Personality Traits and Self-Reported Vocal Fatigue and Other Voice Measures Among Teachers

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Summary: Background. Previous research has examined the correlation between certain personality traits and specific voice disorders. These studies indicated that a predictive relationship exists between an individual's personality and their likelihood of experiencing certain types of voice disorders. The personality type classified as "extravert" was most commonly correlated with voice problems associated with high vocal use such as inflammation or nodules.

Aim. The purpose of this study was to determine if a relationship exists between self-reported vocal fatigue, demographic characteristics, such as assigned sex at birth and age, perception of current voice condition, aerodynamic measures, and voice acoustic parameters with any of the five personality traits measured by the Big Five Personality Index: Extraversion, Agreeableness, Conscientiousness, Neuroticism, and Openness. We hypothesized that vocal fatigue scores and spirometry measurements may be good predictors of specific personality traits, and therefore, can be useful measures to complement vocal assessment.

Methods. Participants in this cross-sectional correlational study included 73 full-time elementary and middle school teachers. Participants completed the Vocal Fatigue Index (VFI) and the Big Five Inventory (BFI)-10 personality index; further, microphone recordings were collected from a battery of voice tasks in addition to spirometry. Descriptive analyzes of the dependent variables (BFI personality traits) and independent variables (demographics, acoustics, spirometry, and VFI total score) were performed, calculating frequency values. Kruskal-Wallis tests were conducted to evaluate independent variables' differences across the scores of the five BFI personality traits. The association between the independent and dependent variables was then investigated using a Generalized Estimating Equations multinomial logit model. The level of significance was defined at 0.05, and the associations are expressed as betas and standard error.

Results and Conclusion. The results suggest that high scores for the traits of extraversion and agreeableness were both predicted by *lower* scores on the VFI ($P \leq 0.05$), indicating that individuals with lower perception of vocal fatigue may be more likely to be identified as extraverted and/or agreeable personalities. These results support previous study's conclusion as well as add additional insights that could be translated into screening protocols and additional supportive care of occupational voice users.

Key Words: Voice markers—Personality traits—Acoustic parameters—Voice assessment—Screening— Teachers.

INTRODUCTION

Personality can be defined as the organization and interaction of durable internal traits. Personality traits are regarded as being hierarchically arranged, meaning that larger, global traits are presumed to constitute the majority of an individual's personality over lower, specific traits.[1,2] Roy et al examined the relationship between three global personality traits and other super factors or specific traits among one vocally healthy control and four vocal disordered groups. They found distinct personality characteristics within the vocal nodule and functional dysphonia groups.[3,4] Those with a diagnosis of functional dysphonia tended to display traits of neuroticism and introversion, whereas those with vocal nodules, while also characterized as neurotic, scored higher on measures of extraversion, impulsivity, aggression, and social dominance. This profile of extraversion and aggression resulted in low measures of control, leading individuals to talk at greater volumes for prolonged periods of time, therefore elevating vocal fatigue (VF) and increasing the risk for phonotraumatic vocal behaviors. Similar results are discussed in additional publications, including those by Roy et al, Carney et al, Whitling et al, and Yano et al that support these diagnostic profiles.[2,4–7]

VF has been defined as "the perceived measurable symptom that influences vocal task performance and is individual specific; it is a multifaceted concept integrating self-perceived vocal symptoms and/or physiologic deficit, which may be a result of high 'vocal demand response,' high 'vocal effort,' or neuromuscular deficit."[8] Nanjundeswaran et al have attempted to better measure symptoms of trait VF through their development of the Vocal Fatigue Index (VFI), which assesses general vocal tiredness, discomfort during phonation, and vocal improvement after rest.[9,10]

VF is a common symptom reported in those diagnosed with voice disorders and is frequently reported in

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occupational voice users (eg, singers, actors, and politicians), including teachers.[11] Studies have evaluated vocal fatigue in this population and have identified biological sex, vocal load, and lack of recovery time, alongside environmental factors such as acoustics within the classroom as potential risk factors.[12–14] A survey completed in 2004 in the United States found that over 50% of teachers experienced three or more voice symptoms that disrupted their ability to teach.[15] Therefore, vocal health problems additionally have negative economic impacts on teachers as an inability to use their voices to teach may result in a loss of wages, reduction in productivity, and work absenteeism. Teachers may also incur medical costs related to treatment.

