Fiscal Year:	FY 2008	**Task Last Updated:**	FY 01/07/2008
PI Name:	Moore, Steven T. Ph.D.		
Project Title:	Head-eye Coordination during Simulated Orbiter Landings		
Division Name:	Human Research		
Program/Discipline:	HUMAN RESEARCH		
Program/Discipline--Element/Subdiscipline:	HUMAN RESEARCH--Physiology		
Joint Agency Name:		**TechPort:**	No
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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City:	New York	**State:**	NY
Zip Code:	10029	**Congressional District:**	14
Comments:	NOTE: PI moved to Central Queensland University, Australia, July 2016.		
Project Type:	GROUND	**Solicitation / Funding Source:**	2003 Biomedical Research & Countermeasures 03-OBPR-04
Start Date:	05/15/2004	**End Date:**	05/31/2010
No. of Post Docs:	1	**No. of PhD Degrees:**	
No. of PhD Candidates:	0	**No. of Master' Degrees:**	
No. of Master's Candidates:	0	**No. of Bachelor's Degrees:**	
No. of Bachelor's Candidates:	0	**Monitoring Center:**	NASA JSC
Contact Monitor:		**Contact Phone:**	
Contact Email:			
Flight Program:			
Flight Assignment:	NOTE: Received NCE to 5/31/2010 (from 6/01/2009) per J. Dardano/JSC (12/08)		
Key Personnel Changes/Previous PI:			
COI Name (Institution):	MacDougall, Hamish (Mt Sinai School of Medicine) Clark, Jonathon (NASA Johnson Space Center) Wuyts, Floris (University of Antwerp) Lesceu, Xavier (Airbus) Speyer, Jean-Jacques (Airbus)		
Grant/Contract No.:	NNJ04HF51G		
Performance Goal No.:			
Performance Goal Text:			

Task Description:	Up to 90% of crewmembers experience spatial disorientation during reentry and landing of the Orbiter, with prevalence proportional to the length of the mission. The possibility of extending shuttle missions is currently under investigation, and it is likely that the incidence and severity of spatial disorientation during reentry will increase with flight duration. This is a critical issue, as Orbiter landing data shows a decrement in performance following microgravity exposure compared to simulated landings in the Vertical Motion Simulator (VMS) at NASA Ames and the NASA Shuttle Training Aircraft. Despite the potential impact on landing operations, the basis of microgravity-related spatial disorientation is poorly understood. The aim of this proposal is to obtain basic data on the characteristics of head and eye movements during simulated Orbiter landings. This information will be used to determine landing tasks that may induce spatial disorientation. In addition, we will model spatial disorientation due to microgravity exposure using a ground-based analogue of post-flight sensorimotor deficits developed during the course of this project. The system uses Galvanic vestibular stimulation (GVS) to modulate vestibualr input to the brain with a pseudorandom current waveform. Preliminary results suggest that per-GVS exposure generate symptoms of spatial disorientation comparable to space flight. Simulated landings in the VMS will be performed both post-centrifugation and with GVS, to test the hypothesis that spatial disorientation diminishes head-eye coordination and landing performance. This may serve as a model for the deterioration in pilot performance during reentry, and provide a training regimen to allow commanders and pilots to experience spatial disorientation in a simulator. To develop a model of spatial disorientation (SD) due to microgravity exposure that can be used to familiarize shuttle pilots with SD symptoms during simulated landings, as well as a training tool to improve landing performance after space flight. This project addresses several questions from the Bioastronautics roadmap concerning disorientation and vertigo during g-level transitions, such as experienced during landing. Development of a ground-based model will help improve shuttle landing performance in the in the short term and will significantly improve mission safety, as several SD incidents impacting Orbiter safety during landing have been documented. In the long term, the SD model developed by this project will have application to future long-duration missions to ensure pilots can monitor automatic landings, and can take manual control of the space craft in off-nominal situations. The SD model may also be used to train astronauts for emergency egress and EVA on a planetary body after g-level transitions.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	Development of a training regime incorporating a model of SD is of potential use in commercial and military aviation, where significant losses of aircraft and life occur each year due to SD-related mishaps.
