Fiscal Year:	FY 2021	**Task Last Updated:**	FY 06/02/2021
PI Name:	Strangman, Gary E Ph.D.		
Project Title:	Quantifying and Predicting Operationally-Relevant Performance in a Long-Duration Spaceflight Analog		
Division Name:	Human Research		
Program/Discipline:			
Program/Discipline--Element/Subdiscipline:	HUMAN RESEARCH--Behavior and performance		
Joint Agency Name:		**TechPort:**	No
Human Research Program Elements:	(1) **HFBP**:Human Factors & Behavioral Performance (IRP Rev H)		
Human Research Program Risks:	(1) **BMed**:Risk of Adverse Cognitive or Behavioral Conditions and Psychiatric Disorders (2) **Sleep**:Risk of Performance Decrements and Adverse Health Outcomes Resulting from Sleep Loss, Circadian Desynchronization, and Work Overload		
Space Biology Element:	None		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
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Zip Code:	02129-2020	**Congressional District:**	7
Comments:			
Project Type:	GROUND	**Solicitation / Funding Source:**	2015-16 HERO NNJ15ZSA001N-ILSRA. Appendix F: International Life Sciences Research Announcement
Start Date:	08/01/2016	**End Date:**	04/30/2023
No. of Post Docs:	1	**No. of PhD Degrees:**	0
No. of PhD Candidates:	0	**No. of Master' Degrees:**	1
No. of Master's Candidates:	2	**No. of Bachelor's Degrees:**	0
No. of Bachelor's Candidates:	0	**Monitoring Center:**	NASA JSC
Contact Monitor:	Whitmire, Alexandra	**Contact Phone:**	
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Flight Program:			
Flight Assignment:	NOTE: End date changed to 4/30/2023 per JSC Grants Office (Ed., 5/2/22) NOTE: End date changed to 4/30/2022 per NSSC information (Ed., 4/12/21) NOTE: End date changed to 4/30/2021 per NSSC information (Ed., 5/4/2020) NOTE: Changed end date to 9/30/2020 per L. Juliette/HRP (Ed., 2/19/2020) NOTE: Extended to 1/31/2020 per K. Ohnesorge/HRP JSC (Ed., 5/24/18) NOTE: Element change to Human Factors & Behavioral Performance; previously Behavioral Health & Performance (Ed., 1/18/17)		
Key Personnel Changes/Previous PI:	June 2021 2-yr report: No changes. June 2019 report: Dr. Vladimir Ivkovic is now CoInvestigator on the project.		

COI Name (Institution):	Zhang, Quan Ph.D. (Massachusetts General Hospital) Ivkovic, Vladimir Ph.D. (Massachusetts General Hospital)
Grant/Contract No.:	NNX16AO30G
Performance Goal No.:	
Performance Goal Text:	
Task Description:	Exploration spaceflight missions will expose crewmembers to many risks that could affect their performance and mission success. Minimizing such risks will require identifying and validating objective indicators of behavioral health and performance (BMed2 Gap), understanding the contribution of sleep loss on individual behavioral health (Sleep2 Gap), and identifying countermeasures that can reduce these risks (BMed1, BMed6, and Sleep9 Gaps). Currently the Robotic On-Board Trainer (ROBoT) is used operationally by astronauts both on the ground and on the International Space Station (ISS) to practice Canada Arm activities. Our group is helping adapt ROBoT for research use and for quantitative performance assessment. In addition, our group is developing and testing NINscan-SE: a multi-use system for measuring brain and physiological function. Both ROBoT and NINscan-SE are being characterized and validated in our laboratory, and will undergo analog feasibility testing during the Human Exploration Research Analog (HERA) C4 and C5 campaigns. In this project, we will deploy both systems to: Aim 1: Characterize operational task performance changes during 45-day HERA missions, including the roles of time-in-mission, workload, sleep debt, and operational emergencies. Aim 2: Characterize brain and systemic physiology changes during 45-day HERA missions, including the roles of time-in-mission, workload, sleep debt, and operational emergencies. Aim 3: Identify physiological or behavioral variables that predict operational performance. Aim 4: Quantify the influence of behavioral health countermeasures on both