Fiscal Year:	FY 2005	**Task Last Updated:**	FY 11/02/2005
PI Name:	Wood, Scott J. Ph.D.		
Project Title:	Sensorimotor Adaptation Following Exposure to Ambiguous Inertial Motion Cues		
Division Name:	Human Research		
Program/Discipline:	NSBRI Teams		
Program/Discipline--Element/Subdiscipline:	NSBRI Teams--Sensorimotor Adaptation Team		
Joint Agency Name:		**TechPort:**	No
Human Research Program Elements:	(1) **HHC**:Human Health Countermeasures		
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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:	Ground	**Solicitation / Funding Source:**	2003 Biomedical Research & Countermeasures 03-OBPR-04
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No. of Master's Candidates:	0	**No. of Bachelor's Degrees:**	2
No. of Bachelor's Candidates:	2	**Monitoring Center:**	NSBRI
Contact Monitor:		**Contact Phone:**	
Contact Email:			
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COI Name (Institution):	Harm, Deborah (NASA JSC) Clement, Gilles (Centre National de la Recherche Scientifique) Rupert, Angus (Naval Aerospace Medical Research Laboratory)		
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Task Description:	The central nervous system must resolve the ambiguity of inertial motion sensory cues in order to derive accurate spatial orientation awareness. Our general hypothesis is that the central nervous system utilizes both multi-sensory integration and frequency segregation as neural strategies to resolve the ambiguity of tilt and translation stimuli. Movement in an altered gravity environment, such as weightlessness without a stable gravity reference, results in new patterns of sensory cues. For example, the semicircular canals, vision and neck proprioception provide information about head tilt on orbit without the normal otolith head-tilt position that is omnipresent on Earth. Adaptive changes in how inertial cues from the otolith system are integrated with other sensory information lead to perceptual and postural disturbances upon return to Earth's gravity. The primary goals of this ground-based research investigation are to explore physiological mechanisms and operational implications of disorientation and tilt-translation disturbances reported by crewmembers during and following re-entry, and to evaluate a tactile prosthesis as a countermeasure for improving control of whole-body orientation during passive tilt and translation motion paradigms. Our first specific aim is to examine the effects of stimulus frequency and different patterns of inertial sensory cues on adaptive changes in eye movements and motion perception during combined tilt and translation motion profiles. Our first hypothesis is that adaptation of otolith-mediated eye movement and perceptual responses will be greatest in the mid-frequency range where there is a crossover of tilt and translation otolith-mediated responses. We are testing this hypothesis by exposing subjects to various combinations of tilt and translation motion profiles over the frequency range from 0.1 Hz to 0.6 Hz. Changes in eye movement and perceptual tilt responses are determined by comparing pre- and post-adaptation runs performed in darkness. The tilt and translation profiles are restricted to one plane at a time to compare adaptation when using either pitch tilt with fore-aft translation or roll tilt with lateral translation. During this first year, we implemented the 'vision aligned' paradigm using the JSC's Preflight Adaptation Training laboratory's Tilt-Translation Device (TTD). Using this device, tilt chair motion is coupled with translation visual scene motion aligned with the horizontal head axis, resulting in a visual-vestibular mismatch in which both canals and otoliths signal tilt while vision does not. Although the dynamic response of this device has limited measurements to <0.2 Hz, we have begun a series of pilot experiments (N=12, 6M, 6F) designed to examine the most effective phase relationships between tilt chair and translational scene motion. Preliminary results indicate that while linear vection is robust during the vision aligned paradigm at 0.1 Hz, the post-adaptative changes are relatively small as predicted at these lower stimulus frequencies. The major effort in the first project year was to design and develop a device to incorporate the 'GIF aligned' paradigm in which the chair will tilt within an enclosure that will simultaneously translate so that the resultant gravitoinertial force (GIF) vector remains aligned with the longitudinal body axis. This paradigm will result in a mismatch in which the canals and vision signal tilt while the otoliths do not. The Naval Aerospace Medical Research Laboratory (NAMRL) Engineering Services in Pensacola has designed an air bearing