

Fiscal Year:	FY 2023	Task Last Updated:	FY 08/31/2023
PI Name:	Strangman, Gary E Ph.D.		
Project Title:	Operational Performance Effects and Neurophysiology in Partial Gravity (OPEN-PG)		
Division Name:	Human Research		
Program/Discipline:			
Program/Discipline-- Element/Subdiscipline:			
Joint Agency Name:	TechPort:	Yes	
Human Research Program Elements:	(1) HHC: Human Health Countermeasures		
Human Research Program Risks:	(1) Sensorimotor: Risk of Altered Sensorimotor/Vestibular Function Impacting Critical Mission Tasks		
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:	2019 HERO 80JSC019N0001-FLAGSHIP & OMNIBUS: Human Research Program Crew Health. Appendix A&B
Start Date:	09/01/2020	End Date:	08/31/2024
No. of Post Docs:	1	No. of PhD Degrees:	0
No. of PhD Candidates:	0	No. of Master' Degrees:	0
No. of Master's Candidates:	1	No. of Bachelor's Degrees:	0
No. of Bachelor's Candidates:	1	Monitoring Center:	NASA JSC
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Flight Program:			
Flight Assignment:	NOTE: End date changed to 08/31/2024 per NSSC information (Ed., 11/25/22)		
Key Personnel Changes/Previous PI:			
COI Name (Institution):	Ivkovic, Vladimir Ph.D. (Massachusetts General Hospital) Zhang, Quan Ph.D. (Massachusetts General Hospital)		
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Performance Goal No.:			
Performance Goal Text:			

	<p>Background: Understanding human performance under various partial-gravity loadings is critical to NASA's crewed mission strategies. For example, current vehicle and mission designs for Mars landings require the crew to use robotic teleoperation within 24 hours of landing—unaided from Earth—to connect landing craft power systems with pre-positioned power generators. This design requires the crew to perform complex sensorimotor operations to maintain life support, as soon as possible after a gravitational transition, and in an unfamiliar partial-gravity setting. Unfortunately, there remains limited knowledge about how the sensorimotor system is affected by exposure to both partial gravity and gravity transitions. Addressing these gaps will in part require integrated assessment of operational and sensorimotor performance alongside neurovestibular and neurophysiological responses during exposure to various gravitational loads.</p> <p>Aim 1: Characterize and quantify changes in operationally-relevant sensorimotor and vestibular performance as a function of gravitational load.</p> <p>Aim 2: Characterize and quantify changes in physiology—particularly in brain function and autonomic activation during behavioral performance—as a function of gravitational load.</p> <p>Aim 3: Develop a model to predict behavioral performance and neurophysiological responses under different gravitational loads based on preflight ground testing data.</p> <p>Hypotheses: (Hyp1) We predict a monotonic but non-linear relationship between Robotics On-Board Trainer-r (ROBoT-r) performance and gravitational load, with larger departures from 1g leading to more impaired performance. (Hyp2) Behavioral alterations will be paralleled by physiological changes at different gravity loads, including activation of prefrontal and vestibular cortex, and autonomic nervous system activation. (Hyp3) Ground-based challenges to the vestibular system will induce detectable neurophysiological responses, and the amplitude of these responses (i.e., an indicator of individual “sensitivity” to these provocations) will help (3a) predict neurophysiological responses in-flight, and (3b) predict behavioral performance in flight.</p> <p>Deliverables: Overall, our project will characterize (1) operationally-relevant performance and (2) neurophysiological responses as a function of gravity load, as well as (3) providing models to predict performance and neurophysiological impacts of partial gravity based on preflight-data. This work has the potential to identify individuals who are particularly resilient to altered gravity, and will be key for planning future exploration-class missions where survival will depend on the operational capabilities of astronauts in partial-gravity environments.</p>
Task Description:	
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	<p>These parabolic flights will help fill critical knowledge gaps regarding human exposure to fractional-gravity conditions. Specifically, our project will address gaps regarding operational performance, neurophysiological status, individual sensitivity to different gravitational loads between 0-1g, as well as prediction of behavioral performance and physiological responses to partial gravity. In addition to filling key gaps surrounding human performance of operationally-relevant tasks in partial gravity, this work may provide a method to help identify crewmembers who are particularly resilient for performing particular tasks under novel gravity loadings. The results have the further benefit of providing a better understanding of the role of disorientation in Earth-based operational performance. This is relevant not only to fighter pilots, but to task performance by individuals with neurological or medical conditions that adversely affect the vestibular system (e.g., stroke, infections).</p>
Task Progress:	<p>TASK DESCRIPTION Background: Understanding human performance under various partial-gravity loadings is critical to NASA's crewed mission strategies. For example, current vehicle and mission designs for Mars landings require the crew to use robotic teleoperation within 24 hours of landing—unaided from Earth—to connect landing craft power systems with pre-positioned power generators. This design requires the crew to perform complex sensorimotor operations to maintain life support, as soon as possible after a gravitational transition, and in an unfamiliar partial-gravity setting. Unfortunately, there remains limited knowledge about how the sensorimotor system is affected by exposure to both partial gravity and gravity transitions. Addressing these gaps will in part require integrated assessment of operational and sensorimotor performance alongside neurovestibular and neurophysiological responses during exposure to various gravitational loads.</p> <p>Aim 1: Characterize and quantify changes in operationally relevant sensorimotor and vestibular performance as a function of gravitational load. Aim 2: Characterize and quantify changes in physiology—particularly in brain function and autonomic activation during behavioral performance—as a function of gravitational load. Aim 3: Develop a model to predict behavioral performance and neurophysiological responses under different gravitational loads based on preflight ground testing data.</p> <p>Hypotheses: (Hyp1) We predict a monotonic but non-linear relationship between Robotics On-Board Trainer-r (ROBoT-r) performance and gravitational load, with larger departures from 1g leading to more impaired performance. (Hyp2) Behavioral alterations will be paralleled by physiological changes at different gravity loads, including activation of prefrontal and vestibular cortex, and autonomic nervous system activation. (Hyp3) Ground-based challenges to the vestibular system will induce detectable neurophysiological responses, and the amplitude of these responses (i.e., an indicator of individual “sensitivity” to these provocations) will help (3a) predict neurophysiological responses in-flight, and (3b) predict behavioral performance in flight.</p> <p>Deliverables: Overall, our project will characterize (1) operationally relevant performance and (2) neurophysiological responses as a function of gravity load, as well as (3) providing models to predict performance and neurophysiological impacts of partial gravity based on preflight data. This work has the potential to identify individuals who are particularly resilient to altered gravity and will be key for planning future exploration-class missions where survival will depend on the operational capabilities of astronauts in partial-gravity environments.</p> <p>RESEARCH IMPACT The proposed parabolic flights will help fill critical knowledge gaps regarding human exposure to fractional-gravity conditions. Specifically, our project will address gaps regarding operational performance, neurophysiological status, individual sensitivity to different gravitational loads between 0-1g, as well as prediction of behavioral performance and physiological responses to partial gravity. In addition to filling key gaps surrounding the human performance of operationally relevant tasks in partial gravity, this work may provide a method to help identify crewmembers who are particularly resilient for performing particular tasks under novel gravity loadings. The results have the further benefit of providing a better understanding of the role of disorientation in Earth-based operational</p>