The respiratory system is a critical component of speech production. Disordered respiratory function has been found within voice disorders, including vocal nodules.[16,17] Regardless of biological sex, a reduction in respiratory function is detrimental to vocal efficiency and in turn, leads to greater VF. This is especially true for individuals with higher vocal demands such as teachers.[10,12,14] It has been shown that teachers who present with voice disorders utilize smaller lung volumes at the beginning and end of speaking tasks than those without a voice disorder.[18] Respiratory function may also be impacted by average lung volume, which creates a reduction in breathing capacity and an increase in glottal effort during phonation. This hypothesis is supported by Hunter et al who found that symptoms of laryngeal pain and discomfort among teachers were related to test results using a spirometer.[12]

The idea that speech could be representative of an individual's personality was first proposed by Sapir in his work "Speech as a Personality Trait."[19] Since then, research has investigated prosodic and acoustic features that may be indicative of certain personality traits, particularly those within the Big Five Personality Index, including Extraversion, Agreeableness, Conscientiousness, Neuroticism, and Openness. Differences in voice acoustic parameters have also been found among individuals presenting with disordered voices. Research done by Roy et al suggests that patients presenting with vocal nodules tend to possess higher levels of personality traits related to extraversion, including social dominance and impulsivity.[3,4] A review of current literature reveals some trends between personality traits of introversion, neuroticism, and extraversion and acoustic parameters such as jitter, shimmer, average fundamental frequency (fo), vocal intensity, and sound pressure level.[20–23] However, despite this body of research, no significant patterns have emerged linking particular acoustic measurements to each of the personality traits outlined in the Big Five Index.

Considering the literature supporting a link between personality and incidence of voice disorders and the corresponding literature identifying risk factors for voice problems among occupational voice users, the current study aims to investigate how acoustic voice quality measures, pulmonary function measures, and self-reported VF may predict personality traits among teachers.

METHODS

Participants

In total, 73 full-time elementary and middle school teachers (57 self-identified females and 16 self-identified males) completed this study. Participants ranged in age from 22 to 70, with an average of 40 y/o. The demographic description of the participants was 90.41% White (66 individuals), 0.05% Hispanic/Latino (4 individuals), 0.03% American Indian/Alaska Native (2 individuals), and 0.01% Hawaiian/Pacific Islander (1 individual). All participants were recruited from the Jordan School District in Salt Lake City, Utah. All protocols used within the study were approved by the University of Utah Institutional Review Board (IRB_00069893). For the initial round of recruitment, an Institutional Review Board-approved email message was distributed by the administrator of each school, inviting teachers in the school to participate. Interested teachers then contacted the research team directly to determine eligibility. A second round of recruitment was also conducted on the day of on-site data collection, with an email from administrators reminding teachers of the opportunity to participate. Teachers from this group were screened for eligibility and consented on-site. All participants who consented and enrolled completed the protocol. Subjects were excluded if they reported any of the following: a significant history of gastrointestinal disease or surgery that was already being treated; greater than mild reflux requiring medical intervention (as determined by symptoms); speech or voice disorders unrelated to (self-reported or indicated in Voice Handicap Index at screening); reported or known neurological or structural abnormalities of vocal folds unrelated to reflux; previous laryngeal surgeries; cardiac abnormalities; and/or recent history of smoking (no smoking in the past 6 months).

Environment

Data were collected on location at the teachers' assigned schools throughout the district. The research team traveled to the teachers' schools with all equipment and set up in a quiet common location such as a library or empty classroom. This allowed teachers to participate at their convenience as they had time in their teaching schedule. A privacy screen was set up to mitigate the potential impact on participation privacy and confidentiality.

Instruments

Big Five Inventory

The Big Five Inventory (BFI) is a widely accepted framework in psychology to understand human personality. The BFI-10 is an abbreviated, 10-item version of the complete BFI. It employs a Likert scale inventory, with two items corresponding to each of five personality traits. Each item is a statement about how participants engage with the world around them, to which they indicate their agreement or disagreement. The five traits are Openness,

Conscientiousness, Extraversion, Agreeableness, and Neuroticism.

