Assessing & monitoring clinical severity in depressive disorders using automated speech analysis

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Background

- Novel digital technologies, including computational speech analysis, may help provide objective and low-burden markers of symptom severity in depressive disorders, which in turn may facilitate more efficient clinical assessment and monitoring.
- However, most prior research has been cross-sectional, which limits conclusions about the sensitivity of speech to longitudinal changes in depression.
- **Objective:** In the current study, we examined associations between speech and clinical severity in a longitudinal observational study of major depressive disorder.

Methods

- **Participants:** 133 outpatient participants with a primary DSM-5 diagnosis of Major Depressive Disorder
- Study design: Longitudinal observational study with assessments at baseline, and at 1-, 2-, and 3-month follow-up.
- **Clinical self-report measures:** Patient Health Questionnaire-9; PHQ-9; depression severity), Generalized Anxiety Disorder-7 (GAD-7; anxiety severity), Sheehan Disability Scale (SDS; functional impairment).
- Speech assessments (Winterlight Assesment App): Picture Description (describing the contents of a complex scene), Journaling (describing how the participant has been spending their time), Positive Fluency (listing all positive events the participant expects to experience in the next week in 1 minute), Phonemic Fluency (listing all words the participant can think of that begin with a specific letter in 1 minute).
- **Speech features:** 72 core acoustic and linguistic features computed using signal analysis of speech recordings and natural language process (NLP) of speech transcripts.
- **Analyses:** Associations between speech features and severity of depression, anxiety, and functional impairment were examined with linear mixed-effects models controlling for demographic variables (age, sex, education). Within these models, both between-subject associations (using participants' subject-level mean across visits) and within-subject associations over time (using participants' visit-specific deviations from their subjectlevel mean) were examined.







Linguistic Features

Participant characteristics at baseline

Age (M, SD)	28.5 (9.7)
Sex (n)	91 female, 42 male
Years of education (M, SD)	15.3 (1.9)
PHQ-9 (<i>M</i> , <i>SD</i>)	13.4 (6.8)
GAD-7 (<i>M</i> , <i>SD</i>)	11.1 (5.7)
SDS (M, SD)	16.4 (7.0)

Highlights & Conclusions

- Several acoustic and linguistic speech features were robust markers of clinical severity in major depressive disorder, showing associations with clinical severity both between and within participants.
- Results indicate the potential utility of digital speech assessment and analysis as an objective and lowburden tool for symptom monitoring in clinical trials.

Results: Between-subject associations

- Significant speech features associated with overall severity differences between participants included:
- 25 features associated with *depression*
- 18 features associated with *anxiety*
- 23 features associated with *functional impairment*

Timing				
	Hesitation	2		
	Verb phrases (rate)	2	1	
	Propositional phrases (rate)	2		
Syntactic	Propositional phrases (word proportion)			
	Noun phrases (word proportion)	1	1	
	Adjactive phrases (rete)			
	Sentiment: Valence	1	2	
Sentiment	Sentiment: Dominance		1	
	Sentiment: Arousal	1	1	
Semantic	Minimum semantic distance			
	Propositional density ratio	1	1	
	Verbs	1	2	
	Particles	2	2	
	Nouns	2	1	
	Adpositions	1	1	
	Adjectives	1	1	
	Noun/Verb ratio	2	2	
Lexical	Imageability			
Loviour	Frequency	1	1	
	Familiarity	1	1	
	Inflected verbs	1	1	
	Function words	·		
	Word length (mean)	3	3	
	Age of acquisition	1		
	TTR			
	Not-in-dictionary words			
	TTR (30-word moving average)	1		
	TTR (10-word moving average)	1		
_Task	Information units – object	1		
	Graph: directed PE	1	1	
5.	Graph: LSC			
Discourse	Graph: density			
	Graph: ASP			
	Average cosine distance	1		_
	Shimmer			
Acquistic	Intensity (variance)			
ACOUSTIC	Intensity (mean)			
	HNR (variance)			
	HINK (mean)			
	Fundamental frequency (mean)			
		Depression	Anxiety	Im
		CI	inical sco	ore

WINTERLIGHT

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Results: Within-subject associations

- 19 features associated with *depression*
- 8 features associated with anxiety

_	Total duration speech (r
liming	Phonation I
	Articulation_
	Verb phrases (ra
	Prepositional phrases (ra
Syntactic	Noun phrases (ra
,	Noun phrases (word proporti
	Adjective phrases (ra
	Adjective phrases (word proporti
	Sentiment: Vale
Sentiment	Sentiment: Arou
	Minimum semantic dista
Semantic	Maximum semantic dista
	Total words (r
	Not-in-dictionary words (r
	Pronoun/Noun r
	Prono
	No
	Adpositi
	Noun/Verb r.
Lexical	Imageab
	Freque
	Familia
	Word length (me
	Noun imageab
	Noun freque
	TTB (30-word moving avera
	TTB (10-word moving avera
Task	Information units – ob
	Graph: A
	Untopoity (veries
Acoustic	
	Fundamental frequency (ma
	i unuamentai nequency (me

Results: consistent between- & withinsubject associations

- **Speech feature**
- fundamental frequency
- harmonic-to-noise-ratio
- word sentiment valence ration
- picture description informat
- word length
- minimum semantic distance
- word sentiment arousal ratir
- use of prepositional phrases
- use of adpositions

Plot for the relationship between depression severity and word sentiment valence (picture description task)



CAMBRIDGE COGNITION

• Significant speech features associated with clinical severity changes within participants over time included:

• 21 features associated with *functional impairment*



Anxiety Clinical score

	Clinical domain
	Depression
	Depression
ng	Depression
ion units	Depression, Functional impairment
	Anxiety
Ð	Functional impairment
ng	Functional impairment
;	Functional impairment
	Functional impairment

Longitudinal within-subject associations (using deviations from within-subject mean)

Between-subject association (using subject-level mean)