track with dual ironless linear motors to provide the translational motion. A dual-wheel friction drive provides tilt chair motion up to 45 deg from vertical inside an 8 feet cube enclosure. In addition to elucidating physiological mechanisms for re-entry disturbances, the adaptation paradigms utilized for our first specific aim also provide a ground-based model for evaluating the adverse operational implications of tilt-translation adaptation. Our second specific aim is to employ a closed-loop nulling task in which subjects will be tasked to use a joystick to null out tilt motion disturbances with or without concomitant translation motion. We predict the ability to control tilt orientation will be compromised following tilt-translation adaptation, with increased control errors corresponding to changes in self-motion perception. During this first year, we performed nulling experiments (N=14, 7M, 7F) during roll-tilt step (up to 45 deg) and pseudorandom profiles (0.01, 0.15, 0.3 & 0.6 Hz). This experiment also allowed us to initiate our third specific aim to evaluate how a tactile prosthesis might improve control performance. A simple 4 electromechanical tactor system was developed that provided 6 threshold levels of orientation information. A significant reduction in RMS error ($p<0.05$) was observed using this simple tactile prosthesis. These results are promising in that a fairly simple device with as few as 4 tactors may prove useful to significantly improve landing performance. During the next project year, we expect to complete the new linear track device in Pensacola, and continue Specific Aims 1 & 2 to examine the effects of stimulus frequency on adaptive changes in otolith ocular reflexes, motion perception and closed-loop nulling performance. We will also continue to refine the simple tactile prosthesis, optimizing feed-forward information from velocity to improve control performance. The results of this study will contribute to the refinement of the tactile prosthesis to improve spatial orientation and navigation on different acceleration platforms, including landing systems used for return to Earth after long duration space travel or landing systems used during space exploration missions.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	This project will provide insight into adaptive mechanisms of otolith function, in particular as they relate to one's perception of motion and gaze stabilization reflexes. The results of this study will be relevant therefore to vestibular pathophysiology, and understanding compensatory processes following loss or disruption of otolith function in clinical applications. The closed-loop nulling tasks employed by our experiment team will provide a new means of addressing the functional implications of vestibular loss, for example, characterizing risks associated with civilian piloting or automobile driving following vestibular loss. Finally, the development of simple tactile displays 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:	1. In support of Specific Aim 1, pilot studies have been initiated with 12 subjects (6M, 6F) to examine the most effective phase relationships between tilt chair and translational scene motion during the 'vision aligned' paradigm using the JSC's Preflight Adaptation Training laboratory's Tilt-Translation Device (TTD). Note that these studies were delayed for ~4 months due to facility lockout. 2. The Naval Aerospace Medical Research Laboratory (NAMRL) Engineering Services in Pensacola has designed a new device to provide the 'GIF aligned (gravitoinertial force) paradigm. This device includes an air bearing track with dual ironless linear motors to provide the translational motion. A dual-wheel friction drive provides tilt chair motion up to 45 deg from vertical inside an 8 feet cube enclosure. The initial progress on this development was delayed due to facility shutdown following Hurricane Ivan. This device should be completed during the first half of project year 2. 3. In support of Specific Aim 2, roll-tilt nulling experiments were completed in 14 subjects (7M, 7F) during step (up to 45 deg) and pseudorandom profiles (0.01, 0.15, 0.3 & 0.6 Hz). 4. In support of Specific Aim 3, a simple electromechanical tactor system using only 4 tactors was developed that provided 6 threshold levels of orientation information. During the next year, we will continue to refine this tactile prosthesis, optimizing feed-forward information from velocity to improve control performance.
Bibliography Type:	Description: (Last Updated: 06/03/2025)

Presentation	Wood, S. J., G. R. Clement, D. L. Harm, A. H. Rupert, F. E. Guedry, and M. F. Reschke "Sensorimotor adaptation following exposure to ambiguous inertial motion cues" N/A Jan-2005