Openness: This trait reflects a person's openness to new experiences, creativity, and willingness to try new things.

Conscientiousness: This trait relates to how organized, responsible, and dependable a person is. It also includes elements of self-discipline and goal-directed behavior.

Extraversion: This trait refers to how outgoing, sociable, and energetic a person is. Individuals high in extraversion tend to seek out social situations and enjoy being around others.

Agreeableness: This trait measures how cooperative, compassionate, and trusting a person is. Individuals high in agreeableness are typically empathetic and considerate of others' feelings.

Neuroticism: Also known as emotional stability, this trait measures the tendency to experience negative emotions such as anxiety, depression, and insecurity. Individuals high in neuroticism may be more prone to stress and emotional instability.

Once the responses are collected, they are scored to determine the individual's level of each trait. There are various methods for scoring the BFI, but one common approach is to calculate the average score for the items related to each trait.

For example, if someone responds to a series of statements assessing extraversion and their responses indicate a high level of extraversion, their average score for extraversion will be higher. Similarly, if their responses indicate low levels of agreeableness, their average score for agreeableness will be lower.

Unlike some psychological assessments that might have clear-cut thresholds for diagnosis or classification, the BFI traits are typically measured on a continuum. There are no universal cutoffs for determining whether someone falls into a specific category of personality trait (eg, highly extraverted, low in conscientiousness). However, researchers and practitioners sometimes use percentile ranks or standard deviations (SD) from the mean to categorize individuals as high, average, or low on each trait. These categorizations can vary depending on the specific assessment tool and the population being studied.

Vocal Fatigue Index and other voice-related questions

The VFI is a self-report questionnaire of perceived trait VF. It consists of 19 questions divided into the following three-factor categories: (Factor 1) tiredness of voice and avoidance of voice use, (Factor 2) physical discomfort, and (Factor 3) improvement of symptoms with rest. In addition to the VFI, participating teachers were also asked to complete a vocal health questionnaire, which included a nominal scale rating of their current voice condition relative to their normal among other questions related to their teaching experience and environment. Factor-3 questions and scores were in an opposite direction for severity compared with the first two factors, leading to a composite score where factor-3 additions were first reversed.

Voice recording

Acoustic recordings of vocal tasks were collected using a head-mounted microphone (Isomax B3, Countryman, Menlo Park, CA) positioned at a 45-degree angle, distal to the airflow, and 6-cm mouth-to-microphone distance. The microphone signal was amplified (FMR Audio, RNP, Austin, TX) before digital conversion (ADInstruments PowerLab, Colorado Springs, CO) and storage. The short mouth-to-microphone distance allowed for a good signal-to-noise ratio given that the environment was not a controlled laboratory, though a quiet environment. Further, acoustic metrics (described below) have been studied for their robustness for use in real-world environments.[24,25]

Pulmonary function assessment

In addition to the questionnaires and voice recording, subjects also completed a pulmonary function (spirometry) test. Spirometry measures were obtained using the Micro Direct MicroLab portable spirometer (Micro Direct, Lewiston, ME). The spirometer was fitted with the manufacturer's disposable filter (SpiroSafe) designed to prevent the spread of airborne pathogens without impeding airflow, allowing for rapid reuse of the spirometer without the need for sanitizing the mouthpiece between subjects.

Procedures

All participants first provided consent to participate. The data collection presented here was part of a larger study of factors influencing vocal health among teachers. Part of that participation included subjects completing the tasks presented here, starting with the BFI-10,[26] the VFI,[27] and some supporting vocal health questions.

Following completion of questionnaires, subjects were fitted with the microphone and asked to perform the following vocal tasks: maximum phonation time on /a/, the rainbow passage in habitual voice (no instruction given), the rainbow passage in simulated classroom voice condition (subjects were instructed to "read as though you are reading to your classroom"), and spontaneous speech production describing a happy day for about 30 seconds.

