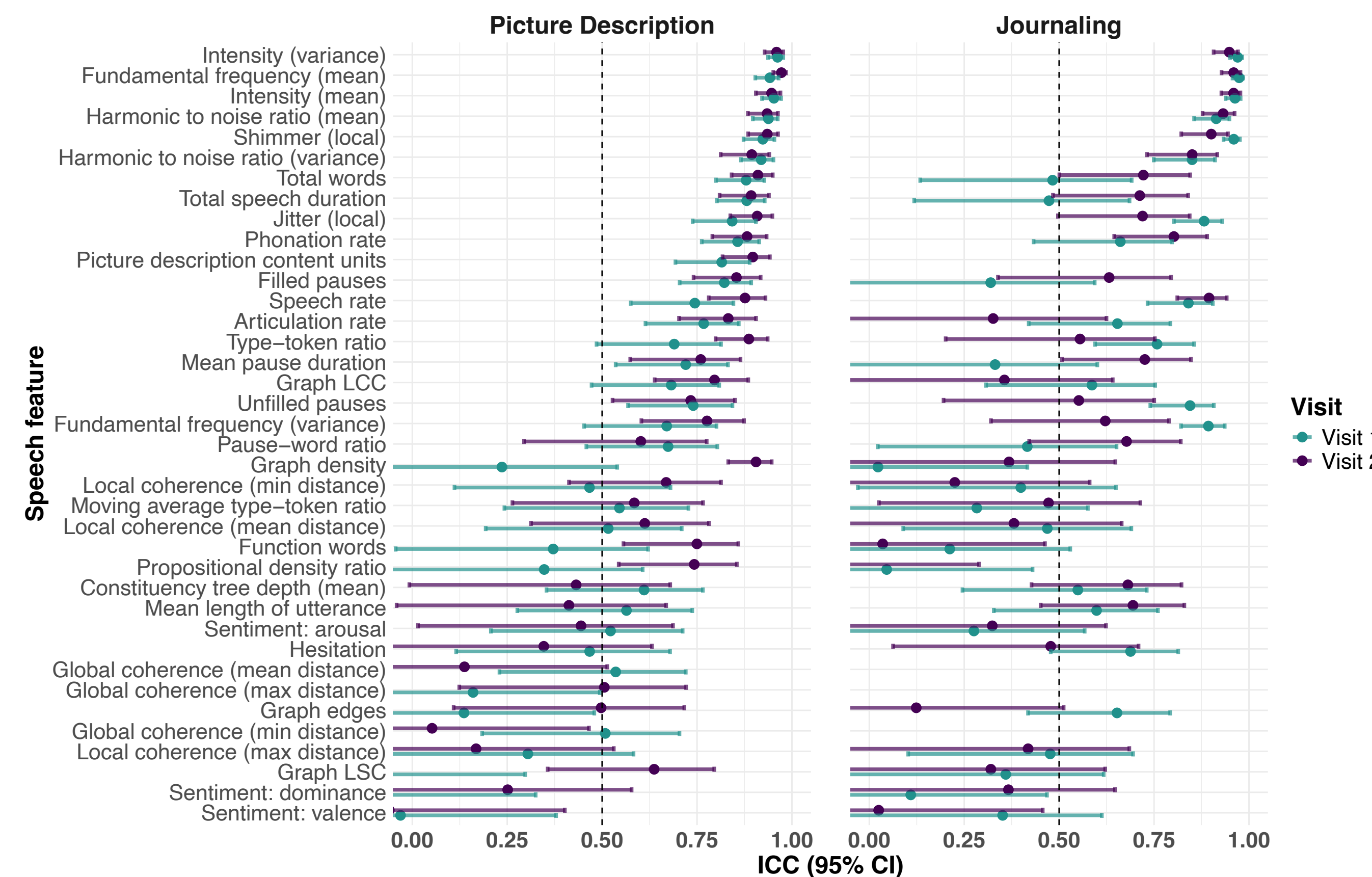
## 1) Speech feature correlations with negative symptoms (SANS Total)

Negative symptoms were predominantly correlated with speech timing-related features, as well as several linguistic features.



## 2) Test-retest reliability (between stimuli)

Reliability between task stimuli within visits was highest for acoustic, timing, and language production features (e.g., total words).



