Fiscal Year:	FY 2006	**Task Last Updated:**	FY 03/08/2006
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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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:**	06/01/2009
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:			
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, two paradigms will be used to model spatial disorientation due to microgravity exposure: 1) long-duration hyper-gravity exposure in a centrifuge, and 2) galvanic vestibular stimulation (GVS). Preliminary results suggest that post-centrifuge disorientation, and 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 second year of this project we have developed an ambulatory system for modeling of spatial disorientation induced by microgravity exposure. In the first year we demonstrated that a pseudorandom Galvanic vestibular stimulation (GVS - electrical current applied via surface electrodes on the mastoid processes that stimulates the balance organs) could be used to model postural instability commonly observed after return from space flight. This work is now published (MacDougall et al. 2006) and included as an Appendix to this report. In the current (second) year of this project we have extended the GVS system in two ways: 1) in addition to the original pseudorandom (stochastic) GVS waveform we have developed a head-coupled Galvanic stimulus that uses the measured head movement to generate a predictable but erroneous vestibular response, analogous to that reported by astronauts post-flight during active and passive head motion; and 2) the GVS apparatus has been miniaturized such that it can be worn by the subject during active tasks such as obstacle course navigation (Fig. 4). In collaboration with Dr. Bloomberg at NASA JSC, 20 subjects underwent two functional tests developed for post-flight astronaut assessment; namely, dynamic visual acuity during treadmill locomotion, and navigation of an obstacle course; while experiencing both forms of GVS. The results demonstrated that GVS generated decrements in visual acuity and mobility that were remarkably similar to that observed in astronauts after both short-duration (shuttle) and ISS missions. Thus, our work has demonstrated that ambulatory GVS is a simple, reversible model for post-flight postural, locomotor and gaze deficits. Moreover, in contrast to other models of spatial disorientation (such as hypergravity centrifugation) GVS does not induce motion sickness. We believe our novel GVS technique may prove useful in astronaut training. Preliminary data was obtained in September 2005 from one subject undergoing GVS during simulated Orbiter landings in the Vertical Motion Simulator (VMS) at NASA Ames Research Center. The pilot reported that GVS added significantly to the workload required to land the shuttle in a manner similar to "fighting" through vertigo during an instrument approach. In addition, the subject noted that "I had really had a physical and mental workout by the time I got the shuttle on the ground – this is much more likely to be what the astronauts have to contend with". In the next phase of testing we aim to use GVS in the VMS to test the hypothesis that GVS generates spatial disorientation similar to that experienced after spaceflight, and will induce degradation in pilot performance analogous to that observed in actual shuttle landings. We examined whether g-transitions alone could account for decrements in pilot performance in an experiment flown aboard two ESA parabolic flight campaigns. Subjects were asked to identify targets that appeared at random on a large screen and head and eye movements were simultaneously acquired. Preliminary data suggests that performance was consistent across the g-transitions (1-g to 1.8-g to 0-g to 1.8-g to 1-g). This supports the original hypothesis of this project; that degradation of pilot performance is due to extended microgravity exposure during space flight, rather than the g-level transitions of reentry. We have applied elements of the measurement technology developed during this project to measure head movement during unrestrained daily activity over 10 hours in normal subjects (N=20). The results were striking: during locomotor activities (walking, cycling etc) subjects adopted a cadence of 2 Hz (SD 0.15) that was independent of age, height, gender or body mass index. This basic result is of considerable significance – there exists a spontaneous 2 Hz tempo of human locomotion. This work has been published (Macdougall and Moore 2005) and is included as an Appendix to this report.
Bibliography Type:	Description: (Last Updated: 09/07/2020)
Abstracts for Journals and Proceedings	Moore, S.T.; MacDougall, H. "Spatial disorientation during shuttle landings." Australian Society for Aerospace Medicine Annual Scientific Meeting, Gold Coast, Australia, September 2005. Proceedings ASAM 2005 , Sep-2005

Abstracts for Journals and Proceedings	Moore, S.T. "Artificial gravity for interplanetary missions" Australian Society for Aerospace Medicine Annual Scientific Meeting, Gold Coast, Australia, September 2005. Proceedings ASAM 2005 , Sep-2005
Abstracts for Journals and Proceedings	MacDougall, H.; Moore, S.T. "Modeling Space Adaptation Syndrome (SAS) with Galvanic vestibular stimulation." Australian Society for Aerospace Medicine Annual Scientific Meeting, Gold Coast, Australia, September 2005. Proceedings ASAM 2005 , Sep-2005
Abstracts for Journals and Proceedings	MacDougall, H.; Moore, S.T. "The spontaneous tempo of human locomotion" Society for Neuroscience Annual Meeting, Washington, DC, November 2005. Program No. 864.9. 2005 Abstract Viewer/Itinerary Planner. Washington, DC: Society for Neuroscience , Oct-2005
Abstracts for Journals and Proceedings	Moore, S.T.; MacDougall, H.; Curthoys, I.S. ; Black, F.O. "Galvanic vestibular stimulation as a model for human locomotor dysfunction." Society for Neuroscience Annual Meeting, Washington, DC, November 2005. Program No. 864.10. 2005 Abstract Viewer/Itinerary Planner. Washington, DC: Society for Neuroscience , Nov-2005
Abstracts for Journals and Proceedings	Black, F.O.; MacDougall, H.G.; Curthoys, I.S.; Moore, S.T. "Modeling vestibulopathic postural instability with Galvanic vestibular stimulation." Society for Neuroscience Annual Meeting, Washington, DC, November 2005. Program No. 168.7. 2005 Abstract Viewer/Itinerary Planner. Washington, DC: Society for Neuroscience , Nov-2005
Articles in Peer-reviewed Journals	MacDougall HG, Moore ST. "Marching to the beat of the same drummer: the spontaneous tempo of human locomotion." J Appl Physiol. 2005 Sep;99(3):1164-73. PMID: 15890757 , Sep-2005
Articles in Peer-reviewed Journals	MacDougall HG, Moore ST, Curthoys IS, Black FO. "Modeling postural instability with Galvanic vestibular stimulation." Exp Brain Res. 2006 Jun;172(2):208-20. Epub 2006 Jan 24. PMID: 16432695 http://dx.doi.org/10.1007/s00221-005-0329-y , Jun-2006
NASA Technical Documents	Moore ST, MacDougall HG. "Enhanced video-oculography system." NASA Technical Brief MSC 23957-1, July 2005. , Jul-2005