Fiscal Year:	FY 2022	**Task Last Updated:**	FY 02/14/2022
PI Name:	Fanchiang, Christine Ph.D.		
Project Title:	HCAAM VNSCOR: Using a Human Capabilities Framework to Quantify Crew Task Performance in Human-Robotic Systems		
Division Name:	Human Research		
Program/Discipline:			
Program/Discipline--Element/Subdiscipline:			
Joint Agency Name:		**TechPort:**	No
Human Research Program Elements:	(1) **HFBP**:Human Factors & Behavioral Performance (IRP Rev H)		
Human Research Program Risks:	(1) **HSIA**:Risk of Adverse Outcomes Due to Inadequate Human Systems Integration Architecture		
Space Biology Element:	None		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
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City:	Centennial	**State:**	CO
Zip Code:	80122-1801	**Congressional District:**	6
Comments:			
Project Type:	GROUND	**Solicitation / Funding Source:**	2017-2018 HERO 80JSC017N0001-BPBA Topics in Biological, Physiological, and Behavioral Adaptations to Spaceflight. Appendix C
Start Date:	04/15/2019	**End Date:**	04/14/2023
No. of Post Docs:	1	**No. of PhD Degrees:**	
No. of PhD Candidates:	1	**No. of Master' Degrees:**	
No. of Master's Candidates:	1	**No. of Bachelor's Degrees:**	
No. of Bachelor's Candidates:		**Monitoring Center:**	NASA JSC
Contact Monitor:	Whitmire, Alexandra	**Contact Phone:**	
Contact Email:	alexandra.m.whitmire@nasa.gov		
Flight Program:			
Flight Assignment:	NOTE: Start date changed to 4/15/2019 per NSSC information (Ed., 5/18/21) NOTE: End date changed to 4/14/2023 per NSSC information (Ed., 1/22/2020)		
Key Personnel Changes/Previous PI:	March 2020 report: Change to PhD graduate student for upcoming semester. August 2021 report: Added a MS graduate student for the 2021-2022 academic year to help deploy subject testing July 2021 report: Added a Postdoc (volunteer) to help with data analysis		
COI Name (Institution):	Klaus, David Ph.D. (University of Colorado, Boulder) Shelhamer, Mark Sc.D. (Johns Hopkins University)		
Grant/Contract No.:	80NSSC19K0655		
Performance Goal No.:			
Performance Goal Text:			

Task Description:	This task is part of the Human Capabilities Assessments for Autonomous Missions (HCAAM) Virtual NASA Specialized Center of Research (VNSCOR). Effective space exploration will require proper task coordination between humans and robotic systems. These systems can be characterized in a variety of ways, from level of autonomy to the number of functions provided. At the most basic level a robotic system can be considered a hand tool while something more complex could be a humanoid companion. To ensure the robotic system is effective, the crew must trust that the system performs its intended function(s), or retain enough Situation Awareness (SA) and capability to find another way to execute the required task. Currently, there are no comprehensive standards for measuring, monitoring, and evaluating task performance with regard to crewmember capabilities, the design of the task, and the dynamic spacecraft environment. This work seeks to address this missing performance infrastructure by providing a conceptual framework for measuring task design quality and developing a path for validation using a task performance metric through experimentation both in university labs and using NASA's analog missions.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	Leveraging wearable technologies for monitoring human health and performance is beneficial for a range of people here on Earth whether it is for elite athletes to rehabilitation patients in the hospital. Currently, there are limitations to the use and integration of data from various wearable sensors. The work done for this project will help to provide some guidance regarding wearable data integration and effectiveness of the data for predicting performance degradation. The ability to predict changes in performance can be useful for a number of scenarios here on Earth.
