Fiscal Year:	FY 2015	**Task Last Updated:**	FY 10/19/2015
PI Name:	Young, Laurence R. Sc.D.		
Project Title:	Countermeasures to Reduce Sensorimotor Impairment and Space Motion Sickness Resulting from Altered Gravity Levels		
Division Name:	Human Research		
Program/Discipline:	NSBRI		
Program/Discipline--Element/Subdiscipline:	NSBRI--Sensorimotor Adaptation Team		
Joint Agency Name:		**TechPort:**	Yes
Human Research Program Elements:	(1) **HHC**:Human Health Countermeasures		
Human Research Program Risks:	(1) **Sensorimotor (SM)**:Risk of Impaired Control of Spacecraft, Associated Systems and Immediate Vehicle Egress Due to Vestibular/Sensorimotor Alterations Associated with Space Flight		
Space Biology Element:	None		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
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Zip Code:	02139-4301	**Congressional District:**	8
Comments:			
Project Type:	GROUND	**Solicitation:**	2012 Crew Health NNJ12ZSA002N
Start Date:	08/01/2013	**End Date:**	07/31/2016
No. of Post Docs:	1	**No. of PhD Degrees:**	1
No. of PhD Candidates:	3	**No. of Master' Degrees:**	0
No. of Master's Candidates:	1	**No. of Bachelor's Degrees:**	0
No. of Bachelor's Candidates:	1	**Monitoring Center:**	NSBRI
Contact Monitor:		**Contact Phone:**	
Contact Email:			
Flight Program:			
Flight Assignment:			
Key Personnel Changes/Previous PI:			
COI Name (Institution):	Merfeld, Daniel (Massachusetts Eye and Ear Infirmary) Oman, Charles (Massachusetts Institute of Technology) Karmali, Faisal (Massachusetts Eye and Ear Infirmary) Priesol, Adrian (Massachusetts Eye and Ear Infirmary)		
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Performance Goal No.:			
Performance Goal Text:			

Task Description:	The effect of altered gravity on astronauts' perceptions and motor skills is significant as it threatens the health, well being, and performance of crews. Astronauts experience gravitational transitions during launch from Earth's gravitational level to microgravity in space, then to partial gravity if landing on the Moon, Mars, or Martian moons, followed by a return to microgravity, and finally re-entry back to Earth. In addition, the use of Artificial Gravity (AG) from an on-board centrifuge also presents an altered gravity challenge, in particular during transitions between gravity levels. During each of these g-transitions astronauts must adapt their sensorimotor programs to coordinate perceptual and motor capabilities and function successfully and safely. The ability to identify and predict individual differences in this adaptability is essential to the development of pharmacological and training interventions for future crew members. This project takes a new approach which could lead to an effective, practical, and acceptable protocol for pre-adapting astronauts to space flight. By using the gravito-inertial alterations possible with centrifugation in different body orientations we will quantify an individual's sensory adaptation capability using measures of sensorimotor impairment and motion sickness under altered gravity. We will use these results to predict and to minimize the consequences of movement in any other gravity environment. In combination with appropriate use of a drug (promethazine) we anticipate the development of a new pre-flight adaptation protocol to minimize disorientation and motion sickness and to overcome disturbances in manual control. An important step in the development will be the determination of the benefit and risks associated with the use of promethazine in conjunction with adaptation training. The specific aims and hypothesis for this project are: SA1) Demonstrate that individual differences exist in the ability to adapt to gravitational transitions, and can be measured quantitatively by measures of subjective orientation, closed loop manual control, and subjective motions sickness reports. Preliminary data analysis show individual differences in performance of the manual control task in terms of initial performance decrement and adaptation time constant. Apart from individual differences, subjects consistently show a performance decrement in the closed-loop manual control task on initial exposure to altered-gravity, followed by an performance return back to baseline performance. SA2) Test whether pre-training by adapting to one altered gravity environment can improve sensorimotor adaptation in another altered gravity environment. SA3) Test whether the leading pharmacological agent, promethazine, affects either basic vestibular perceptual function or the adaptation rate to an altered gravity environment and the associated motion sickness symptoms. SA4) Develop and test a combined pre-adaptation training and pharmacological intervention protocol that can both improve sensorimotor adaptation and reduce the associate motion sickness. The hypotheses are: H1) Individual differences exist in the ability to adapt to altered gravity environments and these differences can be predicted by measuring adaptability in one altered gravity environment. H2) Pre-adaptation training in one altered gravity environment will improve sensorimotor adaptation in another altered gravity environment. H3) Promethazine will reduce motion sickness, but will have no influence on either basic vestibular perceptual function or sensorimotor adaptation to altered gravity environments. To date, one important finding is that promethazine has little effect on vestibular perceptual function. This is important because it eliminates a possible confound in our ongoing adaptation experiments. Deliverables include a methodology for measuring an individual's capacity to adapt to an altered gravity environment using affordable centrifuge tests, and a combined pharmacological and pre-adaptation training intervention to reduce the severity of motion sickness and sensorimotor impairment during gravitational transitions.