The forced expiratory spirometry task was conducted according to a standardized procedure.[28] Subjects were asked to inhale to full capacity, place the spirometer mouthpiece in their mouth, and exhale as quickly and forcefully as possible for as long as possible, followed by a relaxed inhalation back to full capacity. A nose clip was fitted to prevent air leakage through the nose. The task was repeated at least three times. If any trial deviated by more than 20% from another trial, it was rejected, and the task was repeated until three trials met the repeatability criterion. From the forced spirometry test, the following measures were collected: forced expiratory volume in the

TABLE 1.
Associated Factors of Extravert Personality Trait

	Univariate Analysis			Multivariate Analysis		
Parameter	B	SE	*P* Value	B	SE	*P* Value
Gender = male	0.277	0.53	0.60			
Age	−0.038	0.02	0.03			
Forced expiratory volume in the first second_base	0.666	0.38	0.08			
Forced expiratory volume in the first second_pred	0.654	0.39	0.09			
Forced vital capacity_base	0.583	0.32	0.07			
Forced vital capacity_pred	0.410	0.30	0.17			
Peak expiratory flow_base	0.147	0.11	0.20			
Peak expiratory flow_pred	0.125	0.16	0.43			
FEV1 and FVC ratio_base	0.070	0.05	0.14			
FEV1 and FVC ratio_pred	0.153	0.09	0.10			
Forced expiratory time	−0.504	0.28	0.08			
Vocal Fatigue Index total*	−0.120	0.03	0.00	−0.054	0.02	0.00
PTP average	0.722	0.61	0.23			
Vowel production	Reference category					
Rainbow passage	0.000	0.00	0.34			
Spontaneous speech	0.000	0.00	0.35			
Comfortable voice	Reference category					
Loud voice	0.000	0.00	0.00			
Vocal fry percentage	0.000	0.00	0.24			
Alpha ratio	0.001	0.00	0.04	0.044	0.04	0.30
CPP	0.000	0.00	0.11			
CPPS	0.000	0.00	0.01			
NHR	−0.012	0.01	0.02			
HNR	0.001	0.00	0.01			
Pitch period entropy	−0.001	0.00	0.12	−0.409	0.38	0.29
Sound pressure levels mean	0.000	0.00	0.08			
Sound pressure levels standard deviation	0.000	0.00	0.16			
Fundamental frequency mean	0.000	0.00	0.17			
Fundamental frequency standard deviation	0.000	0.00	0.17			
Fundamental frequency skewness	0.000	0.00	0.92			
Fundamental frequency kurtosis	0.000	0.00	0.07			

* The level of significance was defined at ≤ 0.05.

first second (FEV1), forced vital capacity (FVC), peak expiratory flow, forced expiratory time (FET), and the ratio of FEV1 to FVC.

Voice acoustic analysis

The acoustic analysis of voice samples utilized *PRAAT* software and a custom MATLAB script (MathWorks, 2013b), following established methods reported in previous studies.[29,30] A review of relevant literature identified 17 acoustic metrics for inclusion as independent variables: alpha ratio, cepstral peak prominence (CPP), smoothed CPP (CPPS), percentage of vocal fry, harmonic-to-noise ratio (HNR), pitch period entropy, noise-to-harmonics ratio (NHR), vocal sound pressure level mean (SPL), SPL SD, fo mean, fo SD, fo skewness, and fo kurtosis. The sensitivity to a range of acoustic environmental factors for these parameters has been studied previously. [24]

Statistical analysis

Descriptive analyses of the dependent variables (BFI personality traits) and independent variables (demographics, acoustics, spirometry, and VFI total score) were performed using *SPSS 24* software. This included calculating frequency values and conducting Kruskal-Wallis tests to evaluate independent variables' differences across the scores of the five BFI personality traits. The association between the independent and dependent variables was then investigated using a Generalized Estimating Equations multinomial logit model. The level of significance was defined at 0.05, and the associations are expressed as betas (B) and standard error (SE).

