Enhancing Mental and Cognitive Fitness Monitoring via Vocal Biomarkers: Applications for Military Personnel

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Motivation: Develop vocal biomarkers of mental and cognitive status

Maintaining the mental and cognitive fitness of military personnel is critical to ensuring peak operational readiness. Traditional methods like self-reported questionnaires and clinical interviews are often hindered by subjectivity, time constraints, and the stigma surrounding mental health. Vocal biomarkers offer a breakthrough, enabling an unobtrusive, secure, and real-time assessment of mental and cognitive states using readily available smart devices.

Our research validates the effectiveness of vocal biomarkers in remotely monitoring mental and cognitive shifts, including those associated with depression, anxiety, PTSD, and cognitive impairment, as well as real-time cognitive effort. This technology, deployable across consumer electronics and wearables without the need for network connections or recording retention, aligns with the stringent data security requirements of military operations. By providing an immediate, objective measure of mental fitness, these biomarkers are poised to enhance the resilience, readiness, and overall performance of military personnel, enabling earlier intervention and better outcomes in the field.

Eight vocal features (below), identified through literature review[1], are measured and combined in different ways to produce **Mental Fitness** and **Cognitive Fitness** scores (range 0-100). These scores, categorized as Excellent (80-100), Good (70-79), or Pay Attention (0-69), are grounded in population statistics and correlate with clinical assessments, making them a viable tool for maintaining force readiness.

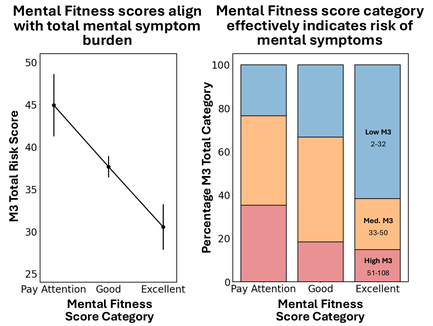
Feature Name	Feature Description
Jitter	Variation in the time between consecutive pitch periods
Shimmer	Variation in the amplitude of consecutive pitch periods
Pitch variability	Intentional variation in voice pitch used for intonation
Energy variability	Intentional variation in energy (intensity) of voice used for emphasis
Vowel space area	Separation between frequencies of the first two formants
Phonation duration	Average duration of glottal vibrations
Speech rate	Number of words spoken per minute
Pause duration	Median duration of gaps in voice activity

Mental Fitness scores identify individuals at higher risk for elevated mental health symptoms[2]

Enrolled 104 adults (73% F/23% M/4% other), age range 16 – 80) who were active therapy patients with a mental health diagnosis. Participants used a smartphone app at home to receive daily Mental Fitness vocal biomarker scores during a 4-week period while creating voice journals in the app.

Mental health symptom burden was assessed using the M3 Checklist[3] at the beginning and end of the 4-week study. The M3 provides an overall mental health severity score and subscores for depression, anxiety, PTSD, and bipolar disorder.

The **risk ratio** of reporting medium-to-high mental symptom burden for users in the "pay attention" score range (<70) is 1.98 relative to users in the "excellent" score range (≥80).

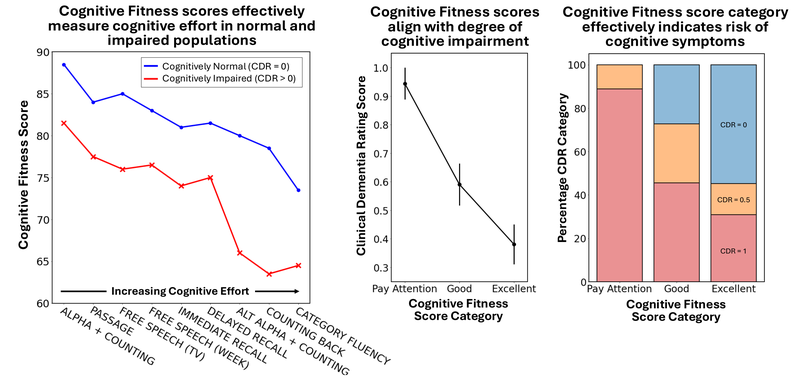


Cognitive Fitness scores identify individuals at higher risk for cognitive symptoms

Enrolled 48 adults (52% F/48% M, age range 54 – 84), both with cognitive impairments and age-matched cognitively normal volunteers from a frontotemporal disorders clinic. Participants used a smartphone app at home to generate Cognitive Fitness vocal biomarker scores over 4 weeks in response to voice tasks of varying cognitive difficulty.

Cognitive status was assessed clinically with the Clinical Dementia Rating (CDR) scale[4]. Participant **feedback** on app usability and benefits was gathered at the study's end.

The **risk ratio** of being assessed with very mild or mild dementia for users in the "pay attention" score range (<70) is 2.21 relative to users in the "excellent" score range (≥80), using the free speech voice tasks only.



		Relative Risk of medium-high **symptoms** vs population		
Risk Category	**Biomarker**	**Excellent**	**Good**	**Pay Attention**
Overall Mental Health	Mental	0.62	1.07	1.23
Depression	Mental	0.64	1.01	1.67
Anxiety	Mental	0.79	0.98	1.58
PTSD	Mental	0.59	1.05	1.42
Cognitive Impairment	Cognitive	0.73	1.17	1.54

User feedback and engagement is encouraging

Engagement and satisfaction with **Mental Fitness** was high**:**

- Participants averaged 3.2 uses/week over 4 weeks
- 70% of participants were still active in week 4
- 40% of participants reported making changes in behavior or lifestyle; 30% reported benefits to their wellbeing

Study feedback (% somewhat or completely agree):

Like seeing scores	Understand the scores	Scores were helpful	Want to keep using the app
81%	73%	67%	72%

Outcome: Vocal biomarkers as a new tool to improve force readiness and resilience

Our research confirms that a specific set of acoustic and prosodic vocal features can reliably assess mental and cognitive fitness in civilian operational settings. This method enables continuous, unobtrusive monitoring, delivering critical, real-time insights into an individual's mental state. High user acceptance, combined with robust security and ease of use, highlights the viability of this technology for Department of Defense applications.

Vocal biomarker analysis provides a scalable, cost-effective solution for monitoring mental and cognitive health, seamlessly integrating with existing physiological and activity data. This integration enhances the capabilities of warfighter resilience programs by extending readiness assessment from physical to mental domains. By embedding this technology into current systems, commanders can gain objective, real-time insights that support proactive training, mission preparation, and mental health management. These contributions are vital to ensuring a more resilient and mission-ready force.

Future Direction: Under a Phase II SBIR contract through AFWERX, we are advancing the Mental Fitness technology specifically for military use. This phase will focus on integrating and evaluating the tool within USAF mental health and resilience programs to validate its effectiveness and scalability across the DoD.

"It became like an old, reliable friend who called to check up on me every day."

References

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