Fiscal Year:	FY 2014	**Task Last Updated:**	FY 09/17/2013
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:	0	**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 CO2, 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 data acquisition in astronauts at JSC, 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

Excellent progress was made in developing the NeuroCATS software platform and integrating already existing and newly developed tests (Aim 3). The first full version was launched in November 2012 and deployed in the laboratory studies at the University of Pennsylvania (Aim 2). Since then, 25 subjects have completed the test battery (all 10 tests) between 13 and 15 times each. We expect to gather NeuroCATS data on up to 80 more subjects in these NIH and ONR funded sleep deprivation protocols in the remaining two years of the protocol. One important finding from these tests completed so far is that, after some initial training, NeuroCATS administration takes less time than 20 min on average and is only 4 minutes longer than WinSCAT administration (although NeuroCATS has twice the number of tests). Preliminary analyses show that all 10 NeuroCATS tests seem to be sensitive to the effects of acute total sleep deprivation (Aim 2). We continued to work on even briefer, adaptive versions of the different NeuroCATS tests (Aim 1). For example, 100 Drexel University students categorized all available 600 stimuli of the Emotion Recognition test for course credit. With this information we established the difficulty and validity of each item. We started gathering normative data in astronauts while in training at JSC (Aim 4). We are currently investigating 12 mission controllers at JSC, who are performing the NeuroCATS battery 15 times total, with a 1 to 2 week interval between tests. These data will be compared to the data of up to 12 astronauts, that will also perform NeuroCATS 15 times. The data will be used to start building a normative data base, to establish learning curves and to gather user feedback for each NeuroCATS test. We are also preparing the ISS feasibility study in N=6 astronauts in close collaboration with ISS-MP (Aim 5). NeuroCATS is scheduled to launch with increment 41/42 in September 2014. For the ISS mission, "NeuroCATS" was re-named by NASA to "Cognition."

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

Data acquisition in mission controllers and astronauts at JSC (instead of during NEEMO missions) was found to be feasible. With NSBRI approval, the number of astronauts investigated during ISS missions was reduced from 8 to 6.

PROPOSED RESEARCH PLAN FOR THE COMING YEAR

The development of adaptive and/or shorter versions of the individual NeuroCATS tests will continue in year 3 of the protocol. We will continue gathering NeuroCATS data in the sleep restriction studies running at the University of Pennsylvania. Data acquisition at JSC (N=12 mission controllers and N=12 astronauts) will finish in year 3. Based on the findings of this study, the battery will be refined and finalized before operational testing on ISS starts at the end of year 3.

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 CO2, 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 space flight): We continued to work on even briefer, adaptive versions of the different NeuroCATS tests (aim 1). For example, 100 Drexel University students categorized all available 600 stimuli of the Emotion Recognition test for course credit. With this information we established the difficulty and validity of each item. 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 the laboratory studies at the University of Pennsylvania (Aim 2). Since then, 25 subjects have completed the test battery (all 10 tests) between 13 and 15 times each. We expect to gather NeuroCATS data on up to 80 more subjects in these NIH and ONR funded sleep deprivation protocols in the remaining two years of the protocol. One important finding from these tests completed so far is that, after some initial training, NeuroCATS administration takes less time than 20 min on average and is only 4 minutes longer than WinSCAT administration (although NeuroCATS has twice the number of tests). Preliminary analyses show that all 10 NeuroCATS tests seem to be sensitive to the effects of acute total sleep deprivation (Aim 2). Specific Aim 3 (CATS Toolkit software development and optimization for space flight): Excellent progress was made in developing the NeuroCATS software platform and integrating already existing and newly developed tests (Aim 3). The first full version was launched in November 2012 and deployed in the laboratory studies at the University of Pennsylvania (Aim 2) and in the study on mission controllers and astronauts at JSC (Aim 4). Specific Aim 4 (JSC field testing, astronaut learning curves, and astronaut norms for performance feedback algorithm development): We started gathering normative data in astronauts while in training at JSC (Aim 4). We are currently investigating 12 mission controllers at JSC, who are performing the NeuroCATS battery 15 times total, with a 1 to 2 week interval between tests. These data will be compared to the data of up to 12 astronauts, that will also perform NeuroCATS 15 times. The data will be used to start building a normative data base, to establish learning curves and to gather user feedback for each NeuroCATS test. Specific Aim 5 (International Space Station (ISS) feasibility study): We are also preparing the ISS feasibility study in N=6 astronauts in close collaboration with ISS-MP (aim 5). NeuroCATS is scheduled to launch with increment 41/42 in September 2014.
Bibliography Type:	Description: (Last Updated: 02/19/2024)
Abstracts for Journals and Proceedings	Schneiderman JS, Gur RC, Dinges DF, Mollicone DJ, Mott CG, McCann T, Roberts ZT, Hansen J, Savitt AP, Basner M. "Individualized Neurocognitive Assessment Toolkit for Spaceflight Fatigue (NeuroCATS)." SLEEP 2013—27th Associated Professional Sleep Societies LLC (APSS) Annual Meeting, Baltimore, MD, June 1-5, 2013. Sleep. 2013;36(Abstract Suppl):A64. Abstract 0168. , Jun-2013
Articles in Peer-reviewed Journals	Goel N, Basner M, Rao H, Dinges DF. "Circadian rhythms, sleep deprivation, and human performance." Prog Mol Biol Transl Sci. 2013;119:155-90. http://dx.doi.org/10.1016/B978-0-12-396971-2.00007-5 ; PubMed PMID: 23899598 , Jan-2013