operational performance and (neuro)physiological measures. To achieve these aims, we will recruit up to 32 crewmembers from eight 45-day missions in the HERA facility during Campaigns 4 and 5, plus up to 32 control subjects. HERA and control participants will all perform ROBoT tasks plus undergo physiological monitoring 2x/week, on matching schedules, thus enabling us to differentiate changes in operational performance due to practice over time from any changes due to HERA sequestration. In addition, two “unexpected operational emergency” events will be introduced in the first and last weeks of each HERA mission. These will consist of an acute need to capture a wayward satellite traveling near the limits of Canada Arm capabilities. We will also work with the Behavioral Health and Performance (BHP) [Ed. note: Element is now known as Human Factors and Behavioral Performance] Element and other HERA investigators to coordinate ROBoT and physiological data collection before, during, and after one or more countermeasure (CM) deployments during the HERA missions. CM(s) may include a lighting intervention, a Virtual Space Station-based behavioral intervention, diet, exercise or some other intervention. The experimental design will depend on the nature of the CM. We will test hypotheses that the CM(s) generate detectable changes in ROBoT performance and rest/task (neuro)physiology recordings. We will also compare ROBoT performance to the standardized Behavioral Core Measures (BCM), if possible. The knowledge-deliverables of this project will describe: (i) changes in operationally-relevant (ROBoT) performance during the HERA mission in a well-controlled analog study of substantial size; (ii) changes in cerebral and systemic physiology associated with HERA mission parameters as well as operational performance; (iii) identification of potential predictors of future ROBoT performance; and (iv) the influence of the investigated countermeasure(s) on operational performance and physiology.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	The ROBoT system—and the HERA isolation protocol—are quite specific to NASA spaceflight operations and hence have relatively few direct Earth applications. However, the ROBoT spacecraft-capture simulations represent a highly skilled, complex operational performance task. It could thus be used as a comparison task in concert with detailed cognitive testing to help dissect the cognitive components complex tasks as well as the influence of other physiological stressors (e.g., sleep deprivation, alcohol consumption, medical radiation) on the performance of such tasks. Use of different complex tasks with the same approach could be useful in assessing and predicting performance in a wide range of other operational environments (diving, pilots, military, surgeons, etc.). Regarding NINscan-SE, no current NIRS (near-infrared spectroscopy), EEG, or polysomnography device has both the portability and the multi-use features of the system we will be deploying. This system could thus have substantial novel Earth applications. Hospital monitoring applications could include long-duration, non-invasive brain monitoring in the NeuroICU following stroke or traumatic injury, for which no similar technology exists. Real-time, in-office brain activation assessment could also be supported, for assessment of psychiatric states, for monitoring the neural effects of cardiovascular or psychoactive drugs or other therapies, or for brain monitoring during rehabilitation. Mobile monitoring could perhaps have an even larger impact outside the hospital setting. A wearable monitor would enable ambulatory syncope monitoring, or multi-parameter ambulatory epilepsy monitoring. If deployed in emergency settings, NINscan-SE could potentially be used to detect cerebral or abdominal hemorrhage, ischemia, and/or cortical spreading depression by first responders. Home monitoring uses include various sleep disorders, as well as various commercial possibilities.