To determine the effectiveness of the independent associated variables (at the multivariate level) in predicting the BFI traits, we used the receiver operating characteristic (ROC) analysis. ROC analysis is a statistical method used to evaluate the accuracy of a measurement by plotting the trade-off between sensitivity and specificity of a test across different threshold values. Sensitivity is the ability of the test to correctly identify individuals who have the disorder (true positives), while specificity is the ability to correctly identify individuals who do not have the disorder (true negatives). By examining the ROC curve, it is possible to

TABLE 2.
Associated Factors of Agreeableness Personality Trait

	Univariate Analysis			Multivariate Analysis		
Parameter	B	SE	*P* Value	B	SE	*P* Value
Gender = male	0.62	0.53	0.24			
Age	−0.01	0.02	0.78			
Forced expiratory volume in the first second_base	0.51	27.20	0.99			
Forced expiratory volume in the first second_pred	2.12	11.06	0.85			
Forced vital capacity_base	0.45	0.39	0.25			
Forced vital capacity_pred	0.13	3.90	0.97			
Peak expiratory flow_base	0.53	0.67	0.43			
Peak expiratory flow_pred	0.24	6.65	0.97			
FEV1 and FVC ratio_base	−0.01	0.05	0.86			
FEV1 and FVC ratio_pred	−0.12	0.13	0.36			
Forced expiratory time	0.27	0.41	0.50			
Vocal Fatigue Index total*	−0.10	0.02	0.00	−0.10	0.02	0.00
PTP average	0.02	0.38	0.95			
Vowel production	Reference category					
Rainbow passage	0.00	0.00	0.32			
Spontaneous speech	0.00	0.00	0.33			
Comfortable voice	Reference category			Reference category		
Loud voice	0.00	0.00	0.00	0.00	0.01	0.80
Vocal fry percentage	0.00	0.00	0.67			
Alpha ratio	0.00	0.00	0.33			
CPP	0.00	0.00	0.97			
CPPS	0.00	0.00	0.93			
NHR	0.01	0.01	0.46			
HNR	0.00	0.00	0.99			
Pitch period entropy	0.00	0.00	0.74			
Sound pressure levels mean	0.00	0.00	0.76			
Sound pressure levels standard deviation	0.00	0.00	0.51			
Fundamental frequency mean	0.00	0.00	0.68			
Fundamental frequency standard deviation	0.00	0.00	0.56			
Fundamental frequency skewness	0.00	0.00	0.81			
Fundamental frequency kurtosis	0.00	0.00	0.12	0.01	0.04	0.75

* The level of significance was defined at ≤ 0.05.

see how sensitivity and specificity change as we vary the threshold for defining a positive test result. The curve helps to identify the optimal threshold that balances sensitivity and specificity, maximizing the accuracy of the test.

RESULTS

Voice-Related Factors of Personality Traits

Table 1 shows the associated factors of extravert personality traits. As shown in the table, at the multivariate level, the total score of the VFI was statistically associated with a lower score on the extravert scale of the BFI-10 (B = −0.054).

Table 2 shows that similar to the extravert personality trait, the higher total score of the VFI was associated with a lower score on agreeableness. These results suggest that teachers with higher perceptions of VF rated aspects related to cooperation and reliance less often.

Table 3 shows the associations between conscientiousness and the independent variables. The analysis suggests that longer FET was associated, at the multivariate level, with teachers considering themselves organized, responsible, and dependable persons less often.

Table 4 shows the associated factors of Neuroticism. As shown in the table, at the multivariate level, CPP was statistically associated with a lower tendency to experience negative emotions such as anxiety, depression, and insecurity. On the contrary, higher values of the alpha ratio were statistically associated with teachers being more prone to stress and emotional instability.

Table 5 shows the associated factors of Openness. As seen in the table, male teachers were more likely to be open to new experiences, creativity, and willingness to try new things. On the contrary, higher values of FET were associated with lower openness.

Predictive Value of Voice-Related Factors of Personality Traits

Table 6 displays the Areas Under the Curve (AUC) of associated factors for BFI traits. The results suggest that the highest AUC (predictive value) was observed for VFI with extraversion. Teachers with a VFI total higher than