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	Sensorimotor function is altered during gravitational transitions, such as those that occur during space flight. Related space motion sickness also occurs regularly during gravity transitions and impacts performance and operations. Astronauts must remain functional during the critical mission phases that occur during or temporally close to gravity transitions, particularly for vehicle control and landing tasks. This project presents an experimental approach aimed at developing combined pharmacological and pre-training countermeasures, using a centrifuge to change the G-level. Specifically, we propose a combination of promethazine application and altered-gravity pre-training to reduce the severity of space motion sickness and sensorimotor impairment during gravitational transitions. Understanding sensorimotor impairment in altered gravity environments is also relevant for Earth applications. For example, it is important to understand how altered gravity exposure affects pilot performance, including perception and manual control, since the consequences could be catastrophic. Pre-training protocols based on our findings could be also applicable to pilots in order to prevent motion sickness and sensorimotor impairment related to altered gravity environments. In addition, sensorimotor rehabilitation is critical important here on Earth for elderly and patient populations. Our findings on sensorimotor adaptation to altered gravity will likely be translatable to the learning and adaptation required during sensorimotor rehabilitation. Understanding sensorimotor adaptation mechanisms, enhancing adaptative rates, and being able to predict individuals who may have trouble with sensorimotor adaptation are all important topics for sensorimotor rehabilitation patients here on Earth.
	Promethazine Study: We conducted a double-blinded, within-subject study to compare vestibular perceptual thresholds with the administration of promethazine and placebo. Perceptual thresholds were measured in three motion directions: 1) yaw rotation at 1 Hz, y-translation at 1 Hz, and roll tilt at 0.2 Hz (otolith/SCC crossover frequency). The dosage of promethazine was the standard 25 mg, given orally. Both the promethazine and placebo were given about 2 hours before the start of testing and the order of administration was counterbalanced across subjects. Vestibular perceptual thresholds were measured using a 6-dof motion device in the Jenks Vestibular Physiology Laboratory (JVPL) at the Massachusetts Eye and Ear Infirmary (MEEI). We found that there was a significant but small effect only on roll tilt perception but we believe that this small effect will not alter our future adaptation results. Refined Perception and Manual Control Measurement Methodologies and Optimized Experiment Design: The measures of adaptation that will be used have been finalized to include a roll tilt perception, manual control task, and subjective reports of motion sickness. Roll tilt perception will be measured from the orientation of a haptic indicator during static and dynamic tilts. The manual control task will be a closed loop task in which the subjects will use the indicator bar to maintain an upright orientation in response to a pseudo-random roll tilt disturbance. Human subject pilot testing of both of these tasks (upright and supine) has been used to investigate and resolve practical implementation issues as well as to inform the simulation tool. Informed by pilot data, the simulation tool allows us to explore where improvements can be

Task Progress:	made in experiment parameters such as length, profile tilt angles, static and continuous tilt time, and frequency of subject reports. Hardware/Software Development: A considerable effort has focused on software and hardware development necessary for our planned experiments. The chair on the centrifuge, which was originally in the upright position, has been moved into the supine position, as it should be to allow for our designed altered gravity levels in our future experiments. During safety testing, we were faced with an unexpected issue with the centrifuge concerning a position control error. This problem delayed our progress but the entire team worked to resolve the issue. We were able to complete extensive human subject safety testing for the device and we are now quickly moving forward with testing and data collection. Exercise and Artificial Gravity (AG): Graduate student, Ana Diaz, completed her PhD thesis investigating the combination of exercise and centrifugation. This research was inspired by the AGREE proposal, which intended to construct a short-radius centrifuge in an International Space Station (ISS) module. Subjects were tested with 3 different levels of AG and ergometer exercise. Results were used to modify and refine a cardiovascular model that captured the transient hemodynamic responses to exercise under AG.
Bibliography Type:	Description: (Last Updated: 04/10/2019)
Abstracts for Journals and Proceedings	Clark TK, Newman MC, Oman CM, Merfeld DM, Young LR. "Modeling Human Orientation Perception in Altered Gravity." 2015 NASA Human Research Program Investigators' Workshop, Galveston, TX, January 13-15, 2015. 2015 NASA Human Research Program Investigators' Workshop, Galveston, TX, January 13-15, 2015. , Jan-2015
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