Task Progress:	The goal of this project is to assess operationally-relevant behavioral performance over 45-day isolation and confinement periods in the Human Exploration Research Analog (HERA), as well as associated neurophysiological status during HERA missions. Operational performance is being evaluated using the ROBoT-r task—an operationally used track-and-capture task for grappling incoming resupply vehicles using Canadarm2. This task was modified for research use as part of the separate Behavioral Core Measures project. Brain and systemic physiological assessments include resting-state connectivity and functional brain activation during the ROBoT-r task trials using our near-infrared spectroscopy and imaging (NIRS/NIRI) based NINscan devices, as well as EKG, EOG, and EEG during ROBoT-r performance. In Years 4-5 of this project, the following tasks have been completed. HERA Data Collection: In the past year, we completed data collection for the remainder of HERA Campaign 5, with the final subjects existing HERA just prior the imposition of COVID-19 lockdown restrictions in March 2020. This completed the in-HERA data collections (C4 and C5) for the project. When not under lockdown, we continued to recruit HERA control subjects to match the HERA participants. To date we have completed running n=10 subjects, with two subjects needing to be aborted related to COVID-19. HERA Data Analysis: To date, all analyses remain preliminary, given the ongoing recruitment of control subjects. However, a number of features have been clearly identified. • Weighted scores increase steadily and significantly throughout the ~60-day pre-, during-, and post-HERA periods, representing improved accuracy at point of contact between Canadarm2 and the HTV-II vehicle. The proportion of successful captures also increases over this period. • Duration to complete vehicle capture decreases steadily and significantly over this same period. Increased speed combined with the improved performance is a hallmark of learning, which appears to continue throughout the 60-day missions (which represent ~10-12 hours of hands-on ROBoT-r performance). • Performance is significantly affected by run difficulty, with each step-up in difficulty resulting in significantly poorer and slower performance. • There were notable and significant differences in performance across the different missions/crews. • Physiological data from NINscan demonstrated significant differences between HERA crews and controls in heart rate (HERA>Controls). Both groups exhibited changes in heart rate, as well as frontal pole and dorsolateral prefrontal brain activation within runs, suggesting progressive “activation” as the more challenging end of the run approached. We are still finalizing dataset cleaning and preparing our analyses. Once complete, we will conduct statistical modeling to address our three specific aims: (1) characterizing changes in ROBoT-r performance in HERA, (2) characterizing brain and systemic physiology changes during HERA missions, and (3) identifying predictive brain and systemic physiological biomarkers for ROBoT-r performance. Given the limited number of controls, we cannot yet assess whether or not there are firm conclusions regarding differences between HERA crewmembers and controls, for either behavioral performance or for physiological variables. Dissemination: The results to date of ROBoT-r data collection were presented at the Human Research Program Investigators' Workshop (HRP IWS) conference in Galveston, TX in late Jan 2020, and additional findings at the virtual HRP IWS meeting in early Feb 2021. Portions of this effort were included in the Master’s Thesis of Dr. Stijn Thoolen at Kings College, London, and one peer reviewed paper has been published. Remainder of Year 5: In the remaining 2 months of grant year 5 we anticipate completing the following activities: Data Collection: We plan to ramp-up the HERA control recruitment and data collection, given the rapid loosening of COVID-19 restrictions on research and masking. We will run additional subjects through the end of this grant year and into the next year to make up for time lost due to COVID. Data Quality Control: We will conduct a detailed data quality-control assessment for all C4 and C5 datasets, building a complete, standardized dataset for eventual delivery to NASA. This process will include identifying more anomalies (not just missing, brief dropout, noise bursts, erroneous values, etc.) in all datasets so that analysis programs can be robust to such data features. Data Analysis: All findings to date represent the results of interim analyses, given the limited number of control subjects. We are working to finalize analyses of the responses of ROBoT-r performance to HERA countermeasures and submit a manuscript for peer review by the end of this grant year.
Bibliography Type:	Description: (Last Updated: 04/26/2024)
Articles in Peer-reviewed Journals	Ivkovic V, Sommers B, Cefaratti DA, Newman G, Thomas DW, Alexander DG, Strangman GE. "Operationally relevant behavior assessment using the Robotic On-Board Trainer for Research (ROBoT-r)." Aerosp Med Hum Perform. 2019 Sep 1;90(9):819-25. https://doi.org/10.3357/AMHP.5324.2019 ; PMID: 31426899 , Sep-2019