Fiscal Year:	FY 2012	**Task Last Updated:**	FY 01/08/2013
PI Name:	Moore, Steven T. Ph.D.		
Project Title:	Galvanic Vestibular Stimulation (GVS) as an Analogue of Post-flight Sensorimotor Dysfunction		
Division Name:	Human Research		
Program/Discipline:	NSBRI		
Program/Discipline--Element/Subdiscipline:	NSBRI--Sensorimotor Adaptation Team		
Joint Agency Name:		**TechPort:**	Yes
Human Research Program Elements:	(1) **HHC**:Human Health Countermeasures		
Human Research Program Risks:	(1) **Sensorimotor**:Risk of Altered Sensorimotor/Vestibular Function Impacting Critical Mission Tasks		
Space Biology Element:	None		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
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Comments:	NOTE: PI moved to Central Queensland University, Australia, July 2016.		
Project Type:	GROUND	**Solicitation / Funding Source:**	2007 Crew Health NNJ07ZSA002N
Start Date:	05/01/2008	**End Date:**	09/30/2012
No. of Post Docs:	2	**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):	Bloomberg, Jacob (NASA Johnson Space Center) Curthoys, Ian (University of Sydney)		
Grant/Contract No.:	NCC 9-58-SA01603		
Performance Goal No.:			
Performance Goal Text:			

This project has further developed an ambulatory, reversible analog of the effects of spaceflight on sensorimotor performance (Galvanic vestibular stimulation - GVS) utilizing electrical stimulation of the vestibular (balance) nerve. The results form the basis of the current proposal.
Aim 1A (complete): Tolerance to GVS. Sixty subjects were exposed to the GVS analog for up to 20-min. The vast majority of subjects (92%) did not experience significant symptoms of motion sickness. Dilda, V, MacDougall HG, Moore, ST. Tolerance to extended Galvanic vestibular stimulation: optimal exposure for astronaut training. Aviat Space Environ Med. 2011 82:770-774.

Aim 1B (complete): Cognitive effects of GVS. Sixty subjects were exposed to subthreshold (0 or 1 mA) and 60 subjects to suprathreshold (3.5 or 5 mA) GVS while performing a range of cognitive tests; reaction time, dual tasking, mental

Task Description:	rotation, match to sample, perspective taking, Stroop, and manual tracking. Consistent with imaging studies, tasks performed in cortical areas shown to receive vestibular input were impaired by GVS (perspective taking and match to sample), whereas attention and tracking abilities were unaffected (as observed in spaceflight studies). Dilda, V, MacDougall HG, Curthoys IS, Moore, ST. (2012) Effects of Galvanic vestibular stimulation on cognitive function. Exp Brain Res, 216:275-285. Aim 2 (complete): GVS as an analog of post-flight spatial disorientation. The GVS system was recently validated in the Vertical Motion Simulator at NASA Ames during high-fidelity shuttle landing simulations. When exposed to GVS, pilot subjects (N=11; including a veteran shuttle commander of 3 flights) experienced spatial disorientation and subsequent decrements in landing performance equivalent to that observed in actual shuttle landings. Moore ST, Dilda V, MacDougall HG (2011) Galvanic vestibular stimulation as an analog of spatial disorientation after spaceflight. Aviat Space Environ Med, 82; 535-542. Aim 3 (complete): Adaptation to repeated exposures to GVS. In the 3rd and final aim of this study, we have studied adaptation to the GVS analog over a period of 9 months. Ten subjects were exposed to 120 min of 5 mA GVS over a period of 12 weeks (10 min per session). In addition, 0 and 1 mA controls group have received the same duration of exposure. All participants were tested on computerized dynamic posturography (CDP), dynamic visual acuity (DVA), and reflex eye movement response. Subjects have completed a 6-week and 6-month follow-up session. Results suggest that: (i) Subjects adapt to GVS over a period of approx. 5 weeks, with a return to baseline performance on CDP and DVA. (ii) Low-level reflex responses, such as torsional eye movement and mediolateral sway, were not affected by repeated GVS exposure. (iii) Pre-exposure preference score on CDP (relative dependence on visual/vestibular input to balance) is a strong predictor of time to adapt. (iv) GVS adaptation provided a protective effect in novel inertial environments, which persisted at least 6-months post-training. (v) GVS -trained subjects exhibited dual adaptation (to a perturbed and normal vestibular environment) with the ability to rapidly switch between states.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	1. Development of a self-contained ambulatory current generator for the safe application of low-level pseudorandom electrical current between surface-mounted mastoidal electrodes. The GVS system has been evaluated by the Food and Drug Administration and is approved for use as an investigational device for the purpose of replicating sensorimotor effects of gravity transitions. This device is also used by another National Space Biomedical Research Institute (NSBRI) Principal Investigator (PI) (Dr. Mulavara). 2. Preliminary studies demonstrating: adaptation to repeated GVS induces a similar central reweighting of sensory input as that observed in microgravity, resulting in a dual-adapted state (vestibular-perturbed and baseline) analogous to veteran astronauts; rapid switching between states; a protective effect when performing a visuomotor task in a novel vestibular environment; and persistence of dual-adaptation 6 months post-training. This pre-adaptation approach to novel vestibular environment has potential applicability for vestibular patients, utilizing the same 'dual-adaptation' premise. We have begun pilot studies applying our GVS paradigm in patients with intractable vertigo, with promising results (patient reports of diminished dizziness in daily life).
Task Progress:	Aim 1A (complete): Tolerance to GVS. Dilda, V, MacDougall HG, Moore, ST. Tolerance to extended Galvanic vestibular stimulation: optimal exposure for astronaut training. Aviat Space Environ Med. 2011 82:770-774. Aim 1B (complete): Cognitive effects of GVS. Dilda, V, MacDougall HG, Curthoys IS, Moore, ST. (2012) Effects of Galvanic vestibular stimulation on cognitive function. Exp Brain Res, 216:275-285. Aim 2 (complete): GVS as an analog of post-flight spatial disorientation. Moore ST, Dilda V, MacDougall HG (2011) Galvanic vestibular stimulation as an analog of spatial disorientation after spaceflight. Aviat Space Environ Med, 82; 535-542. Aim 3 (complete): Adaptation to repeated exposures to GVS. Postural and locomotor function recovered in an exponential pattern over 12 weeks of weekly 10-min GVS exposures, and this improvement was maintained at week 18 and 36 follow-ups. The exponential pattern of postural recovery was similar to that observed in shuttle astronauts post-flight. GVS adaptation did not occur at the vestibular end-organs or involve changes in low-level vestibulo-ocular or vestibulo-spinal reflexes. Faced with unreliable vestibular input, the CNS reweighted sensory input to emphasize veridical somatosensory and visual information to regain postural and locomotor function. After a period of recovery subjects exhibited dual adaptation and the ability to rapidly switch between the perturbed and natural vestibular state for up to 6 months, analogous to veteran astronauts. GVS trained subjects performed significantly better than untrained controls (p=0.01) on a visuomotor task in a full motion simulator during unpredictable motion, suggesting a protective effect of GVS exposure in novel vestibular environments.
Bibliography Type:	Description: (Last Updated: 09/07/2020)
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