## Conclusions

3 journaling and 4 picture description speech features consistently demonstrated significant associations with negative symptom severity and acceptable or higher test-retest reliability: **↑ mean pause duration, ↓ phonation rate, ↓ speech rate, and ↑ unfilled pauses.**

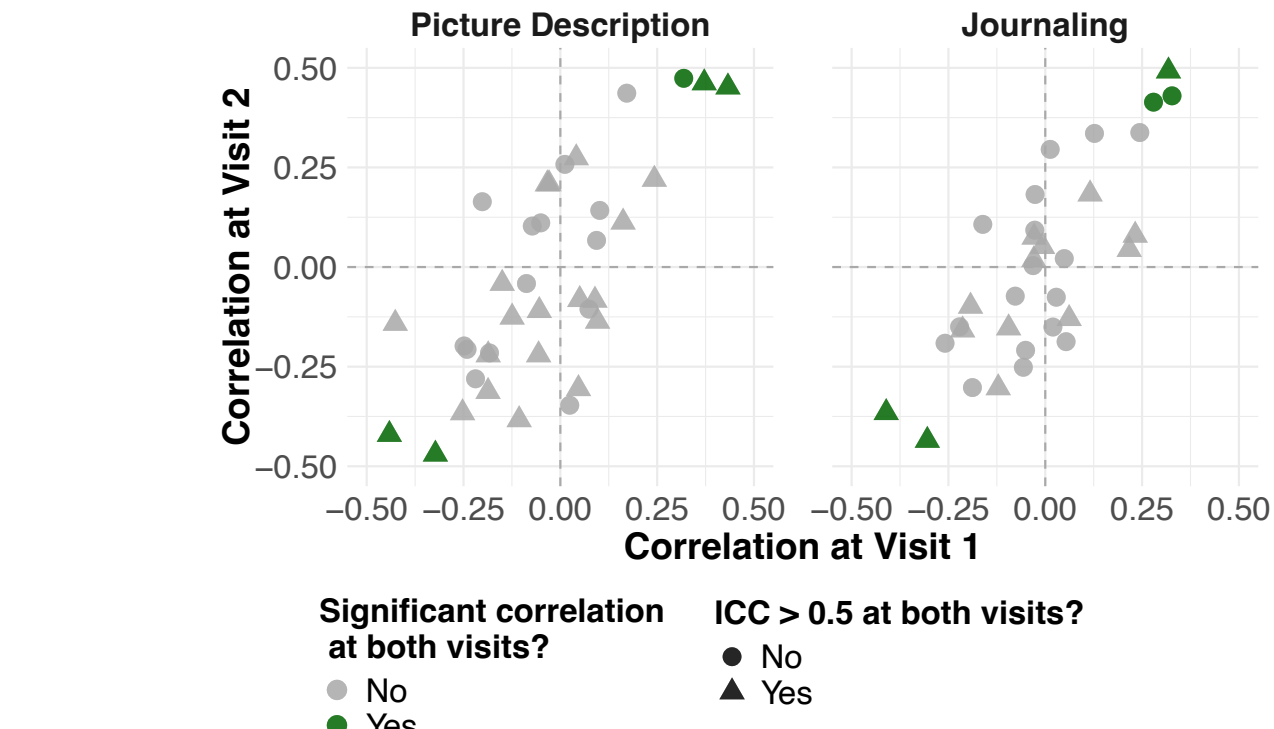
**Speech rate** consistently demonstrated convergent and discriminant validity, and specificity for negative symptom severity. **Results suggest that speech rate may serve as a robust speech-based marker of negative symptom severity to complement existing measures in SSD.**