	<p>performance. This is relevant not only to fighter pilots but to task performance by individuals with neurological or medical conditions that adversely affect the vestibular system (e.g., stroke, infections).</p> <p>TASK PROGRESS Over the past year, we finished all preparations for the planned experiments, and all parabolic flight data collection was conducted over a 2-week period from June 3-16, 2023. Achievements include the following: • Completion of Novespace paperwork: All paperwork (in particular the Experiment Safety Data Package, ESDP), and related forms were completed as required to fly, in collaboration with Novespace. • New Hand Controllers: Dr. Strangman worked closely with NASA Human Research Program (HRP) and the NASA Dynamic Skills Trainer (DST) lab to finalize the design and performance characteristics of the new hand controllers. Four sets of controllers were fabricated to be used in this study, and Dr. Strangman worked with NASA Human Factors and Behavioral Performance (HFBP) and DST to optimize the controllers prior to final delivery. • New ROBoT-r Workstations: A set of 4 workstations (8 HP Zbook computers plus cabling) were assembled by the DST lab for use aboard the parabolic flights. These were delivered to Novespace in Bordeaux along with the other hardware coming directly from NASA (see Shipping, below). • ROBoT-r Task Truncation – Revised Initial Conditions: Dr. Strangman developed new initial conditions for the ROBoT-r task to accommodate the short (~20 sec) periods of altered gravity available during each parabola for task performance. • ROBoT-r Racks: Novespace required specialized racks to support the ROBoT workstations in flight, which ultimately needed to be fabricated from scratch. Since all ROBoT-r workstation hardware was being developed and finalized at the DST Lab, the DST Lab was engaged to fabricate these support racks. The racks were primarily an adjustable (sliding) “stand-up desk” to which computers, trackballs, and cabling could be attached. These were completed mid-May 2023 for shipment to France. • Shipping: ROBoT-r workstations and racks were shipped directly from NASA, whereas all remaining hardware was hand-carried to Novespace in June 2023. • Data Collection: Ground-based data collection was conducted over 4 days (totaling 45 hours of testing time, plus setup/cleaning/breakdown). Ground tests included (1) familiarization with ROBoT-r and Zibrio, donning/doffing of NINscan, (2) two training sessions, and (3) baseline data collection on ROBoT-r and balance tasks with vection, head-tilt, and GVS challenges. On Flight Day 1 (0g parabolas), flight data collection involved all 12 subjects, where each subject participated in 10 parabolas. They performed the abbreviated ROBoT-r task for the first 7 parabolas and the balance task for the last 3 parabolas. After every 10 parabolas, subjects were swapped in/out of stations. On Flight Days 2-4 (involving 10 parabolas at each partial-g value), we only had 4 subjects per flight, so no equipment swaps were necessary. 99% of the data inflight was collected as expected. • Data Quality Control: Data was downloaded and assessed on each day of experimental data collection, to confirm that all equipment was still operating nominally.</p>
Bibliography Type:	Description: (Last Updated: 04/26/2024)
Abstracts for Journals and Proceedings	Ivkovic V, White BM, Shelhamer M, Pollonais J, Zhang Q, Strangman GE. "Open-Pg: Operational Performance Effects and Neurophysiology in Partial Gravity – 2023 Update." 2023 NASA Human Research Program Investigators' Workshop, Galveston, Texas, February 6-9, 2023. Abstracts. 2023 NASA Human Research Program Investigators' Workshop, Galveston, Texas, February 6-9, 2023. , Feb-2023