Fiscal Year:	FY 2015	**Task Last Updated:**	FY 08/01/2014
PI Name:	Wood, Scott J. Ph.D.		
Project Title:	Effect of Sensorimotor Adaptation Following Long-Duration Spaceflight on Perception and Control of Vehicular Motion		
Division Name:	Human Research		
Program/Discipline:	HUMAN RESEARCH		
Program/Discipline--Element/Subdiscipline:	HUMAN RESEARCH--Biomedical countermeasures		
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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Comments:	NOTE: PI returned to NASA JSC in January 2017. PI was at Azusa Pacific University from August 2013 – January 2017; prior to August 2013, PI was at NASA JSC.		
Project Type:	FLIGHT	**Solicitation / Funding Source:**	2008 Crew Health NNJ08ZSA002N
Start Date:	10/01/2009	**End Date:**	02/29/2016
No. of Post Docs:	0	**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:**	NASA JSC
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Flight Program:	ISS		
Flight Assignment:	ISS Expeditions 32S, 33S, 35S, 37S, 38S, 39S, and 41S (per PI) (Ed., 8/7/14) ISS Increments 33-34, 35-36, and 37-38 (pending in September 2012)--per PI (Ed., 8/7/2012) NOTE: End date is now 2/29/2016 per HRP Master Task List dated 7/12/2011 (Ed., 8/4/2011)		
Key Personnel Changes/Previous PI:	None		
COI Name (Institution):			
Grant/Contract No.:	Internal Project		
Performance Goal No.:			
Performance Goal Text:			

Task Description:

The central nervous system must resolve new patterns of sensory cues during movement in a novel gravitoinertial environment in order to maintain accurate spatial orientation awareness. We hypothesize that adaptive change in how inertial cues from the vestibular system are integrated with other sensory information leads to perceptual disturbances and impaired manual control during transition to a new gravity environment. The primary goals of this investigation are to quantify post-flight decrements in manual control performance during a rover simulation (both acute and recovery), and to examine the relationship between manual control errors and adaptive changes in sensorimotor function and motion perception. Eight crewmembers returning from 6 month stays onboard the International Space Station (ISS) will be tested on a six degree-of-freedom motion simulator during four pre-flight and three post-flight sessions on R+1, 4 and 8 days following landing. Ground control studies on non-astronauts will assess effects associated with learning across multiple sessions, changes in proficiency as a function of time between pre- and post-flight sessions and changes in performance during galvanic vestibular stimulation.
This rover simulation study has been incorporated within the manual control study titled "Assessment of operator proficiency following long-duration spaceflight" under the direction of principal investigator Dr. Steven Moore. Dr. Moore's project includes a test battery to assess sensorimotor and cognitive function, including vestibular (pitch/roll tilt motion perception), visual acuity, manual dexterity, manual tracking with and without dual tasking, reaction time, sleepiness scale, perspective taking and spatial memory (match-to-sample). Dr. Moore's experiment also includes driving and flying simulations. According to our hypothesis, we predict that decrements in sensorimotor and cognitive function will correlate with performance metrics during the operator simulations.

The simulator utilizes a Stewart-type motion base (CKAS, Australia), single-seat cabin with triple scene projection covering 150° horizontal by 50° vertical, and joystick controller. The rover simulation consists of a serial presentation of four discrete docking tasks that the crewmember attempts to complete within each session. Each task consists of 1) perspective-taking, using a map that defines the rover orientation and location relative to the docking target, 2) navigation toward the target around a Martian outpost as efficiently as possible, and 3) docking a side hatch of the rover to another rover or habitat hatch using a visually guided targeting system. The primary dependent variables obtained from each component include time to completion and accuracy. At the completion of each task, a new perspective map will appear to initiate the next task in the series. The total time the crewmember can complete four docking tasks will determine the overall operator proficiency for the rover simulation.

Rationale for HRP Directed Research:

Research Impact/Earth Benefits:

Sensorimotor function is critical for spatial orientation, gaze stabilization, and postural stability. This project examines how adaptive changes in sensorimotor and cognitive function may increase the risk of impaired ability to maintain control of vehicles and other complex systems. The goal is to map changes in physiological function with functional measures of manual control. Establishing these relationships will be relevant to how pathophysiological impairments in sensorimotor processing may affect other vehicular control tasks, such as driving with vestibular patients. Vehicle driving is one of the most complex tasks required of humans. A majority of vestibular-impaired patients report that driving is difficult or dangerous. Successful completion of this project will contribute to the development of assessment techniques for determining fitness for driving duty. Specifically, the rover simulation utilizes a multiple degree-of-freedom motion base simulator to address aspects of vehicular control performance, including perspective taking, navigating a course safely, and fine positioning control. This approach can be easily adapted to a wide variety of simulated vehicle designs to provide similar assessments in other operational and civilian populations.