## 3) Replicability of negative symptom correlations and test-retest reliability

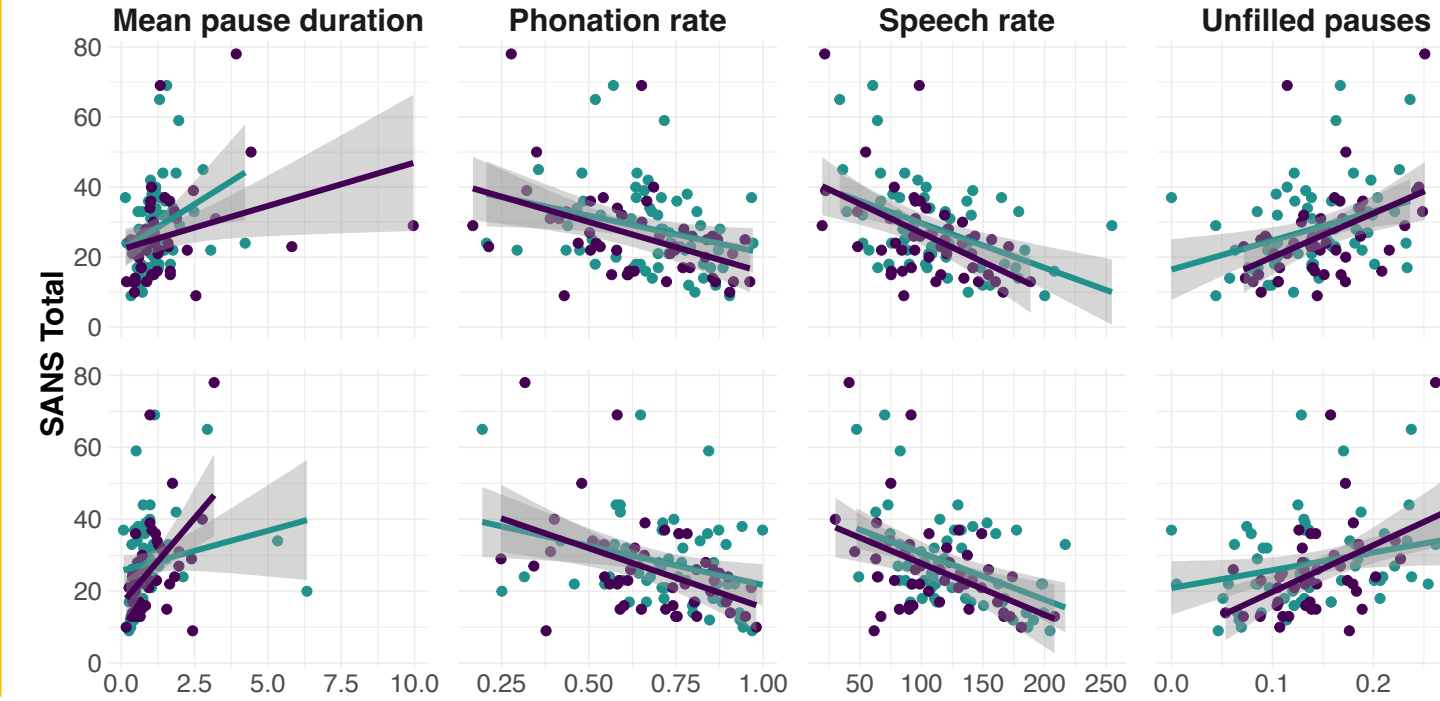
4 speech timing-related features from the Picture Description task had replicable correlations with negative symptom severity and acceptable or above (ICC > 0.5) test-retest reliability between task stimuli.

3 of these features met the above criteria for the Journaling task.

Summary of correlations and test-retest reliability



Speech correlations with SANS Total for identified features



Feature	Correlation with SANS Total (Spearman rho)		Test-retest reliability (ICC)	
	Picture Description	Journaling	Picture Description	Journaling
Mean pause duration	<b>0.43</b>	<b>0.45</b>	<b>0.72</b>	<b>0.76</b>
Phonation rate	<b>-0.32</b>	<b>-0.47</b>	<b>0.86</b>	<b>0.88</b>
Speech rate	<b>-0.44</b>	<b>-0.46</b>	<b>0.74</b>	<b>0.88</b>
Unfilled pauses	<b>0.37</b>	<b>0.46</b>	<b>0.74</b>	<b>0.73</b>

Note. Features with significant correlations and ICC > 0.5 at both visits are indicated in bold.

