Fiscal Year:	FY 2007	**Task Last Updated:**	FY 01/04/2007
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 (Revised as of IRP Rev M)		
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 third year of this project we have continued work on the development of an ambulatory system for modeling of spatial disorientation induced by microgravity exposure. 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 model postural, locomotor and gaze instability commonly observed after return from space flight (MacDougall et al. 2006; Moore et al. 2006). In the current year of this project we begun to test GVS on 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. Seven veteran astronaut subjects have undergone GVS, and 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. 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. We presented the results of our GVS research to the NSBRI User Group (comprised of active and retired astronauts) in October 2006, with the aim of incorporating GVS as a model of spatial disorientation in shuttle pilot training. We have also continued to work on analysis of head-eye coordination during simulated Orbiter landings. Head, eye and aircraft movement during the banking turn prior to final approach, termed the HAC (Heading Alignment Circle) maneuver, were obtained in 5 pilot subjects in an Airbus A340 full-motion simulator. The data shows that both the head and eyes tilt into the turn with a combined magnitude of 6º, tending to align the retina with the visual horizon. This response was not apparent in zero visibility, and is likely produced from the tilted image of the horizon on the retina. Previous studies (Gallimore et al. 1999, 2000; Patterson et al. 1997) have shown that pilots tilt their head into the turn during banking (the optokinetic cervical reflex); our results extend this finding by demonstrating that the eyes also tilt into the turn, providing a combined visually-induced head/eye roll-tilt reflex with a gain of around 14% of bank angle. In a related project we have modified the hardware used in the current project to measure stride length in patients with Parkinson's Disease (PD). A recent publication (Moore et al 2006) demonstrated that long-term community monitoring of gait in PD patients provided an objective measure of stride length changes due to levodopa-related medications and disease severity.
Bibliography Type:	Description: (Last Updated: 09/07/2020)
Abstracts for Journals and Proceedings	Moore ST, MacDougall H. "Galvanic vestibular stimulation as a model of space adaptation syndrome." Presented at the Aerospace Medical Association (AsMA) Annual Scientific Meeting, Orlando, Florida, May 2006. Proceedings 77th AsMA Scientific Conference, May 2006. , May-2006
Abstracts for Journals and Proceedings	Wuyts FL, MacDougall HG, Pattyn N, Moore ST. "Head-eye coordination and reaction time during G-level transitions experienced during the 39th and 41st ESA-parabolic flight campaigns." Presented at Aerospace Medical Association (AsMA) Annual Scientific Meeting, Orlando, Florida, May 2006. Proceedings 77th AsMA Scientific Meeting, May 2006. , May-2006
Abstracts for Journals and Proceedings	Moore ST, MacDougall H, Cohen, H. "The spontaneous tempo of human locomotion." Presented at Barany Society Meeting, Uppsala Sweden, June 2006. Proceedings Barany Society 2006 Meeting, June 2006. , Jun-2006

Abstracts for Journals and Proceedings	MacDougall H, Moore ST, Cohen, H, Bloomberg JJ, Peters B, Black FO, Curthoys IS. "Galvanic vestibular stimulation as a model for human vestibulopathic postural instability and locomotor dysfunction." Presented at Barany Society Meeting, Uppsala Sweden, June 2006. Proceedings Barany Society 2006 Meeting, June 2006. , Jun-2006
Abstracts for Journals and Proceedings	Moore ST, MacDougall HG, Clark J, Wuyts F, Lesceu X, Speyer J. "Spatial disorientation during orbiter landing." 7th Symposium on the Role of the Vestibular Organs in Space Exploration, ESA ESTEC, Noordwijk, The Netherlands, June 2006. Proc. 7th Symposium on the Role of the Vestibular Organs in Space Exploration, ESA ESTEC, Noordwijk, The Netherlands, June 2006. , Jun-2006
Abstracts for Journals and Proceedings	MacDougall H, Moore ST. "Galvanic vestibular stimulation as a model of space adaptation syndrome." 7th Symposium on the Role of the Vestibular Organs in Space Exploration, ESA ESTEC, Noordwijk, The Netherlands, June 2006. Proc. 7th Symposium on the Role of the Vestibular Organs in Space Exploration, ESA ESTEC, Noordwijk, The Netherlands, June 2006. , Jun-2006
Abstracts for Journals and Proceedings	Moore ST, MacDougall HG, Gracies J-M, Cohen HS, Ondo WG. "Assessment of locomotor response to levodopa in fluctuating Parkinson's disease." 10th International Congress of Parkinson's Disease and Movement Disorders, Kyoto, Japan, October 2006. Movement Disorders 2006 Sep; 21(Suppl. 15): S462. , Sep-2006
Articles in Peer-reviewed Journals	Moore ST, MacDougall HG, Peters BT, Bloomberg JJ, Curthoys, IS, Cohen HS. "Modeling locomotor dysfunction following spaceflight with Galvanic vestibular stimulation." Exp Brain Res 2006 Oct;174: 647-659. PMID: 16763834 , Oct-2006
Articles in Peer-reviewed Journals	Moore ST, MacDougall HG, Gracies J-M, Cohen HS, Ondo WG. "Long-term monitoring of gait in Parkinson's disease." Gait Posture. 2006 Oct 12; [Epub ahead of print] PMID: 17046261 http://www.gaitposture.com/ , Oct-2006