Fiscal Year:	FY 2016	**Task Last Updated:**	FY 11/04/2015
PI Name:	Basner, Mathias M.D., Ph.D.		
Project Title:	Individualized Real-Time Neurocognitive Assessment Toolkit for Space Flight Fatigue		
Division Name:	Human Research		
Program/Discipline:	NSBRI		
Program/Discipline--Element/Subdiscipline:	NSBRI--Neurobehavioral and Psychosocial Factors Team		
Joint Agency Name:		**TechPort:**	Yes
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		
Space Biology Element:	None		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
PI Email:	basner@pennmedicine.upenn.edu	**Fax:**	FY
PI Organization Type:	UNIVERSITY	**Phone:**	215-573-5866
Organization Name:	University of Pennsylvania		
PI Address 1:	Department of Psychiatry, Division of Sleep and Chronobiology		
PI Address 2:	423 Service Dr, 1013 Blockley Hall		
PI Web Page:			
City:	Philadelphia	**State:**	PA
Zip Code:	19104-4209	**Congressional District:**	2
Comments:			
Project Type:	FLIGHT,GROUND	**Solicitation / Funding Source:**	2010 Crew Health NNJ10ZSA003N
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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:	1	**Monitoring Center:**	NSBRI
Contact Monitor:		**Contact Phone:**	
Contact Email:			
Flight Program:	ISS		
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Key Personnel Changes/Previous PI:			
COI Name (Institution):	Gur, Ruben (University of Pennsylvania Health System) Dinges, David (University of Pennsylvania) Mollicone, Daniel (Pulsar Informatics, Inc.) Mott, Christopher (Pulsar Informatics, Inc.)		
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Task Description:	ORIGINAL PROJECT AIMS This project addresses the National Space Biomedical Research Institute (NSBRI) Human Factors and Performance Team goal to develop tools to assess crew performance in real-time and evaluate countermeasures to mitigate the effects of fatigue, circadian misalignment, and work-overload. It has secondary relevance to the Neurobehavioral and Psychosocial Factors and Sensorimotor Adaptation Teams. It is responsive to the critical need to identify how a range of cognitive functions of astronauts can be affected in space flight by fatigue alone, its interaction with other risk factors and conditions (e.g., elevated CO2, intracranial pressure, space fog), and countermeasures. The project will deliver a comprehensive, software-based, neurocognitive toolkit (Cognition). By building on state-of-the-art neuropsychological test development, the toolkit will permit evaluation of a full range of cognitive functions using brief (1-5 min), validated procedures. The tests include -- but go beyond -- what is currently measured by WinSCAT and the Reaction Self Test on International Space Station (ISS). Importantly, the toolkit will permit rapid assessment of performance in cognitive, social-emotional, and sensorimotor domains. Performance assessment algorithms will be individualized to each astronaut's norm, and adjusted for learning using a data modeling approach, in order to optimize individual performance relative to the effects of fatigue and related cognitive impacts. The toolkit will facilitate identification of underlying neural mechanisms affected when cognitive deficits are identified, by using tests selected on the basis of published fMRI studies that identify the specific brain regions subserved by each test. The project begins at TRL (Technology Readiness Level) 5/CRL (Countermeasure Readiness Level) 6 and ends at TRL 7/CRL 8. Toolkit development will progress from laboratory, to data acquisition in astronauts at Johnson Space Center (JSC), to ISS. The resulting comprehensive, neuroscience-validated, cognitive test battery for real-time evaluation of astronauts in space will be an essential detection technology for effective fatigue countermeasure management of astronaut performance in space. The link to neuroscience will yield directions for mechanisms of