TABLE 3.
Associated Factors of Conscientiousness Personality Trait

	Univariate Analysis			Multivariate Analysis		
Parameter	B	SE	*P* Value	B	SE	*P* Value
Gender = Male	−1.39	0.57	0.02	−0.74	0.64	0.25
Age	−0.02	0.02	0.39			
Forced expiratory volume in the first second_base	−0.17	0.33	0.61			
Forced expiratory volume in the first second_pred	−0.16	0.32	0.62			
Forced vital capacity_base	−0.24	0.27	0.38			
Forced vital capacity_pred	−0.15	0.27	0.59			
Peak expiratory flow_base	−0.20	0.15	0.16			
Peak expiratory flow_pred	−0.12	0.15	0.44			
FEV1 and FVC ratio_base	0.11	0.05	0.02			
FEV1 and FVC ratio_pred	0.02	0.09	0.82			
Forced expiratory time*	−1.22	0.29	0.00	−1.10	0.26	0.00
Vocal Fatigue Index total	0.01	0.02	0.80			
PTP average	0.26	0.45	0.56			
Vowel production	Reference category					
Rainbow passage	0.00	0.00	0.31			
Spontaneous speech	0.00	0.00	0.32			
Comfortable voice	Reference category					
Loud voice	0.00	0.00	0.00			
Vocal fry percentage	0.00	0.00	0.33			
Alpha ratio	0.20	2.08	0.92			
CPP	0.00	0.00	0.49			
CPPS	0.00	0.00	0.60			
NHR	0.00	0.01	0.95			
HNR	0.00	0.00	0.45			
Pitch period entropy	0.00	0.00	0.31			
Sound pressure levels mean	0.00	0.00	0.74			
Sound pressure levels standard deviation	0.00	0.00	0.69			
Fundamental frequency mean	0.00	0.00	0.03			
Fundamental frequency standard deviation	0.00	0.00	0.13			
Fundamental frequency skewness	0.00	0.00	0.84			
Fundamental frequency kurtosis	−0.20	0.99	0.84			

* The level of significance was defined at ≤ 0.05.

17.50 were less likely to be identified as extraverts (the cutoff for this trait was 4.5). Additionally, with a sensitivity of 0.80 and a specificity of 0.82, 80% of the extraverts and 82% of the nonextraverts would be correctly identified.

For Agreeableness and VFI Total, the AUC was calculated to be 0.68. The determined cutoff point was 17.50. With a sensitivity of 0.73 and a specificity of 0.67, the predictive value of VFI Total with Agreeableness suggests that individuals with VFI Total scores above the identified cutoff point were less likely to exhibit high levels of Agreeableness. Specifically, 73% of individuals with high Agreeableness scores would be correctly identified, while 67% of individuals with low Agreeableness scores would be accurately classified.

Regarding Conscientiousness and FET, the AUC was calculated to be 0.68. The identified cutoff point for FET was 2.45. With a sensitivity of 0.69 and a specificity of 0.63, the predictive value of FET about Conscientiousness indicates that individuals scoring above the cutoff point were less likely to demonstrate high levels of Conscientiousness. Specifically, 69% of individuals with high Conscientiousness scores would be correctly identified, while 63% of individuals with low Conscientiousness scores would be accurately classified.

For Neuroticism and alpha ratio, the AUC was calculated to be 0.59. The determined cutoff point for the alpha ratio was −20.80. With a sensitivity of 0.60 and a specificity of 0.57, the predictive value of alpha ratio in relation to Neuroticism suggests that individuals with alpha ratio scores above the identified cutoff point were more likely to exhibit high levels of Neuroticism. Specifically, 60% of individuals with high Neuroticism scores would be correctly identified, while 57% of individuals with low Neuroticism scores would be accurately classified.

Regarding Openness and FET, the AUC was calculated to be 0.64. The identified cutoff point for FET was 2.55. With a sensitivity of 0.58 and a specificity of 0.63, the predictive value of FET with Openness suggests that individuals scoring above the cutoff point were less likely to demonstrate high levels of Openness. Specifically, 58% of individuals with high Openness scores would be correctly identified, while 63% of individuals with low Openness scores would be accurately classified.