Task Progress:	The objective of this investigation is to provide a method for validating a previously defined Capabilities Framework, which describes the relationship between human capabilities and performance. The approach is to have human subjects perform representative spaceflight-like task scenarios while being monitored by a suite of non-invasive biometric measures. The data collected will be analyzed to determine whether these non-invasive biometric measures can be used as proxy indicators to performance changes. The work performed this year was adjusted to fit the extenuating circumstances of a global pandemic in which our subject testing was relocated to the subjects' residences. The major effort of this grant year comprised of two main phases: 1) running our at-home test protocol with 13 participants and post processing and analysis of the data to prepare for our next round of testing which we call Block 2. In addition, this grant year we supported NASA's Human Exploration Research Analog (HERA) Campaign #6 Mission #1 and are helping with the start of Mission #2. In response to the ongoing coronavirus national crisis, steps were taken to ensure that testing could proceed without introducing any added risk of COVID-19 contraction among test participants or the test operator(s). In order to implement this mitigation strategy, several updates to the original proposal research approach were required. The primary change was moving the testing to an At-Home protocol consisting of step-by-step instructions for the test participant and the development of a mobile/portable testing system that includes a stationary bike set-up with a tablet with pre-loaded instructional software with specific testing instructions. The majority of this year's accomplishments revolved around the deployment of the At-Home test protocol and data collection and analysis. Thirteen test participants (age 23.77 ± 4.11 years; six female), conducted between eight and ten days of testing each, depending on availability. The participants were mostly undergraduate or graduate aerospace engineering students, and all had backgrounds in science/technology/engineering/mathematics (STEM). Our test protocol had the test subject perform two main tasks interspersed with questionnaires and rests in between. The first task is slow biking on a stationary bike while performing a set of 50 arithmetic multiple choice problems. Then, after a five minute rest, they perform a two minute warmup on the bicycle to get up to an 85-90 RPM pace, and then begin the second task, which is to maintain the fast biking pace while simultaneously answering the same set of 50 randomized arithmetic problems. While there are many approaches to analyzing this data to identify predictors for performance on the two main tasks, for now we are starting with the most basic analysis using characteristic statistics for each biomeasure signal, where we represent the signal as means, medians, slope, and standard deviation values for each subject over each test day. We use these aggregated values to compare against the performance outcomes and determine if there are any correlations. We found that there was no single biomeasure statistic that could reliably predict performance for either of the main tasks, but this could be for a number of reasons. Potentially our hardware has limited resolution and cannot adequately capture small effect sizes for some of the more delicate measures, such as blood oxygenation in the prefrontal cortex. Or it is possible that the tasks we selected do not adequately challenge the subjects, so we lack a range of performance outcomes to compare against. Or we may not have the appropriate biomeasure characteristics; for example, using the average electrodermal activity (EDA) over a specific timeframe may not be as relevant as the measure of latency of the EDA response to stressors. From this testing we are working towards defining a second test protocol to address these confounding factors more clearly, as well as revisiting our framework and restructuring it based on our findings. Additional data analysis is still underway with this first test block. We structured our testing into three blocks that coincide with increasing operational fidelity. We finished Block 1 testing, and are now moving into our Block 2 testing and using our findings from Block 1 to address many of the confounding factors we discovered. Additionally, our results from Block 1 suggests it will be important to have a separate validation test of the biosignalsplux functional near-infrared spectroscopy (fNIRS) hardware with a higher fidelity sensor, as it is one of our more intricate hardware systems. Our Block 3 test would be done in a space habitat mock-up developed at the University of Colorado and be more representative of spaceflight. Meanwhile, we are participating in NASA's HERA Campaign 6 and are just starting to get back data from the first mission for analysis.
Bibliography Type:	Description: (Last Updated: 05/05/2023)

Abstracts for Journals and Proceedings	Fanchiang C, Zero M, Klaus D, Shelhamer M, Hauber K, Arquilla K, Reynolds R. "HCAAM: Using a human capabilities framework to quantify crew task performance in human-robotic systems - year 3." 2022 NASA Human Research Program Investigators’ Workshop, Virtual, February 7-10, 2022. Abstracts. 2022 NASA Human Research Program Investigators’ Workshop, Virtual, February 7-10, 2022 (Abstract # #1133-000365). , Feb-2022
Abstracts for Journals and Proceedings	Zero M, Klaus D, Hauber K, Arquilla K, Reynolds R, Shelhamer M, Fanchiang C. "Investigating correlations between biomeasures and task performance metrics for predictive capabilities." 2022 NASA Human Research Program Investigators’ Workshop, Virtual, February 7-10, 2022. Abstracts. 2022 NASA Human Research Program Investigators’ Workshop, Virtual, February 7-10, 2022 (Poster Abstract # 1133-000136). , Feb-2022
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Abstracts for Journals and Proceedings	Arquilla K, Zero M, Hauber K, Reynolds R, Shelhamer M, Klaus D, Fanchiang C. "Discriminating between cognitive vs. physical workload and tasks vs. rest using the ECG signal." 2022 NASA Human Research Program Investigators’ Workshop, Virtual, February 7-10, 2022. Abstracts. 2022 NASA Human Research Program Investigators’ Workshop, Virtual, February 7-10, 2022 (Poster Abstract # 1133-000401). , Feb-2022