

Linus Health Speech Vitals: Assessing Speech and Language in Schizophrenia

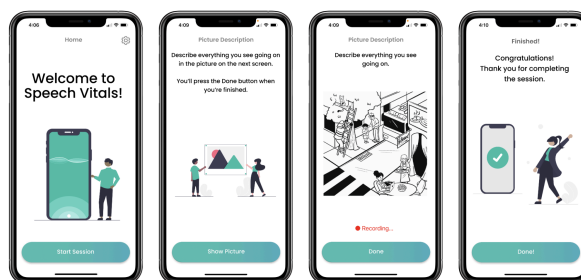
PROBLEM | The field of psychiatry has been looking at the inclusion of objective biomarkers for the diagnosis and monitoring of schizophrenia¹. These biomarkers may improve understanding of disease-related changes and complement existing clinical scales and patient-reported outcomes in differential diagnosis and assessment of treatment effects during clinical trials². Because symptom presentation may fluctuate over time, including outside of scheduled clinic visits, there is growing interest in biomarkers that can be collected more frequently in remote settings³.

Among these approaches, decades of research have characterized speech and language patterns associated with schizophrenia⁴⁻⁶.

Many assessments used in schizophrenia clinical trials are speech-based, e.g. the Social Skills Performance Assessment (SSPA), creating an opportunity to derive additional objective measures from patient responses beyond traditional scoring methods. For example, analyses of speech recordings can quantify features such as pause rate, speaking rate, and total speaking time, providing objective measures of changes that may already be observed clinically^{4,7}.

SOLUTION | The suggested protocol captures **measures of speech and language** for a clinical trial study in schizophrenia.

The [Linus Health](#) Speech Vitals application consists of mobile and web-based tools that elicit audio recording samples from participants, which are subsequently analyzed to derive clinically relevant speech and language features. Speech Vitals draws on decades of neuroscience, speech, and language research to generate interpretable measures of speech production and has been utilized in studies across conditions including Amyotrophic Lateral Sclerosis, Alzheimer's Disease, depression, and Schizophrenia. Modules include targeted speech elicitation tasks designed to assess specific motor, linguistic, and cognitive domains informed by neuroanatomy and neurophysiology. Metrics derived from these tasks may serve as outcome measures in clinical research studies. The application can be administered by clinicians or trained study staff and is also designed for participant self-administration through guided prompts and instructions.



For example, a proposed 6-month clinical trial design could include a monthly comprehensive speech and language assessment alongside shorter weekly tasks to enable more frequent monitoring of speech and language changes associated with schizophrenia. The monthly assessment is designed to capture speech motor, linguistic, and cognitive changes that may occur over time, while the abbreviated weekly assessment is intended to monitor incremental changes and reduce the risk of practice effects associated with repeated administration of more structured tasks. Weekly recordings may additionally support within-subject longitudinal monitoring by establishing an individualized baseline that can be used to assess treatment-related effects or changes associated with disease progression. This could be administered in addition to analysis of the recorded clinical assessments conducted as part of the study's design, such as the SSPA.

SPEECH & LANGUAGE	Task	Task Description
Monthly Assessment 7 Tasks Duration: 10 minutes	Verbal Fluency	Participants name as many items as they can within the category shown in 15 seconds
	Picture Description	Participants describe a picture of a complex scene in their own words
	Sentence Reading	Participants read a set of sentences
	Spontaneous Speech	Participants are asked open-ended questions, such as telling a story or describing a dream
	Story Recall	Participants see and hear a story, then attempt to repeat it verbatim
	Visual Naming	Participants name all items in an array of items
	Visual Search	Participants name a subset of items in an array
Weekly Assessment Duration: 2 minutes	Spontaneous Speech	Participants are asked open-ended questions, such as telling a story or describing a dream

Data Elements, Metadata, and Endpoint Derivation

The table below provides an example of the metrics that are derived from the monthly assessment. The metrics can be augmented based on the context of use to include metrics that can capture additional speech and linguistic constructs, which may be necessary if multiple indications are included in the trial.

SPEECH STAGE	Domain	Associated Speech Vitals Measures
Conceptualization	Volition Desire to verbally express a response	Raw word token count, mean sentence length, number of turns taken in a particular dialogue sequence, DEPID
	Affect An individual's mood in terms of valence (positive or negative) and arousal (high or low)	Number of positive and negative emotion words used in participant responses, sentiment analysis through lexical, semantic, and syntactic features
	Semantic Coherence Semantic relatedness of the participant's response	Semantic relevance, sentence embeddings and validated similarity measures between the prompt and each response
	Appropriateness of Response The likelihood that the participant's response follows the prompt	Appropriateness score, picture description score, recall score
Formulation	Lexical Diversity The diversity in vocabulary of a participant's speech	Type-to-token ratio, Brunét's index, Honore's statistic
	Lexical Density The amount of semantic content within a response	The ratio of content words (information-dense) to function words (information-sparse), frequency and proportion of parts of speech
	Syntactic Complexity The complexity of constructed sentences during speech	Maximum Yngve depth, mean sentence length, parse tree height
Articulation	Articulation The use of parts of the vocal tract to generate phonemes when speaking	Articulation rate, articulatory precision, buttercup count, speaking rate, formant statistics, objective hypernasality metric
	Respiratory Support & Phonatory Control The coordination and control of the lungs and vocal folds	Harmonic strength, pitch instability, amplitude/loudness statistics, regulation of voicing, duration of speech, vocal quality (e.g., hoarseness, harshness)
	Prosody The use of intonation, stress, and rhythm to convey meaning and emphasis	Monotonicity, pause rate, duration of speech



Advantages of Measurement of Changes in Speech and Language

The primary value of the **speech and language measures** is to provide a set of metrics that augment existing clinical endpoints and that can be measured at a higher frequency. The nature of the tasks within the assessments additionally allow for more naturalistic speech through elicitation of spontaneous speech responses as well the at-home data collections. The metrics additionally provide objective measures of speech and language that capture patterns typically assessed by existing scales, such as anhedonia, or the reduced ability to experience pleasure. With these assessments and metrics, decreased output of speech can be assessed objectively by word count, or irregular prosody will be objectively measured through pitch variability.

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