Fiscal Year:	FY 2021	**Task Last Updated:**	FY 07/22/2021
PI Name:	Basner, Mathias M.D., Ph.D.		
Project Title:	Advanced Algorithms for the Prediction of Adverse Cognitive and Behavioral Conditions in Space		
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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Zip Code:	19104-4209	**Congressional District:**	2
Comments:			
Project Type:	Ground	**Solicitation / Funding Source:**	2018 TRA BRASH1801: Translational Research Institute for Space Health (TRISH) Biomedical Research Advances for Space Health
Start Date:	01/01/2019	**End Date:**	12/31/2020
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:	0	**No. of Bachelor's Degrees:**	0
No. of Bachelor's Candidates:	2	**Monitoring Center:**	TRISH
Contact Monitor:		**Contact Phone:**	
Contact Email:			
Flight Program:			
Flight Assignment:			
Key Personnel Changes/Previous PI:			
COI Name (Institution):	Dinges, David Ph.D. (University of Pennsylvania) Romoser, Amelia Ph.D. (KBR/NASA Johnson Space Center) Shou, Haochang Ph.D. (University of Pennsylvania) Stahn, Alexander Ph.D. (University of Pennsylvania) Williams, Edward Ph.D. (NASA Johnson Space Center)		
Grant/Contract No.:	NNX16AO69A-T0403		
Performance Goal No.:			
Performance Goal Text:			

Task Description:	This study utilizes Reaction Self-Test (RST) data collected in N=24 astronauts on 6-month International Space Station missions, arguably the largest cognitive dataset ever collected in spaceflight. The main objective is to additionally obtain data on key environmental stressors (i.e., CO2 levels, temperature, noise, and radiation) and combine them with RST data and other operational data. All data will be integrated in one carefully annotated database, which will be delivered to NASA at the end of the project and could be later amended and mined by other researchers. In addition, this project will develop an individualized dynamic prediction model that informs future Psychomotor Vigilance Test (PVT) performance based on environmental data, survey data, prior PVT administrations, and person-specific characteristics using state-of-the-art machine learning techniques such as functional concurrent regressions and neural networks for time series forecasting. At the end of the study, the team will deliver an algorithm to NASA that, for the first time, can predict adverse cognitive conditions in astronauts early and with an unprecedented precision.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	This project develops a state-of-the-art predictive algorithm for adverse cognitive conditions. It is unique as it utilizes the arguably largest cognitive data set ever collected in spaceflight. It is innovative as it combines data on key environmental stressors prevalent in spaceflight with other contextual and time series data to predict cognitive performance. The fact that it will be possible for the first time to predict adverse cognitive conditions in astronauts early and with an unprecedented precision demonstrates the high impact of this proposal for both spaceflight and Earth.
Task Progress:	This proposal addresses the Human Research Program (HRP) Risk of Adverse Cognitive or Behavioral Conditions and Psychiatric Disorders and several other critical HRP risks and gaps. This study utilizes Reaction Self-Test (RST) data collected by the Principal Investigator (PI) and his team in N=24 astronauts on 6-month International Space Station (ISS) missions, arguably the largest cognitive dataset ever collected in spaceflight. RST consists of a survey module and a 3-minute version of the Psychomotor Vigilance Test (PVT). Our main objective is to additionally obtain data on key environmental stressors (i.e., CO2 and O2 levels, temperature, noise, and radiation) and combine them with RST data and other operational data collected by the PI and his team (Specific Aim 1). All data will be integrated in one carefully annotated database, which will be delivered to NASA at the end of the project and could be later amended and mined by other researchers (Deliverable 1). We will then develop an individualized dynamic prediction model that informs future PVT performance based on environmental data, survey data, prior PVT administrations, and person-specific characteristics using state-of-the-art machine learning techniques such as