## 4) Convergent validity, discriminant validity, and specificity

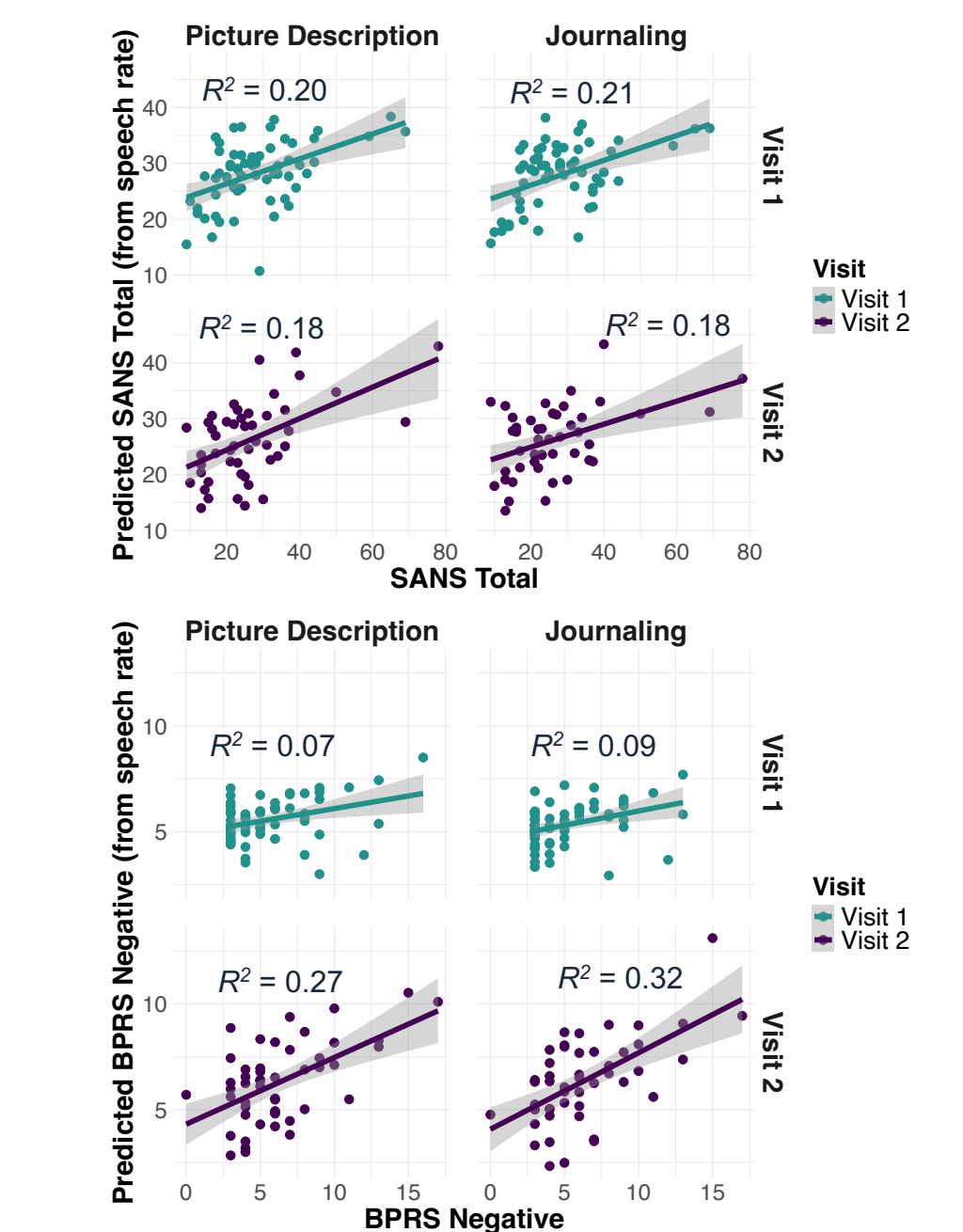
The 4 features showed discriminant validity (not correlated with positive symptom severity) and specificity for negative symptoms (not correlated with overall clinical severity).

Speech rate most consistently demonstrated convergent validity (correlations with BPRS Negative score) across tasks and visits.

Feature	Convergent Validity (BPRS Negative)		Discriminant validity (BPRS Positive)		Specificity (BPRS Total)	
	Picture Description	Journaling	Picture Description	Journaling	Picture Description	Journaling
Mean pause duration	ns	<b>0.48</b>	ns	ns	ns	ns
Phonation rate	ns	<b>-0.45</b>	ns	ns	ns	ns
Speech rate	<b>-0.32</b>	<b>-0.37</b>	ns	ns	ns	ns
Unfilled pauses	<b>0.26</b>	<b>0.29</b>	ns	ns	ns	ns

Note. Features demonstrating significant convergent validity at both visits are indicated in bold.

Predicted negative symptom severity from speech rate (linear regression)



## 5) Speech feature intercorrelations

The 4 features were correlated with each other. The unfilled pauses feature was redundant (r > 0.8) with speech rate across tasks and visits.