Task Progress:	In the fourth year of this project we have continued work on the development of an ambulatory ground-based analogue of post-flight sensorimotor function. In years one and two we demonstrated that Galvanic Vestibular Stimulation (GVS - electrical current applied via surface electrodes on the mastoid processes that stimulates the balance organs) could be used to replicate postural, locomotor and gaze instability commonly observed after return from space flight (MacDougall et al. 2006; Moore et al. 2006). In year three we demonstrated the GVS analogue to seven veteran astronaut subjects to determine how well the device recreates subjective post-landing motion illusions, as well as the postural, locomotor and oculomotor effects already established. All subjects reported that the perceptions of motion (and the postural and locomotor deficits) generated by the device were remarkably similar to that experienced after landing (NSBRI 2006). In addition, the magnitude of the GVS current required to recreate landing day sensation was proportional to the mission duration of each veteran astronaut. Thus, our work has demonstrated that ambulatory GVS is a simple, reversible model for post-flight spatial disorientation that may be titrated to model the effects of missions of varying duration. In the current year we have continued our work on the GVS analogue of post-flight sensorimotor dysfunction, focusing on the long-term response to GVS. Intermittent exposure to GVS did not elicit habituation to the stimulus (strategies to ignore, tune out, or cope with the destabilizing effects of disruptive vestibular stimuli). Determining the long-term response to GVS has important operational significance, as habituation to repeat applications could potentially diminish the value of GVS as an analogue of post-flight sensorimotor deficits. We have also continued to work on analysis of head-eye coordination during simulated orbiter landings in an Airbus A340 simulator and the Vertical Motion Simulator (VMS) at NASA Ames. In year three we characterized head, eye and aircraft movement during the banking turn prior to final approach, termed the HAC (Heading Alignment Circle) maneuver. The data demonstrated that both the head and eyes tilt into the turn with a combined magnitude of 6º, providing a combined visually-induced head/eye roll-tilt reflex with a gain of around 14% of bank angle, tending. The roll of the head and eyes likely represents a tendency to align the retina with the earth horizon, to improve spatial orientation by establishing the retinal image of the horizon as a primary visuo-spatial cue. In the current year we extended this result to orbiter landings in the VMS, demonstrating that the Heads Up Display (HUD) did not suppress the tilt of the head and eye towards the visual horizon. In addition, we characterized head-eye coordination during final approach in the A340 and VMS. These results have been submitted as a paper to Aviation Space Environmental Medicine, which is currently in review.
Bibliography Type:	Description: (Last Updated: 09/07/2020)
Abstracts for Journals and Proceedings	Moore ST, MacDougall HG. "A high fidelity model of microgravity exposure for mission simulation and astronaut training." 16th IAA Humans in Space Symposium, Beijing / China, May 20-24, 2007. Proceedings 16th IAA Humans in Space Symposium, Beijing / China, May 20-24, 2007. , May-2007
Abstracts for Journals and Proceedings	Moore ST, MacDougall HG, Ondo W. "Ambulatory monitoring of freezing of gait in Parkinson's disease." 11th International Congress on Movement Disorders, Istanbul, Turkey, June 3-7 2007. Movement Disorders 2007 Apr; 22(16 Suppl): 255. , Apr-2007
Articles in Peer-reviewed Journals	Moore ST, Macdougall HG, Ondo WG. "Ambulatory monitoring of freezing of gait in Parkinson's disease." J Neurosci Methods. 2008 Jan 30;167(2):340-8. PMID: 17928063 , Jan-2008
Articles in Peer-reviewed Journals	Moore ST, Macdougall HG, Gracies JM, Ondo WG. "Locomotor response to levodopa in fluctuating Parkinson's disease." Exp Brain Res. 2007 Sep 8; [Epub ahead of print] PMID: 17828529 , Sep-2007

Articles in Peer-reviewed Journals	Moore ST, MacDougall HG, Gracies JM, Cohen HS, Ondo WG. "Long-term monitoring of gait in Parkinson's disease." Gait Posture. 2007 Jul;26(2):200-7. Epub 2006 Oct 13. PMID: 17046261 , Jul-2007