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Joint Federal Research Funding for Military Personnel and Veterans

Project Report Summary Template

Funding Opportunity
Human Mental States in Military Personnel to Detect Bias in Human-Autonomy Teaming
Brief Overview
This project examined how bias related to biological sex, age, and other Gender-Based Analysis Plus (GBA Plus) variables may affect the measurement of mental states in human-autonomy teaming systems. Researchers conducted a literature review, evaluated demographic bias in physiology-based mental workload models, developed bias mitigation strategies, and designed a research protocol to support more equitable human-AI teaming research in military settings.
What is this Research About? As artificial intelligence becomes increasingly integrated into military operations, systems are being developed that adapt to human cognitive states such as mental workload and trust. Many of these systems rely on physiological signals, including electroencephalography (EEG), heart activity, and other wearable sensor data. However, physiological and behavioral differences associated with sex, age, and cultural background may unintentionally introduce bias into machine learning models. This project explored how these biases arise and how they can be reduced to support fair, reliable, and inclusive human-autonomy teaming systems.
What did the Research Do? Researchers completed three key activities: 1. Literature Survey: Conducted a comprehensive review of human-autonomy teaming studies using physiological data to assess the extent to which biological sex, age, and other GBA Plus variables were considered during study design and model development. [Final Deli...my teaming | PDF] 2. Bias Quantification and Mitigation: Evaluated demographic bias in EEG-based mental workload detection models by assessing performance differences across demographic groups and applying fairness metrics. Researchers also evaluated a domain-adversarial deep learning approach designed to reduce the influence of demographic information on model predictions. [Final Deli...my teaming | PDF] 3. Research Protocol Development: Developed a detailed ethics and research protocol for a future human-AI teaming experiment incorporating GBA Plus considerations throughout participant recruitment, data collection, and analysis. The proposed study would examine mental workload and trust while participants collaborate with an AI teammate in a dynamic simulation environment

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What did the Research Find?

The project found that physiological differences linked to biological sex and age are well documented but are rarely considered when developing or validating cognitive-state detection models. As a result, these models may unintentionally perform differently across demographic groups.

Key findings included:

- Human-autonomy teaming studies frequently fail to report or analyze demographic factors despite evidence that physiological and behavioural differences exist across sex and age groups.
- EEG signals contain demographic information that can "leak" into mental workload detection models, potentially creating systematic bias.
- Domain-adversarial training reduced biological sex-related disparities in model outcomes, improving fairness metrics from an odds ratio of 0.83 to 0.90.
- Reducing demographic bias resulted in a trade-off, lowering overall workload classification performance by approximately 12.7%, highlighting the challenge of balancing fairness, privacy, and predictive accuracy.
- Existing gaps in the literature support the need for future studies that deliberately incorporate GBA Plus considerations into participant recruitment, experimental design, and model evaluation.

What does this Research Mean?

The findings demonstrate that demographic bias is an important consideration in the development of cognitive-state detection systems designed for military human-autonomy teaming. Accounting for GBA Plus variables during research, data collection, and model development can help ensure that future AI-enabled systems perform equitably across diverse populations. The proposed research protocol provides a foundation for collecting representative datasets and developing fairer cognitive models that support trust, workload management, and effective human-AI collaboration in military and other high-stakes operational environments.

Sources

Abhishek Tiwari, Robert Arrabito, Alan Davoust, and Tiago Falk. Final Deliverables - RF-0027-Human mental states in military personnel to detect bias in human-autonomy teaming. Funded through the Joint Federal Research Funding Program for Military Personnel and Veterans.

Associated Outputs:

- *Bias in Physiology-Based Cognitive State Detection for Human–Autonomy Teaming: A Survey* accepted for presentation at the 2026 International Conference on Human-Computer Interaction, Montréal.
- *Quantifying Biological Sex Leakage in Electroencephalography-Based Mental Workload Measurement and its Impact on Model Performance* accepted for presentation at the 2026 IEEE International Conference on Human-Machine Systems, Singapore.

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