cause and potential interventions. The project has the following 5 specific aims: 1: Development of short-duration adaptive versions of neuropsychological tests for space flight; 2: Establish learning curves for neuropsychological tests and validate sensitivity to sleep deprivation; 3: Cognition software development and optimization for space flight; 4: JSC field testing, astronaut learning curves, and astronaut norms for performance feedback algorithm development; 5: International Space Station (ISS) feasibility study KEY FINDINGS -The first full version of Cognition was launched in November 2012 (Aims 1 and 3) and deployed in the sleep restriction studies at UPenn (Aim 2). - Since then, 97 laboratory participants have completed the test battery (all 10 tests) 12-18 times (N=55 total sleep deprivation, N=87 partial sleep restriction, N=10 control subjects). Preliminary analyses presented at both the 2014 and 2015 Human Research Program (HRP) meetings suggest that 3 of the 10 Cognition tests are sensitive to the effects of acute total sleep deprivation, with the Psychomotor Vigilance Test (PVT) being the most sensitive test (Aim 2). - Collection of normative data from mission controllers (N=11) and astronauts (N=7) at JSC was completed (Aim 4). - Data acquisition was also found to be feasible in space analog environments, particularly at the Human Exploration Research Analog (HERA) facility, the Hawaii Space Exploration Analog and Simulation (HI-SEAS) facility, and several Antarctic research stations (Concordia, Halley-VI, and Neumayer-III). - In the past year, we tested 4 HERA crew members in a 7-day mission, 12 in three 14-day missions, 6 HI-SEAS crew members in an 8-month mission, and began data collection in N=35 winter-over crew at 3 Antarctic research stations, along with N=13 control subjects at DLR (German Space Agency) to compare changes over mission-duration. - Also in the past year, we completed data collection from our first in-flight astronaut as part of the ISS feasibility study in close collaboration with ISS-MP (Aim 5), started data collection from 3 more in-flight astronauts, and familiarized 2 more with the battery. - Data collection is ongoing from 1 twin astronaut on ground (for our involvement in NASA's twins study), and from one cosmonaut that will remain on ISS for 1 year. - Additionally, a Validation study was designed and started that will compare Cognition on both Windows and iPad with WinSCAT in N=96 high-performing subjects. - Finally, data collection was completed for an NSBRI head down-tilt and elevated CO2 study at German Aerospace Center (DLR)'s envihab facility (SPACE-COT). IMPACT OF KEY FINDINGS ON HYPOTHESES, TECH. REQUIREMENTS, OBJECTIVES AND SPECIFIC AIMS OF THE ORIGINAL PROPOSAL Preliminary findings support the feasibility of Cognition administration in astronauts and astronaut surrogate populations, on both the Windows and iPad platform, and in space analog environments. Participant feedback provided during debriefs (N=52) provided helpful insights for current and future improvements of the battery. Cognition was selected for 8 HERA missions, 3 HI-SEAS missions, Scott Kelly's and Michail Kornienko's 12-month ISS mission, NASA's TWIN study, a study on cognitive effects in Antarctic winter-overers, and an NSBRI study on the effects of CO2 and fluid shifts. Additionally, Cognition was selected as a core component in the project to develop a standardized behavioral measures toolkit (SBMT) for space flight operations, demonstrating the need for and the success of the Cognition battery. PROPOSED RESEARCH PLAN FOR THE COMING YEAR Data acquisition at HERA, and in sleep restriction studies at UPenn will be finalized in the coming year. Data collection will continue on ISS, in HI-SEAS, and in Antarctica through the year. Finally, Cognition will be integrated as part of SBMT into a comprehensive toolkit for space flight operations.
