Fiscal Year:	FY 2010	**Task Last Updated:**	FY 05/21/2010
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
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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:			
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Key Personnel Changes/Previous PI:			
COI Name (Institution):	Bloomberg, Jacob (NASA JSC) Curthoys, Ian (University of Sydney)		
Grant/Contract No.:	NCC 9-58-SA01603		
Performance Goal No.:			
Performance Goal Text:			
Task Description:	The recent NASA Small Assessment Team (SAT) and the draft NASA Human Research Program (HRP) Integrated Research Plan evaluated sensorimotor risks for future exploration class missions. A high priority was placed on the development and validation of ground-based operational tests to determine the effects of long-term microgravity exposure on sensorimotor performance, particularly manned control or supervision of spacecraft during docking and landing maneuvers. Head down bed rest (HDBR) was suggested as the ground-based analogue with which to conduct these tests. However, our recent artificial gravity study has demonstrated that HDBR does not reproduce sensorimotor deficits observed following spaceflight. There is currently no operational analogue of post-flight sensorimotor effects, and the primary aim of this proposal is to deliver such a system to facilitate the sensorimotor risk assessments mandated by the NASA SAT and HRP, as well as for crew training and countermeasure development. To this end we have developed a prototype ambulatory system that generates a reversible sensorimotor deficit. The system uses Galvanic		

	vestibular stimulation (GVS), which modulates afferent vestibular input with a pseudorandom current delivered via surface electrodes placed on the skin behind each ear. The GVS analogue has been designed such that the sensorimotor perturbation delivered accurately reproduces postural, locomotor, gaze and perceptual deficits observed in astronauts following short and long duration missions, without inducing significant motion sickness symptoms. In this proposal we aim to bring the GVS sensorimotor analogue to operational readiness by answering the following critical questions: (i) What are the optimal parameters for a single exposure to the GVS analogue? (ii) What is the long-term response to GVS? (iii) How well does the GVS analogue reproduce post-flight deficits in shuttle landing performance?
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	Our GVS paradigm disrupts normal functioning of the human vestibular system, essentially adding noise to veridical afferent information from the peripheral vestibular apparatus. In our studies we have shown that GVS replicates the sensorimotor dysfunction observed in astronauts post-flight (gait, gaze, balance, manual control). The GVS approach maybe useful for modeling spatial disorientation in commercial aviation. Another potential application is modeling of vestibular pathology.
Task Progress:	In the second year of this grant we completed Specific Aim 1 (Optimal parameters for GVS exposure). We found that (i) GVS is well tolerated by 92% of subjects (55/60), (ii) continuous exposure up to 20 min at 3.5 mA peak current and 12 min at 5 mA did not elicit adverse effects (iii) GVS, like microgravity exposure, does not affect basic cognitive function (reaction time, dual tasking, Stroop, mental rotation, manual tracking), (iv) but GVS does adversely affect complex spatial tasks (matching to sample and perspective taking). This last finding is interesting as deficits in perspective taking (the imagined movement of one's point of view in relation to another object) were implicated in the collision of the unmanned Progress module with Mir in 1997. We also completed Specific Aim 3 (GVS as an analog of spatial disorientation during orbiter landings). Pilot subjects (12) comprising veteran astronauts, NASA test pilots, and veteran USAF and Navy pilots) performed simulated shuttle landings in the Vertical Motion Simulator at NASA Ames Research Center. The VMS, the largest flight simulator in existence, is used for shuttle pilot training. Subjects performed 8 pairs of identical landing profiles with and without GVS (16 landings per subject; 176 total; 88 with and 88 without GVS). Simulation parameters were a landing weight of 226,244 lbs (the VMS uses Imperial units), 9910 ft initial altitude, 295 kts initial airspeed, and target touchdown at 204 kts ('good' range 194 - 209 kts) at a vertical sink rate of less than 3.5 ft/s. Touchdown speed was significantly higher ($p=0.026$; ANOVA) with GVS (208.6 kts [SE 3.6]) compared to the no GVS condition (204.6 kts [SE 3.5]); vertical sink rate (no GVS 3.8 ft/s [SD 0.6]; with GVS 4.5 ft/s [SD 0.8]) was also higher with GVS, but not significantly so ($p=0.085$). The adverse effects of GVS on pilot performance were obvious. Unsuccessful (crash) landings increased from 2.3% (2/88) without GVS to 9% (7/88) with GVS. Hard landings, with touchdown speed in the 'red' (unacceptable) range (>214 kts), almost doubled from 14 (15.9%) without GVS to 27 (30.7%) with GVS; GVS also induced a 32% increase in the number of landings with a vertical sink rate in the unacceptable range (>5 ft/s), from 19 to 26. GVS was an effective analog of decrements in shuttle pilot performance (in particular, 'hard' landings) following microgravity exposure.
Bibliography Type:	Description: (Last Updated: 09/07/2020)