Task Progress:

ISS Flight Study: Our flight study utilizes repeated measures pre- versus post-flight design on eight ISS astronauts, where each subject will serve as their own control. Between November and May of this past year postflight data collection was completed on three additional subjects. A sixth crewmember is scheduled to complete the study by the end of this reporting period. Preflight data was also conducted on the final three flight subjects. The final subject is targeted for the 41S landing in May 2015.
Ground control studies

Changes as a function of session recency (shadow control study). For the flight study, some changes in proficiency are expected as a function of time independent of the effects of microgravity. There are typically about 8 months between the last preflight and first postflight sessions. One of our ground control studies will examine the changes in operator proficiency following an 8-month gap between the 4th and 5th sessions as a control for this recency effect. One of the major efforts for the team at JSC this past year was to initiate this shadow control study to be conducted on at least 8 subjects. Since this control study will include Dr. Moore's T38 simulation, age and gender matched non-astronaut pilots have been recruited to participate. To date nine subjects are in progress and 11 subjects have been recruited. Up to 12 subjects will be recruited to account for attrition following the 8 month gap between the simulated "preflight" and "postflight" sessions.

Effects of learning across sessions. Our first ground study was conducted to determine the acquisition of skill proficiency in our novel rover simulation. Twenty healthy subjects were tested in 5 sessions, with 1-3 days between sessions. This study also served as a normative data set to establish the reliability of the rover analysis methods and finalize the set of four docking tasks used throughout the flight study.

Changes during galvanic vestibular stimulation (GVS). As a factor of influence study, we also measured performance during the rover simulation in 11 subjects with and without GVS. High levels of GVS (3-5 mA) have been utilized extensively as a sensorimotor spaceflight analog to assess the effects of disrupting vestibular function on posturography, locomotion, manual control, and cognitive function. Each subject performed four different rover trials with GVS, and the same four trials without GVS, for a total of eight trials each. As previously reported, the presence of GVS increased the variability of responses for all three subtasks – perspective taking, navigation, and docking. Some subjects were more affected than others. These results suggest that some subjects may be utilizing visual feedback more effectively to compensate for the vestibular disturbance caused by GVS.

Therefore, we also conducted a second session in which subjects were asked to perform both subjective vertical tasks and closed-loop nulling with and without GVS with both visual feedback and in the dark. For the perception task, subjects were asked to report their perceived tilt during roll axis disturbances by maintaining the joystick aligned with Earth-vertical. The primary measure was the root mean square (RMS) error. For the nulling task, subjects were asked to null roll axis disturbances using the same joystick. Nulling gain was derived from least squares regression fits relative to

	the tilt profile command, using 1-slope so that higher gain meant that more tilt was nulled and the cabin remained more upright, while lower gains reflected more tilt movement of the cabin. Tilt perceptual errors were significantly increased with GVS. Perceptual errors were reduced with eyes open and an Earth visual reference. With the visual reference, subjects were able to indicate tilt as accurately with or without GVS, suggesting a visual compensation for the vestibular disturbance. Tilt nulling gain was generally greatest in the same conditions in which tilt perceptual errors were reduced. While GVS had less effect on nulling performance, the closed loop control task with a visual reference was significantly improved over the eyes closed conditions. In a similar manner, we might expect that any decrements in the post-flight rover performance due to vestibular impairment may be compensated by the visual references that the rover simulation provides.
Bibliography Type:	Description: (Last Updated: 03/08/2024)
Abstracts for Journals and Proceedings	Pereira MA, Paloski W, Wood SJ. "Head and trunk stability during roll motion with galvanic vestibular stimulation." Presented at the 37th Association for Research in Otolaryngology MidWinter Meeting, San Diego, CA, February 22-26, 2014. Association for Research in Otolaryngology Abstracts. 2014;37: Abstract #PS-640. p. 398. , Feb-2014
Abstracts for Journals and Proceedings	Moore ST, Dilda V, Morris TR, MacDougall HG, Wood SJ. "Assessment of operator proficiency after long duration spaceflight." Paper presented at the 2014 NASA Human Research Program Investigators' Workshop, Galveston, TX, February 12-13, 2014. 2014 NASA Human Research Program Investigators' Workshop, Galveston, TX, February 12-13, 2014. http://www.hou.usra.edu/meetings/hrp2014/pdf/3169.pdf , Feb-2014