Fiscal Year:	FY 2022	**Task Last Updated:**	FY 01/19/2023
PI Name:	Gao, Wei Ph.D.		
Project Title:	A Multimodal Wearable System for Deep Space Monitoring of Stress and Anxiety		
Division Name:	Human Research		
Program/Discipline:			
Program/Discipline--Element/Subdiscipline:	TRISH--TRISH		
Joint Agency Name:		**TechPort:**	Yes
Human Research Program Elements:	None		
Human Research Program Risks:	None		
Space Biology Element:	None		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
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Comments:			
Project Type:	GROUND	**Solicitation / Funding Source:**	2020 TRISH BRASH1901: Translational Research Institute for Space Health (TRISH) Biomedical Research Advances for Space Health
Start Date:	04/01/2020	**End Date:**	03/31/2022
No. of Post Docs:	1	**No. of PhD Degrees:**	0
No. of PhD Candidates:	2	**No. of Master' Degrees:**	0
No. of Master's Candidates:	0	**No. of Bachelor's Degrees:**	0
No. of Bachelor's Candidates:	0	**Monitoring Center:**	TRISH
Contact Monitor:		**Contact Phone:**	
Contact Email:			
Flight Program:			
Flight Assignment:			
Key Personnel Changes/Previous PI:			
COI Name (Institution):	Yue, Yisong Ph.D. (California Institute of Technology)		
Grant/Contract No.:	NNX16AO69A-T0501		
Performance Goal No.:			
Performance Goal Text:			

Task Description:	The goal of this project is to develop a holistic hardware/software solution based on a multimodal wearable sensing platform to achieve dynamic deep space stress and anxiety assessment. Sweat could serve as an excellent candidate for non-invasive stress response monitoring as it contains rich physiological information. The hypothesis is that sweat analyte levels monitored continuously along with the key vital signs, when coupled with machine learning approach, will provide accurate and dynamic stress and anxiety assessment. The approach is to simultaneously monitor the molecular analytes in human sweat including stress hormones (i.e., cortisol, adrenaline, and noradrenaline), glucose, lactate, sodium, potassium, pH, sweat rate, and key vital signs (i.e., skin temperature, blood pressure, heart rate, and heart rate viability) using the wearable multimodal sensing platform. Based on a combination of the physical/molecular data and machine learning model, a more comprehensive stress assessment system with significantly higher accuracy and robustness can be achieved.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	High levels of anxiety and stress due to the extreme working environment, significantly affect the performance abilities of NASA astronauts to perform the mission. A dynamic stress-detection system would be extremely useful for the self-management of mental as well as physical health. Early detection and classification of the severity of stress followed by timely intervention are crucial factors in improving human performance. Current approaches for stress assessment are largely limited to questionnaire-based scales which can be very subjective and cumbersome to implement in the space. The data collected from our wearable devices could potentially revolutionize traditional health monitoring practices and to empower investigations of non-invasive dynamic stress assessment. Our approach will also enable numerous fundamental investigations on chronic health conditions such as depression. We envision that this technology, along with longitudinal and cross-sectional cohort studies, will significantly benefit the understanding of the health needs of individuals and society as a whole during the COVID-19 pandemic.
Task Progress:	The original goal of this project is to develop a holistic hardware/software solution based on a multimodal wearable sensing platform to achieve dynamic deep space stress and anxiety assessment. Sweat could serve as an excellent candidate for non-invasive stress response monitoring as it contains rich physiological information. The hypothesis is that sweat analyte levels monitored continuously along with the key vital signs, when coupled with machine learning approaches, will provide accurate and dynamic stress and anxiety assessment. During Year 2, we successfully optimized all individual sensors with high stability and accuracy (including glucose, lactate, Na, K, pH, blood pulse wave, temperature, and galvanic skin response (GSR)) for continuous monitoring. With materials and chemistry innovation, we have made major progress to improve the long-term stability of our wearable chemical sensors (most of these sensors now have stable performance during multiple-day in vitro operation). We also integrated all the sensors into a multimodal flexible sensor system. A miniaturized iontophoresis module was also integrated into the system that allows stable localized sweat extraction across activities. The entire sensor patch can be prepared with inkjet printing at a large scale and low cost. This multimodal system was validated in human trials against gold standards. We simultaneously monitored the molecular analytes in human sweat including glucose, lactate, uric acid, sodium, potassium, pH, and key vital signs (i.e., skin temperature, pulse wave, GSR) using this wearable multimodal sensing platform. The substantial changes in all sensor responses were observed under physiological and psychological stressors. We also performed machine learning-based data analysis to classify the stress levels based on the data collected. Based on a combination of the physical/molecular data and machine learning model, we have obtained a comprehensive stress assessment system with high accuracy and robustness.
Bibliography Type:	Description: (Last Updated: 07/11/2023)
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Articles in Peer-reviewed Journals	Sempionatto JR, Lasalde-Ramírez JA, Mahato K, Wang J, Gao W. "Wearable chemical sensors for biomarker discovery in the omics era." Nat Rev Chem. 2022 Nov 15;1-17. Review. https://doi.org/10.1038/s41570-022-00439-w ; PMID: 37117704; PMCID: PMC9666953 , Nov-2022
Awards	Gao W. "International Academy of Medical and Biological Engineering (IAMBE) Early Career Award, March 2022." Mar-2022
Awards	Gao W. "National Science Foundation (NSF) Career Award, May 2022." May-2022
Awards	Gao W. "Office of Naval Research (ONR) Young Investigator Award, May 2021." May-2021
Awards	Gao W. "Pittsburgh Conference Achievement Award, March 2022." Mar-2022
Awards	Gao W. "US Frontiers of Engineering Symposium (USFOE), National Academy of Engineering, November 2021." Nov-2021