functional concurrent regressions and neural networks for time series forecasting (Specific Aim 2). We will perform model selection and identify those variables that have the highest predictive value for PVT performance (Deliverable 2) and could preferentially be collected on future spaceflight missions to inform relevant changes in cognition and behavioral health. At the end of the study, we will deliver an algorithm to NASA that, for the first time, can predict adverse cognitive conditions in astronauts early and with an unprecedented precision (Deliverable 3). The predictive algorithms can be translated to several settings on Earth where high performing individuals have to sustain high levels of cognitive performance while facing several environmental or other challenges (e.g., US Navy personnel on submarines). We obtained approval from the Lifetime Surveillance of Astronaut Health Board, the Institutional Review Board (IRB) of Johnson Space Center, European Space Agency (ESA), and Japan Aerospace Exploration Agency (JAXA), and the IRB of the University of Pennsylvania to use already collected RST data for the purposes of this project. N=7 non-US astronauts who had not provided broad consent for the re-use of their RST data were re-consented. These included 6 non-US astronauts, for which NASA previously had no process in place for re-consenting them. We also obtained key environmental variables from the ISS for the duration of the RST project (2009-2014): O2 and CO2 levels, noise levels, radiation levels, temperature levels. The temporal resolution of these data varies. We also extracted key demographic (prior days in space, prior missions, DOB, sex, nationality, space agency, military background, degree, marital status, number of children), and operational (number of ISS occupants, date of extravehicular activities (EVAs) or spacecraft dockings/undockings, sleep schedule)) information for the relevant time period. The four data streams (RST data, environmental data, demographic data, operational data) were combined in a data matrix. We have identified those variables that have the highest predictive value for PVT performance combining a number of variable selection methods: Past PVT performance Self-reported RST PC scores (Workload, Sleep Quality, Sleepiness, Physical Exhaustion, Mental Fatigue, Stress), Radiation, Temperature, O2 and CO2 levels, Sleep duration, predicted lapses based on sleep history, and Age. We investigated predictive properties of three classes of prediction models (Linear Mixed Effect Model, Functional Concurrent Regression Model, Random Forest Model) and an Ensemble Model that combines predictions from the previously mentioned three models. The ensemble model was found to provide the highest prediction accuracy. Finally, we built a Shiny App for visualizing the effects of several stressors on PVT performance, which can be a powerful tool for investigating the effects of individual stressors, their combination, and to generate hypothesis. This tool could be amended to include additional predictors and/or outcomes.
Bibliography Type:	Description: (Last Updated: 06/19/2025)
Articles in Peer-reviewed Journals	Mason CE, Green J, Adamopoulos KI, Afshin EE, Baechle JJ, Basner M, Bailey SM, Bielski L, Borg J, Borg J, Broddrick JT, Burke M, Caicedo A, Castañeda V, Chatterjee S, Chin C, Church G, Costes SV, De Vlaminck I, Desai RI, Dhir R, Diaz JE, Etlin SM, Feinstein Z, Furman D, Garcia-Medina JS, Garrett-Bakelman F, Giacomello S, Gupta A, Hassanin A, Houerbi N, Irby I, Javorsky E, Jirak P, Jones CW, Kamal KY, Kangas BD, Karouia F, Kim J, Kim JH, Kleinman A, Lam T, Lawler JM, Lee JA, Limoli CL, Lucaci A, MacKay M, McDonald JT, Melnick AM, Meydan C, Mieczkowski J, Muratani M, Najjar D, Othman MA, Overbey EG, Paar V, Park J, Paul AM, Perdyan A, Proszynski J, Reynolds RJ, Ronca AE, Rubins K, Ryon KA, Sanders LM, Glowe PS, Shevde Y, Schmidt MA, Scott RT, Shirah B, Sienkiewicz K, Sierra M, Siew K, Theriot CA, Tierney BT, Venkateswaran K, Hirschberg JW, Walsh SB, Walter C, Winer DA, Yu M, Zea L, Mateus J, Beheshti A. "A second space age spanning omics, platforms, and medicine across orbits." Nature. 2024 Jun 11. Review. Online ahead of print. https://doi.org/10.1038/s41586-024-07586-8 ; PMID: 38862027 , Jun-2024
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