TABLE 4.
Associated Factors of Neuroticism Personality Trait

	Univariate Analysis			Multivariate Analysis		
Parameter	B	SE	*P* Value	B	SE	*P* Value
Forced expiratory volume in the first second_base	−0.98	0.36	0.01			
Forced expiratory volume in the first second_pred	2.82	6.00	0.64			
Forced vital capacity_base	0.31	0.85	0.72			
Forced vital capacity_pred	−1.69	0.69	0.01	−0.37	0.36	0.29
Peak expiratory flow_base	−0.04	0.23	0.87			
Peak expiratory flow_pred	−0.90	0.50	0.07			
FEV1 and FVC ratio_pred	0.04	0.08	0.62			
Forced expiratory time	−0.33	0.35	0.34			
Vocal Fatigue Index total	0.13	0.16	0.43			
PTP average	0.08	0.51	0.87			
Vowel production	Reference category					
Rainbow passage	−0.01	0.01	0.35			
Spontaneous speech	0.02	0.02	0.36			
Comfortable voice	Reference category			Reference category		
Loud voice*	0.00	0.00	0.00	−0.91	0.35	0.01
Vocal fry perception	−0.02	0.03	0.52			
Alpha ratio*	0.29	0.14	0.04	0.35	0.12	0.00
CPP*	0.13	0.06	0.04	−0.22	0.09	0.01
CPSS	−0.08	0.05	0.14			
NHR	−2.15	1.91	0.26			
HNR	−4.59	894.82	1.00			
Pitch period entropy	−0.29	0.41	0.48			
Sound pressure levels standard deviation	−0.04	0.06	0.56			
Fundamental frequency mean	0.01	0.00	0.00			
Fundamental frequency standard deviation	0.00	0.00	0.33			
Fundamental frequency skewness	0.16	0.08	0.05			
Fundamental frequency kurtosis	−0.29	80.29	1.00			

* The level of significance was defined at ≤ 0.05.

DISCUSSION

With a robust assessment of acoustic voice quality, pulmonary function, and self-assessed VF, each of the five personality traits measured by the BFI-10 was predicted, with sensitivities ranging from 57% to 82%, by at least one measure of the subject's vocal quality or function. The predictive relationships sometimes correspond to and build upon current understandings of personality and voice disorders. In contrast, other relationships are contradictory or may expose a potential bias in certain metrics.

Extraversion was the personality trait that was most reliably predicted from our measured variables. Participants who reported experiencing strong symptoms of VF were significantly less likely to identify as extraverted. Extraversion is a personality dimension that implies an "energetic approach to the social and material world."[26] When considered with respect to earlier findings of Roy et al, these results support a predisposition of extraverted participants to being less attuned to symptoms of VF, perhaps leading to increased talkativeness and, ultimately, increased likelihood of developing vocal fold nodules.[2] Meanwhile, introverts appear more likely to report symptoms of fatigue, and the VFI was validated to be sensitive to the presence or absence of functional dysphonia.[27] Again, this relationship supports the findings of Roy et al that indicated introverts are more likely to experience functional dysphonia.[2]

Similarly, total VFI scores reliably predicted a subject's Agreeableness 73% of the time, with higher total VFI scores associated with a decreased likelihood of high scores in the Agreeable dimension. Agreeableness, as a personality dimension, includes traits such as altruism, trust, and modesty.[26] One interpretation of this relationship is that these traits predispose individuals to minimize their experiences of problems in self-reports such as the VFI. Alternatively, highly agreeable individuals may be less bothered by symptoms of VF than those who identify as less agreeable.

Conscientiousness, identified with traits such as organization, responsibility, and dependability, was predicted by larger values in FET. The forced expiratory spirometry task is an unusual task, requiring subjects to exhale as quickly and forcefully as possible and then extend their exhalation until they feel they have completely exhausted their lungs' vital capacity. The relationship between longer FET and increased scores in conscientiousness hints at these subjects' willingness to "dependably" follow instructions, even on a challenging or uncomfortable task. A

TABLE 5.
Associated Factors of Openness Personality Trait

	Univariate Analysis			Multivariate Analysis		
Parameter	B	SE	*P* Value	B	SE	*P* Value
Gender = male*	0.84	0.47	0.07	1.79	0.69	0.01
Age	−0.01	0.01	0.52			
Forced expiratory volume in the first second_pred	0.74	0.58	0.20			
Forced vital capacity_pred	0.54	0.43	0.21			
Peak expiratory flow_pred	0.30	0.24	0.22			
FEV1 and FVC ratio_base	0.07	0.06	0.31			
FEV1 and FVC ratio_pred	0.05	0.09	0.60			
Forced expiratory time*	−0.58	0.29	0.04	−0.90	0.37	0.02
Vocal Fatigue Index total	0.01	0.02	0.78			
PTP average	−0.16	0.34	0.63			
Vocal fry percentage	0.00	0.00	0.82			
Alpha ratio	0.00	0.00	0.42			
CPP	0.00	0.00	0.37			
CPPS	0.00	0.00	0.21			
NHR	0.00	0.00	0.82			
HNR	0.00	0.00	0.64			
Pitch period entropy	0.00	0.00	0.52			
Sound pressure levels mean	0.00	0.00	0.88			
Sound pressure levels standard deviation	0.00	0.00	0.92			
Fundamental frequency mean	0.00	0.00	0.28			
Fundamental frequency standard deviation	0.00	0.00	0.61			
Fundamental frequency skewness	0.00	0.00	0.33			
Fundamental frequency kurtosis	0.00	0.00	0.54			

