Fiscal Year:	FY 2009	**Task Last Updated:**	FY 04/23/2010
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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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:**	09/30/2011
No. of Post Docs:	0	**No. of PhD Degrees:**	0
No. of PhD Candidates:	1	**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
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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: Received extension to 9/30/2011 per PI (10/2010)		
Key Personnel Changes/Previous PI:			
COI Name (Institution):	Clement, Gilles (Centre National de la Recherche Scientifique, Toulouse, France) Rupert, A. (U.S. Army Aeromedical Research Laboratory) Harm, Deborah (NASA Johnson Space Center)		
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:	Study Schedule: The current plans include testing on 8 short duration subjects (ZAG & Otolith) and 8 long duration subjects (Otolith only). Measurements will be obtained for each experiment pre-flight at L-120 (±30), L-90 (±30), and L-30 (±10) days and post-flight at R+0, R+1 (TTS only), R+2 or 3, R+4 or 5, and R+8 days. This experiment has been manifested on STS-123 (ZAG only), STS-128, STS-129, STS-130, STS-132, STS-134 and STS-134. Complete data sets have been obtained to date on 5 subjects for ZAG and 4 subjects for Otolith. Other crewmembers have incomplete R+0/1 data sets and therefore will not be included. In addition to these subjects, the normative data collection was initiated with 7 ground control subjects. ZAG: One of the first aims for the ZAG experiment is to examine the effect of stimulus frequency on otolith-mediated responses. We hypothesize that adaptation of otolith-mediated responses will be greatest in the mid-frequency range where there is a crossover of tilt-translation responses. Our findings to date emphasize 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 faadback can improve control performance. There are clear deficits in some crewmembers ability to null out tilt disturbances during VRC. Preliminary results also indicate that the RMS error is also significantly reduced with vibrotactile feedback. Otolith: 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 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. Conclusions: 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 evidence of impaired manual control in the absence of vision when subjects are relying primarily on

	vestibular and somatosensory cues for orientation. 4. A simple tactile prosthesis improves the ability to null out tilt motion within a limited range of tilt disturbances.
Bibliography Type:	Description: (Last Updated: 06/03/2025)
Abstracts for Journals and Proceedings	Clément GR, Harm DL, Rupert AH, Beaton KH, Wood SJ. "Ambiguous tilt and translation motion cues in astronauts after space flight." Proceedings from the Space Life Sciences Conference in Angers (France), June 2008. Journal of Gravitational Physiology, 2008. , Jun-2008
Abstracts for Journals and Proceedings	Beaton KH, Holly JE, Clément GR, Wood SJ. "Effects of frequency and motion paradigm on perception of tilt and translation during periodic linear acceleration." Presented at Association for Research in Otolaryngology Mid-Winter Meeting, Baltimore MD, February 2009. ARO meeting abstracts, 2009. , Feb-2009
Abstracts for Journals and Proceedings	Wood SJ, Clarke AH, Harm DL, Rupert AH, Clément GR. "Ambiguous tilt and translation motion cues after space flight and otolith assessment during post-flight re-adaptation." Presented at the NASA Human Research Program Investigators' Workshop, League City, TX, February 2009. NASA Human Research Program Investigators' Workshop, meeting abstracts, 2009. , Feb-2009