Fiscal Year:	FY 2011	**Task Last Updated:**	FY 11/30/2010
PI Name:	Wood, Scott J. Ph.D.		
Project Title:	(ZAG/Otolith) Ambiguous Tilt and Translation Motion Cues After Space Flight / Otolith assessment during postflight re-adaptation		
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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Zip Code:	77058	**Congressional District:**	36
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:**	2004 Space Life Sciences 04-OBPR-01: ILSRA 2004
Start Date:	10/01/2005	**End Date:**	04/30/2012
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:	1	**No. of Bachelor's Degrees:**	0
No. of Bachelor's Candidates:	0	**Monitoring Center:**	NASA JSC
Contact Monitor:	Baumann, David	**Contact Phone:**	
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Flight Program:	Shuttle/ISS		
Flight Assignment:	ISS STS-123 (ZAG only), STS-128, STS-129, STS-130, STS-132, STS-134 NOTE: End date is now 4/30/2012 per HRP Master Task List dated 7/12/2011 (Ed., 8/4/2011) NOTE: Received extension to 9/30/2011 per PI (10/2010)		
Key Personnel Changes/Previous PI:			
COI Name (Institution):	Clement, Gilles (International Space University) Rupert, A. (U.S. Army Aeromedical Research Laboratory) Harm, Deborah (NASA Johnson Space Center) Andrew, Clarke (Charité Medical School)		
Grant/Contract No.:	ILSRA-04-136 (ZAG), ILSRA-04-235 (Otolith)		
Performance Goal No.:			
Performance Goal Text:			

Task Description:	Adaptive changes during space flight in how the brain integrates vestibular cues with other sensory information can lead to impaired movement coordination, vertigo, spatial disorientation and perceptual illusions following G-transitions. These two collaborative NASA-ESA studies are designed to examine both the physiological basis and operational implications for disorientation and tilt-translation disturbances following space flight. 1. Ambiguous Tilt and Translation Motion Cues after Space Flight (See also http://www.nasa.gov/): This experiment utilizes a unique motion paradigm on NASA's Tilt-Translation Sled (TTS) in which the resultant gravitoinertial vector remains aligned with the body longitudinal axis during tilt motion (referred to as the Z-axis gravitoinertial or ZAG paradigm). One specific aim is to examine the effects of stimulus frequency on adaptive changes in eye movements and motion perception during independent tilt and translation motion profiles. The TTS provides pitch tilt combined with fore-aft translation. The variable radius centrifuge (VRC) provides lateral translation during rotation, resulting in illusory roll-tilt. We hypothesize that the great adaptive changes will occur in the mid-frequency range where there is a crossover of tilt and translation otolith-mediated responses. Another specific aim is to employ a closed-loop nulling task in which subjects are tasked to use a joystick to null out tilt motion disturbances on these two devices. The stimuli consist of random steps or sum-of-sines stimuli, including the ZAG profiles on the TTS. We hypothesize the ability to control tilt orientation will be compromised following space flight, with increased control errors corresponding to changes in self-motion perception. A final specific aim is to evaluate how sensory substitution aids (e.g., vibrotactile feedback) can be used to improve manual control performance. We hypothesize that performance on the closed-loop tilt control task will be improved with tactile display feedback of tilt orientation. 2. Otolith Assessment during Post-flight Re-adaptation (See also http://www.nasa.gov/): This experiment utilizes two experiment paradigms that allow unilateral assessment of otolith function. During unilateral centrifugation (constant rotation at 400 deg/s), subjects are displaced by 3.5 cm so that one utricle is located off-axis while the opposite side is centered over the axis of rotation. A second protocol utilizes the vestibular evoked myogenic potentials (VEMP) as an indicator of unilateral saccule function via vestibulo-collic pathways. One specific aim is to examine the variability (gain, asymmetry) in both otolith-ocular responses and the subjective visual vertical to unilateral centrifugation (UC), and measure the time course of post-flight recovery. Similarly, another aim is to assess the variability in amplitude and latency of VEMPs. This study design will allow test of hypotheses regarding changes in sensitivity to gravitoinertial acceleration, as well as the otolith asymmetry hypothesis as an explanation of individual variability for sensorimotor adaptation. Note that the Otolith experiment includes both short and long-duration crewmembers. Since these experiments share similar methodologies and equipment (VRC), they have been integrated although they remain separate experiments (ILSRA-04-136 ZAG, and ILSRA-04-235 - Otolith)
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	Otolith function is critical for spatial orientation, gaze stabilization, and postural stability. This project examines adaptive mechanisms of otolith function, in particular how decrements in otolith function may increase the risk of impaired ability to maintain control of vehicles and other complex systems. Both experiments address a research gap regarding functional recovery of otolith function data following space flight. Changes measured in these otolith-mediated reflexes will provide insight into the high inter-subject variability in sensorimotor impairment observed during and following G-transitions. The closed-loop nulling tasks employed during the ZAG experiment will provide a new means of addressing the functional implications of vestibular loss. These measures will be relevant to how impairments in otolith processing may affect other vehicular control tasks, such as driving with vestibular impairments. The refinement of a tactile prosthesis to improve spatial orientation will serve as a countermeasure for tilt-translation disturbances on a variety of acceleration platforms. Validation of simple sensory aids will be applicable to balance prosthesis applications for vestibular loss patients and the elderly to mitigate risks due to falling or loss of orientation.
