Fiscal Year:	FY 2014	**Task Last Updated:**	FY 09/08/2014
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:**	0
No. of PhD Candidates:	1	**No. of Master' Degrees:**	0
No. of Master's Candidates:	2	**No. of Bachelor's Degrees:**	0
No. of Bachelor's Candidates:	0	**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. 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 lead to a loss of a vehicle. 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 critically 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.
Task Progress:	In the previous year, we focused our efforts on the design and preparation of the experiments. We will implement 5 different experiments to tests our hypothesis. In Experiment 1 we aim to test whether an individual's adaptation rate in one altered gravity environment can be predicted by an individual's adaptation in a different gravity environment. For this purpose we will test if an individual's adaptation rate in -1.5 Gz (headward centrifugal force) will predict their adaptation rate in +1.5 Gz (footward centrifugal force). Since we expect adaptation to one environment to temporarily influence an individual's ability to adapt to other environments, we will separate these two adaptation conditions by at least six months. In Experiment 2, we will test the hypothesis that pre-training by adapting to one altered gravity (-1.5 Gz) will temporarily enhance an individual's ability to adapt to another altered gravity environment (+1.5 Gz). For this purpose we will separate the pre-training and testing sessions by 1 week. In Experiment 3 we will test the impact that promethazine has on basic vestibular function using perceptual thresholds, tilt perception, and manual control measures. In Experiment 4, we will test whether promethazine influences adaptation to altered gravity. Specifically, we will study adaptation to a +1.5 Gz environment with and without promethazine application. We hypothesize that motion sickness will be reduced with promethazine, but that adaptation rate will be unaffected. Finally in Experiment 5, we will combine the promethazine use with the pre-training countermeasure. We hypothesize

	that the combined intervention will result in reduced motion sickness and improved sensorimotor adaptation during adaptation to an altered gravity environment (+1.5 Gz). A considerable effort has focused on software and hardware development to be used during the experiments. A key component for all experiments is a somatosensory joystick used to report the perceived tilt angle during experiments, as well as to do the manual control task. Furthermore, the centrifuge at Massachusetts Eye and Ear Infirmary (MEEI) is being modified to include this joystick, as well as to facilitate orienting the device in a supine mode.
Bibliography Type:	Description: (Last Updated: 04/10/2019)
Abstracts for Journals and Proceedings	Clark TK, Newman MC, Oman CM, Merfeld DM, Young LR. "Human Perception of Roll Tilt in Hyper-Gravity: Experiments and Modeling." XXVIIIth Barany Society Meeting, Buenos Aires, Argentina, May 25-28, 2014. XXVIIIth Barany Society Meeting, Buenos Aires, Argentina, May 25-28, 2014. , May-2014
Abstracts for Journals and Proceedings	Galvan RC, Bloomberg JJ, Mulavara AP, Clark TK, Merfeld DM, Oman CM. "Improving Sensorimotor Function and Adaptation using Stochastic Vestibular Stimulation." 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/ , Feb-2014
Abstracts for Journals and Proceedings	Beckers NWM, Young LR, Karmali F, Clark TK. "Studying the Innate Capacity for Sensorimotor Adaptation to Altered Gravity Levels." 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/ , Feb-2014
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Articles in Peer-reviewed Journals	Oman CM, Cullen KE. "Brainstem processing of vestibular sensory exafference: implications for motion sickness etiology." Exp Brain Res. 2014 Aug;232(8):2483-92. Epub 2014 May 18. http://dx.doi.org/ ; PubMed PMID: 24838552; PubMed Central PMCID: PMC4130651 , Aug-2014
Awards	Clark TK. "2014 Stanley Roscoe Award for Best Doctoral Thesis from the Aerospace Human Factors Association (AsHFA). Thesis title: 'Human Perception and Control of Vehicle Roll Tilt in Hyper-Gravity,' May 2014." May-2014
Papers from Meeting Proceedings	Clark TK, Newman MC, Merfeld DM, Young LR. "Pilot control and stabilization of a rate-controlled vehicle in hyper-gravity." 2014 IEEE Aerospace Conference, Big Sky, MT, March 1-8, 2014. In: 2014 IEEE Aerospace Conference, Digest of Papers, p. 1-8. http://dx.doi.org/ ; accessed 9/17/2014. , Mar-2014