Fiscal Year:	FY 2013	**Task Last Updated:**	FY 10/19/2012
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:	GROUND	**Solicitation / Funding Source:**	2010 Crew Health NNJ10ZSA003N
Start Date:	10/01/2011	**End Date:**	09/30/2015
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:			
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 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 CO_2, intracranial pressure, space fog), and countermeasures. The project will deliver a comprehensive, software-based, neurocognitive toolkit. 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 ISS. Importantly, the toolkit will permit rapid assessment of performance in cognitive, social-emotional and sensorimotor domains. Real-time 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 and team 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. Toolkit development will begin at TRL 5/CRL 6, and progress from laboratory, to space analog (NEEMO), to ISS (TRL 7/CRL 8). 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 CATS neuropsychological tests for spaceflight; Specific Aim 2: Establish learning curves for CATS neuropsychological tests and validate sensitivity to sleep deprivation; Specific Aim 3: CATS Toolkit software development and optimization for spaceflight; 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

New items for the Matrix Reasoning Test were developed and tested for their usability in an adaptive version of the test. The Conditional Exclusion Test was replaced by the Abstraction and Working Memory (AIM) Task, as the latter is more suitable for repeated administration. We published a paper on an adaptive duration version of the PVT, and the same methods can be applied to many of the NeuroCATS tests after baseline data for astronauts are available. Using already existing test versions, the 10 NeuroCATS tests were inserted into 2 sleep restriction protocols currently underway at the University of Pennsylvania. Thus far, we recorded 290 full test batteries in 19 subjects. We wrote a specific software that visualizes test data immediately after acquisition. One important finding from these tests completed so far is that, after some initial training, NeuroCATS administration takes less time than expected (ca. 30 min for the whole battery). The current test software will be replaced by the CATS Toolkit software in year 2 of the protocol. Excellent progress was made in developing the CATS toolkit software platform and integrating already existing and newly developed tests. The first full version will be launched in the beginning of year 2 and deployed both in the laboratory studies at the University of Pennsylvania (Aim 2) and in the astronaut study at JSC (Aim 4). The Conditional Exclusion Task was replaced with another abstraction task (AIM, Glahn et al., 1999) with higher suitability for repeated administration. In this process, 1,000 AIM stimuli were piloted in 16 students. Instead of participating in 3 NEEMO missions, we are planning to have N=20 astronauts or astronaut candidates perform the NeurCATS battery 15 times to start building a normative data base, and to establish learning curves and gather astronaut feedback for each NeuroCATS test.

IMPACT OF KEY FINDINGS ON HYPOTHESES, TECHNOLOGY REQUIREMENTS, OBJECTIVES AND SPECIFIC AIMS OF THE ORIGINAL PROPOSAL

We were not able to get access to astronauts in NEEMO, and accordingly changed specific aim 3 with NSBRI approval. We will now investigate astronauts and astronaut candidates while preparing for missions at JSC. Data from our laboratory studies showed that the Conditional Exclusion Test is not adequate for repeated administration. It was thus replaced by the AIM, which taps into the same cognitive domain (abstraction).

PROPOSED RESEARCH PLAN FOR THE COMING YEAR

The development of adaptive and/or shorter versions of the individual NeuroCATS tests will continue in year 2. In the sleep restriction studies running at the University of Pennsylvania, the current NeuroCATS software will be replaced with the CATS toolkit software. Data acquisition at JSC (N=20 astronauts) is projected to start in year 2 of the protocol. Based on the findings of this study, the battery will be refined and finalized before operational testing on ISS starts in years 3 and 4 of the protocol.

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. NeuroCATS 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, etc.); and relative to symptom reports of fatigue associated with occult neurobehavioral risks in space (e.g., space fog, space asthenia/neurasthenia). 2. NeuroCATS 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. NeuroCATS 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 CO_2, hypoxia, radiation); medically urgent events (e.g., head injury, papilledema and/or the possibility of elevated intracranial pressure [ICP], etc.); and neurobehavioral conditions brought on by prolonged stays in space (e.g., time in confinement, neural remodeling from sensorimotor

	alterations, affective disorders). Although the NeuroCATS 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. NeuroCATS 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 neuropsychological tests for spaceflight): New items for the Matrix Reasoning Test were developed and tested for their usability in an adaptive version of the test. The Conditional Exclusion Test was replaced by the Abstraction and Working Memory (AIM) Task, as the latter is more suitable for repeated administration. We published a paper on an adaptive duration version of the PVT, and the same methods can be applied to many of the NeuroCATS tests after baseline data for astronauts are available. Specific Aim 2 (Establish learning curves for CATS neuropsychological tests and validate sensitivity to sleep deprivation): Using already existing test versions, the 10 NeuroCATS tests were inserted into 2 sleep restriction protocols currently underway at the University of Pennsylvania. Thus far, we recorded 290 full test batteries in 19 subjects. We wrote a specific software that visualizes test data immediately after acquisition. One important finding from these tests completed so far is that, after some initial training, NeuroCATS administration takes less time than expected (ca. 30 min for the whole battery). The current test software will be replaced by the CATS Toolkit software in year 2 of the protocol. Specific Aim 3 (CATS Toolkit software development and optimization for spaceflight): Excellent progress was made in developing the CATS toolkit software platform and integrating already existing and newly developed tests. The first full version will be launched in the beginning of year 2 and deployed both in the laboratory studies at the University of Pennsylvania (Aim 2) and in the astronaut study at JSC (Aim 4). The Conditional Exclusion Task was replaced with another abstraction task (AIM, Glahn et al., 1999) with higher suitability for repeated administration. In this process, 1,000 AIM stimuli were piloted in 16 students. Specific Aim 4 (JSC field testing, astronaut learning curves, and astronaut norms for performance feedback algorithm development): Instead of participating in 3 NEEMO missions, we are planning to have N=20 astronauts or astronaut candidates perform the NeurCATS battery 15 times to start building a normative data base, and to establish learning curves and gather astronaut feedback for each NeuroCATS test. We plan to start this study in year 2 of the protocol. Specific Aim 5 (International Space Station (ISS) feasibility study): Baseline data collection will start in year 3 of the protocol. First contact with ISSMP has been established.
Bibliography Type:	Description: (Last Updated: 04/05/2024)
Articles in Peer-reviewed Journals	Basner M, Dinges DF. "An adaptive-duration version of the PVT accurately tracks changes in psychomotor vigilance induced by sleep restriction." Sleep. 2012 Feb 1;35(2):193-202. PubMed PMID: 22294809 ; http://dx.doi.org/10.5665/sleep.1620 , Feb-2012