Task Progress:	During the covered reporting period, 5 subjects participated in ZAG and 4 participated in the Otolith experiment. There are now 9 ZAG subjects and 8 Otolith subjects projected to complete the experiments by the last Shuttle flight. In addition to these subjects, normative data collection was completed with 8 ground control subjects on both VRC and TTS sessions. ZAG Variable Radius Centrifuge (VRC) and Tilt-Translation Sled: One of the first aims for the ZAG experiment is to examine the effect of stimulus frequency on otolith-mediated responses. We hypothesized that adaptation of otolith-mediated responses will be greatest in the mid-frequency range where there is a crossover of tilt-translation responses. Our preliminary findings suggest differences in the neural processing to distinguish tilt and translation between eye movements and motion perception. Specifically, during dynamic linear stimuli in the absence of canal and visual input, a change in stimulus frequency alone elicits similar changes in the amplitude of both self motion perception and eye movements. However, in contrast to the eye movements, the phase of both perceived tilt and translation motion is not altered by stimulus frequency over this limited range. A preliminary comparison between pre- and post-flight motion perception results suggest there is a shift of the cross-over frequency between tilt and translation responses. Additional specific aims are to examine changes in manual control error as a function of short-duration space flight, and to examine whether vibrotactile feedback can improve control performance. There are clear deficits in some crewmembers' ability to null out tilt disturbances during VRC on landing day. Preliminary results also indicate that both RMS position error and velocity are significantly reduced with vibrotactile feedback. Changes in tilt motion perception appear highly correlated with changes in the nulling gain as derived from a linear regression of the tilt position on the amount of tilt disturbance. On landing day the manual control performance was reduced by ~37% based on these gain measures. Although a similar decrement was observed with tactile feedback, the performance with TSAS on landing day was within range of the preflight performance without tactile feedback. Subsequent data collection suggests that most crewmembers return to preflight baselines within 2 days post-flight on the VRC. There is evidence of additional learning effects on subsequent post-flight tests, so that these observed deficits may be underestimated. Otolith VRC: One of the primary aims of the Otolith study is to examine the variability (gain, asymmetry) in both otolith-ocular responses and the subjective visual vertical during unilateral centrifugation. Based on the initial findings, there is evidence of reduced otolith-ocular gain in some subjects. Consistent with the ZAG results above, there is also a trend for subjects to overestimate their tilt orientation using the SVV task. Of particular interest, there is also an increased SVV asymmetry on landing day.

	These preliminary findings, if confirmed by further data collection, would suggest the following: 1. There is reduced OOR in some subjects during unilateral centrifugation post-flight. 2. There is an overestimation of the amplitude of tilt and translation perception immediately after space flight (especially low and medium frequencies), but no changes in the phase of tilt-translation perception. 3. There is an increase in SVV asymmetry early post-flight. 4. There is evidence of impaired manual control in the absence of vision when subjects are relying primarily on vestibular and somatosensory cues for orientation. 5. A simple tactile prosthesis improves the ability to null out tilt motion within a limited range of tilt disturbances. More testing will be required to confirm these findings, as well as explore how the variability in otolith-mediated motion perception and eye movements relate to the impaired ability to perform manual control tasks.
Bibliography Type:	Description: (Last Updated: 03/08/2024)
Abstracts for Journals and Proceedings	Wood SJ, Clarke AH, Rupert AH, Harm DL, Clément GR. "ZAG-Otolith: Modification of otolith-ocular reflexes, motion perception and manual control during variable radius centrifugation following spaceflight." Presented at the NASA Human Research Program Investigators' Workshop, Houston TX, February 2010. NASA Human Research Program Investigators' Workshop, Houston TX, February 2010. http://www.dsls.usra.edu/meetings/hrp2010/pdf/Sensorimotor/1044Wood.pdf , Feb-2010
Abstracts for Journals and Proceedings	Wood SJ, Clément GR. "Translational vestibulo-ocular reflexes during off-vertical axis rotation." Presented at the 33rd Association for Research in Otolaryngology Mid-Winter Meeting, Anaheim, CA, February 6-10, 2010. 33rd Association for Research in Otolaryngology Mid-Winter Meeting, Anaheim, CA, February 6-10, 2010. , Feb-2010
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Abstracts for Journals and Proceedings	Clarke AH, Wood SJ, Schoenfeld U. "The OTOLITH Experiment - assessment of otolith function during post-flight re-adaptation." Presented at the Life in Space for Life on Earth joint life sciences meeting, Trieste, Italy, 13-18 June 2010. Life in Space for Life on Earth joint life sciences meeting, Trieste, Italy, 13-18 June 2010. , Jun-2010