Rationale for HRP Directed Research:	

Research Impact/Earth Benefits:	The project will have substantial impact on progress in three major areas relevant to the needs of NASA and state of the knowledge. 1. Cognition will markedly enhance astronauts' and flight physicians' ability to quickly (real-time) and objectively evaluate the neurocognitive status of astronauts relative to activities that can induce fatigue in space (i.e., acute sleep loss from prolonged duty, chronic sleep estriction, inadequate recovery sleep, slam shifts and circadian misalignment, high physical and/or cognitive workloads, EVAs, etc.); relative to fatigue countermeasures, e.g., different sleep-wake schedules, sleep-promoting and wake-promoting medications, light exposure for circadian associated with occult neurobehavioral risks in space (e.g., space fog, space asthenia/neurasthenia). 2. Cognition will permit identification of important fatigue-related individual differences (i.e., differential vulnerability) in the nature and severity of cognitive performance deficits (e.g., from deficits in spatial orientation, to working memory, to abstract reasoning, to risk decision- making) during space flight, in a comprehensive and precise manner to permit optimal targeting of fatigue countermeasures to specific individuals, and to help predict the performance capability of individual astronauts relative to specific space flight tasks (i.e., align cognitive performance readiness relative to the need to conduct specific space flight tasks). 3. Cognition will help in the medical identification and treatment management course of neurologically-based performance deficits in space flight due to environmental stressors (e.g., exposure to high CO2, hypoxia, radiation); medically urgent events (e.g., head injury, papilledema, and/or the possibility of elevated intracranial pressure [ICP]); and neurobehavioral conditions brought on by prolonged stays in space (e.g., time in confinement, neural remodeling from sensorimotor alterations, affective disorders). Although the Cognition test battery is primarily developed for space flight, it will be a valuable tool in many Earth-based patient and non-patient population settings, where identification of suboptimal cognitive performance is important for safe operations (e.g., truck drivers, operators of heavy machinery) or for tracking therapeutic effectiveness. Cognition will be optimized for repeated administration, a feature that many of the currently available test batteries are lacking.
Task Progress:	Aim 1 (Development of short-duration adaptive versions of Cognition neuropsychological tests for space flight): We continued data analysis of the Emotion Recognition test. This analysis provided us with the difficulty of each item, a prerequisite for adaptive testing. We also identified items that do not seem to work and will be eliminated from future versions of the battery (further decreasing test time). We believe that, with additional development work, it will be possible to further reduce administration time of the battery, increasing its operational feasibility and acceptance in the astronaut population. Additionally, we began a validation study that will compare Cognition on both Windows and iPad with WinSCAT in 96 high-performing subjects. Aim 2 (Establish learning curves for Cognition neuropsychological tests and validate sensitivity to sleep deprivation): The first full version was launched in November 2012 and deployed in laboratory studies at UPenn. Since then, 97 subjects have completed the test battery (all 10 tests) 12-18 times. We plan to finalize data collection in these sleep deprivation protocols in the following year. Preliminary analyses suggest that 3 of the 10 Cognition tests are sensitive to the effects of acute total sleep deprivation. Aim 3 (Cognition Toolkit software development and optimization for space flight): The software has an easy to use web interface that allows for real-time quality control and export of test data gathered anywhere on Earth and in space if an Internet connection is available. Cognition has been deployed on the ISS, in laboratory studies at the University of Pennsylvania, in ground studies at JSC, in space analog studies at the HERA and HI-SEAS facilities, and in three research stations in Antarctica. Cognition has been translated to four other languages (German, Italian, French, Russian) for our international studies. Aim 4 (JSC field testing, astronaut learning curves, and astronaut norms for performance feedback algorithm development): Data acquisition in mission controllers (N=11) and astronauts (N=7) at JSC was found to be feasible. Mission controllers and astronauts each performed the full battery 15 times total in 1-2 week intervals between tests. Feedback provided during debriefs provided us with important information for current and future improvements of the Cognition software. Aim 5 (ISS feasibility study): We have deployed the Cognition battery on the ISS to assess feasibility, and completed data collection in 1 in-flight Astronaut, started data collection in 3 more in-flight astronauts, and familiarized 2 more with the battery. All in-flight Astronauts perform the battery on ISS with a 1-3 week interval between tests. In addition, we have also started collecting data from both Scott Kelly and Mikhail Kornienko as one of the projects that examine them over the course of the 12-month mission, and from Mark Kelly on Earth.
Bibliography Type:	Description: (Last Updated: 04/05/2024)
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