Psychometric Approach to Speech Feature Analysis as an Objective Measure of Anxiety

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Background

Anxiety disorders, including generalized anxiety disorder (GAD), are among the most common mental illnesses in North America. Despite the high prevalence, they are often underdiagnosed and undertreated due to barriers such as access to care, cost, and stigma [1]. To overcome these limitations, one growing way to objectively detect mental health symptoms is to analyze speech collected with personal devices, using natural language processing (NLP) methods. While speech measures can be indicative of mental health status [1-3], few studies have specifically focused on symptoms of generalized anxiety. The objective of the current study was to examine the relationship between speech and anxiety symptoms in the general population using remotely collected standardized speech samples and the Generalized Anxiety Disorder 7-item (GAD-7) scale. Additionally, we used a psychometric approach to explore the the two-factor structure of the GAD-7 to determine how speech measures were related to cognitive-affective and somatic aspects of anxiety.

Methods

Participants were included from our larger study investigating crowdsourced speech data for psychiatric research using Amazon's Mechanical Turk (mTurk) accessed on personal devices. Participants meeting the following criteria were included:

- English speaking
- US resident
- 20 - 60 years old
- GAD-7 total scores ≥10 (moderate to severe symptoms)

Audio recordings obtained during a Picture Description task were deconstructed using signal and NLP tools to derive over 500 acoustic and linguistic speech measures (**Fig. 1**). Data cleaning steps were carried out to ensure audio quality.

Figure 1: Schematic representation for deriving acoustic and linguistic speech features from audio files.

Psychometric Analysis of the GAD-7

Exploratory (EFA) and confirmatory (CFA) factor analyses assessed the factor structure of the GAD-7, with CFA specifically testing the two-factor structure of the GAD-7 comprised of cognitive-affective and somatic anxiety loadings [4].

Associations between Speech and Anxiety Measures

Non-parametric (Spearman's) partial correlations, controlling for age, sex, and years of education explored associations between speech measures and total anxiety and factor subscores.

Results

Participants

- 96 participants (mean age: 34 ± 13 years; 66 women) were included in the study
- Mean GAD-7 total scores: 15 ± 3

Factor Analyses Revealed a Two Factor Solution

- EFA, which makes no *a priori* assumptions about relationships among factors, revealed a two factor solution accounting for 36.6% of total variance of GAD-7 responses
- Both EFA (**Table 1**) and CFA confirmed Factor 1 ("cognitive-affective") comprised GAD-7 items 1, 2, 3, and 7, while Factor 2 ("somatic") comprised items 4, 5, 6

GAD-7 Items	Factor 1 "Cognitive-Affective"	Factor 2 "Somatic"
1. Feeling nervous, anxious, or on edge	0.531	
2. Not being able to stop or control worrying	0.827	
3. Worrying too much about different things	0.691	
4. Trouble relaxing	0.229	0.507
5. Being so restless that it is hard to sit still		0.413
6. Becoming easily annoyed o irritable		0.737
7. Feeling afraid something awful might happen	0.293	

Table 1: Consistent with the literature [4], EFA results revealed that GAD-7 items loaded onto two factors accounting for 36.6% of response variance.

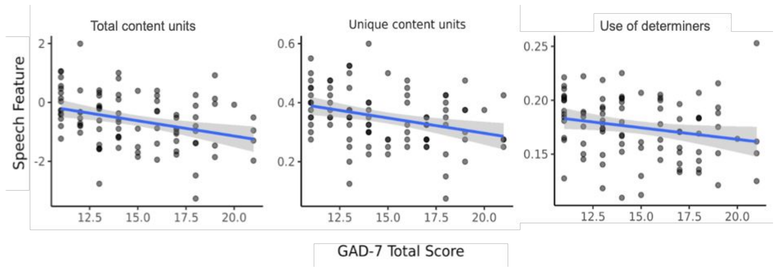

Figure 2: Representative scatterplots of significant associations between GAD-7 total scores and speech measures (partial Spearman correlation coefficients: |0.3 - 0.33|; *p*-values: 0.0015 to 0.0047). Content units refer to elements of the picture described and determiners refer to articles, possessives etc. Original plots are shown for display purposes.

Results

GAD-7 Total Scores were Negatively Associated with Speech Measures

Using a partial correlation coefficient (cc) threshold of |0.3| and $p < 0.05$, six speech measures, primarily related to picture description *information units* and use of *determiner* words, were negatively associated with GAD-7 total scores (**Fig. 2**).

Cognitive-Affective Subscores were Uniquely Associated with Speech Measures

Exploratory subscore analyses revealed only GAD-7 cognitive-affective subscores were uniquely associated with certain speech measures including use of non-words, verb arousal scores, and acoustic (MFCC) features (**Fig. 3**).

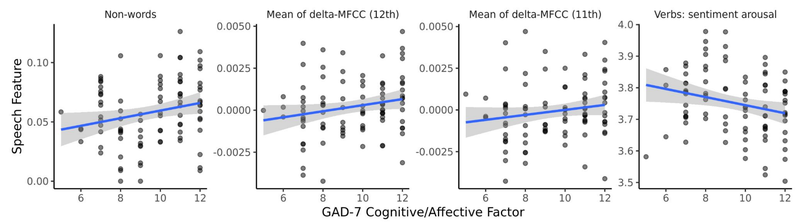

Figure 3: Representative scatterplots for associations between GAD-7 cognitive-affective subscore and speech measures (partial Spearman correlation coefficients: |0.25 - 0.26|; *p*-values: 0.0154 to 0.0198). Original plots are shown for display purposes..

Discussion

We provide support for the assessment of generalized anxiety symptoms measured by the GAD-7 through speech analysis of remotely collected audio samples. Per previous research [4], participant responses to the GAD-7 factored into cognitive-affective and somatic domains. Significant negative associations between GAD-7 total scores and speech features primarily measuring information units were observed such that the greater the anxiety symptoms, the less information or content units reported during a picture description task. Additionally, cognitive-affective anxiety scores were associated with greater use of non-words, increased acoustic MFCC measures, and decreased verb sentiment arousal. Taken together, a psychometric approach to analyze anxiety symptoms through speech may provide insight into anxiety symptom heterogeneity missed using total GAD-7 scores alone. Future studies involving larger, clinical cohorts are needed to further validate this method.

References

[1] Low et al. *Laryngoscope Investigative Otolaryngology* 5, 96–116 (2020). **[2]** Mundt et al. *Journal of Neurolinguistics* 20, 50–64 (2007). **[3]** Sonnenschein et al. *Cognitive Behaviour Therapy* 47, 315-327 (2018). **[4]** Boothroyd et al. *Health and Primary Care* 2, 1-4 (2018).

Presented at SOBP 2021 Virtual Meeting, April 29 - May 1, 2021