* The level of significance was defined at ≤ 0.05.

patient's level of conscientiousness, then, could have an impact on their ability or willingness to complete any number of voice diagnostic tasks when seeking voice care.

FET was also predictive of the Openness dimension, with longer FET times predicting low openness values 63% of the time. High levels of openness are associated with traits such as creativity, and willingness to try new things. Given the novelty to most teachers of the spirometry task, as mentioned earlier, this relationship is somewhat contradictory. It may be expected that more open personality types would be more willing to experiment with their expiratory time in a task they have never tried before. However, openness is also associated with traits such as impulsivity and impracticality, which may make it difficult to follow very specific instructions.[31] Pulmonary function literature provides evidence that external factors such as experience with the spirometry tests and anthropometric factors (age and body mass index), but the authors have not found literature investigating any link between FET and personality.[32,33] It is not clear from this dataset how or if this personality dimension may impact an individual's voice quality or their experience of VF.

Two acoustic perturbation measures showed significant associations with the personality dimension of Neuroticism. High scores on the Neuroticism scale are indicative of traits such as anxiety, depression, insecurity, and emotional instability. CPP and alpha ratio had opposite correlations with Neuroticism scores, but only the alpha ratio had a predictive sensitivity any greater than chance. Subjects with high alpha ratio scores could accurately predict high levels of neuroticism 60% of the time. The mechanism governing this weak predictive relationship remains unclear.

TABLE 6.
Areas Under the Curve of Associated Factors for BIF Traits

BIF Trait	Predictor	AUC	SE	Cutoff	Sensitivity	Specificity
Extravert	VFI total	0.86	0.01	17.50	0.80	0.82
Agreeableness	VFI total	0.68	0.03	17.50	0.73	0.67
Conscientiousness	FET	0.68	0.02	2.45	0.69	0.63
Neuroticism	Alpha ratio	0.59	0.02	−20.80	0.60	0.57
Openness	FET	0.64	0.02	2.55	0.58	0.63

CONCLUSION

The results of this study provide a view of the complexity of associations between the human psychological condition and how subjects use and experience their voice. Using a relatively large sample of occupational voice users (teachers) who were not targeted because of their voice condition (ie, subjects were not seeking help with their voice, nor were they self-selecting as exceptional voice users) provides a valuable dataset that represents a unique cross section of the teacher population. This dataset indicates that individuals with a strong indicator of extraversion are less likely to report symptoms of VF. Combining an increased likelihood of talkativeness with a decreased awareness of symptoms of fatigue may help explain the incidence of certain types of vocal fold lesions in this population. [4,34]

This study also indicated relationships between reports of current voice condition, several acoustic features, and measures of pulmonary function. These associations warrant further investigation, particularly concerning how and to what degree self-report measures are used in clinical voice assessments where psychological traits are not considered in tandem with these measures. While it is possible that a connection exists between personality dimensions and the occurrence of VF, it is also possible that personality dimensions, innate to these participants, are instead influencing how they experience and report symptoms of VF. In either case, extending this research to a larger cross-sectional sample of voice users and using a more robust personality index, such as the full 44-item BFI, is warranted. These results support the previous study's conclusion as well as add additional insights that could be translated into screening protocols and additional supportive care of occupational voice users.

Declaration of Competing Interest

The authors declare the following financial interests/personal relationships that may be considered as potential competing interests: Eric Hunter reports financial support was provided by National Institute on Deafness and Other Communication Disorders. The other authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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