Fiscal Year:	FY 2015	**Task Last Updated:**	FY 10/14/2014
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		
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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		
Flight Assignment:			
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/OBJECTIVES

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 5/CRL 6 and ends at TRL (Technology Readiness Level) 7/CRL (Countermeasure Readiness Level) 8. Toolkit development will progress from laboratory, to data acquisition in astronauts at Johnson Space Center (JSC), to International Space Station (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: Specific Aim 1: Development of short-duration adaptive versions of neuropsychological tests for space flight; Specific Aim 2: Establish learning curves for neuropsychological tests and validate sensitivity to sleep deprivation; Specific Aim 3: Cognition software development and optimization for space flight; Specific Aim 4: JSC field testing, astronaut learning curves, and astronaut norms for performance feedback algorithm development; Specific Aim 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 the University of Pennsylvania (Aim 2). Since then, 71 laboratory participants have completed the test battery (all 10 tests) 12-18 times (N=40 total sleep deprivation, N=64 partial sleep restriction, N=7 control subjects). Preliminary analyses presented at the 2014 Human Research Program (HRP) meeting suggest that all 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). Progress was also made in gathering normative and analog data from astronauts and astronaut surrogate populations. Data acquisition in mission controllers (N=11/11) and astronauts (N=7/8) at JSC was found to be feasible (Aim 4). Data acquisition was also found to be feasible in space analog environments, particularly at the Human Exploration Research Analog (HERA) and the Hawaii Space Exploration Analog and Simulation (HI-SEAS) facilities. In the past year, we tested 12 HERA crew members of three 7-day missions and 5 HI-SEAS crew members of one 4-month mission. In July 2014, we familiarized 3 astronauts to the Cognition test battery as part of the ISS feasibility study in close collaboration with ISS-MP (Aim 5). The first astronaut is scheduled to launch for a 6-month mission with increment 41S in November 2014.

IMPACT OF KEY FINDINGS ON HYPOTHESES, TECHNOLOGY 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 7 and iPad platform, and in space analog environments. Participant feedback provided during debriefs (N=34) provided helpful insights for current and future improvements of the battery. Cognition was selected for 4 HERA missions, 3 HI-SEAS missions, Scott Kelly's and Michail Kornienko's 12-month ISS mission, NASA's TWIN study, and a study on cognitive effects in Antarctic winter-overers, demonstrating both the need for and the success of the Cognition battery.

PROPOSED RESEARCH PLAN FOR THE COMING YEAR

Data acquisition in sleep restriction studies at the University of Pennsylvania will continue and data analysis will be finalized by the end of year 4 of the project (Aim 2). Data acquisition and analysis of mission controllers and astronauts at JSC will also be finalized in the next year (Aim 4). We plan to enroll 4 more HERA crew members in September 2014 and 12 more HI-SEAS crew members over two missions between October 2014 and July 2016. We will start our ISS feasibility study in November 2014.

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 restriction, 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 entrainment, and acute alertness); and relative to symptom reports of fatigue 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:	Specific Aim 1 (Development of short-duration adaptive versions of CATS (Comprehensive Aphasia Test) 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 (thus further decreasing test time). Results on an adaptive duration PVT were published in SLEEP. Specific Aim 2 (Establish learning curves for CATS neuropsychological tests and validate sensitivity to sleep deprivation): The first full version was launched in November 2012 and deployed in laboratory studies at the University of Pennsylvania. Since then, 71 subjects have completed the test battery (all 10 tests) 12-18 times. We plan to gather data on up to 40 more subjects in these sleep deprivation protocols. Preliminary analyses suggest that all 10 Cognition tests are sensitive to the effects of acute total sleep deprivation. Specific Aim 3 (CATS Toolkit software development and optimization for space flight): The software now exists both on a Windows 7 and iPad platform, with an easy to use web interface that allows for real-time quality control and export of test data gathered anywhere on the Earth and in space if a connection to the Internet is available. Cognition has been deployed in laboratory studies at the University of Pennsylvania, ground studies at JSC, and space analog studies at the HERA and HI-SEAS facilities. In the next year, Cognition will be deployed to Antarctica (e.g., Concordia Station) and the International Space Station. Cognition has been translated to four other languages (German, Italian, French, Russian) for our international studies. Specific 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. JSC mission controllers and astronauts each performed the full test 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. Specific Aim 5 (International Space Station (ISS) feasibility study): We have familiarized the Cognition test battery to 3 astronauts who are scheduled to launch for a 6-month missions. They will perform Cognition up to 18 times total with a 1 to 3 week interval between tests in-flight. In addition, Cognition has been approved to be one of the projects flying on the 12-month ISS mission of one U.S. astronaut and one Russian cosmonaut. Cognition has also been approved as one of 9 other projects involved with NASA's Twins study, with one twin flying the 12-month ISS mission (as previously mentioned) while the other twin remains on Earth. The launch date for the 12-month mission is scheduled for March 2015.
Bibliography Type:	Description: (Last Updated: 06/19/2025)
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