

<b>Fiscal Year:</b>	FY 2014	<b>Task Last Updated:</b>	FY 10/16/2013
<b>PI Name:</b>	Bloomberg, Jacob J. Ph.D.		
<b>Project Title:</b>	Developing Predictive Measures of Sensorimotor Adaptability to Produce Customized Countermeasure Prescriptions		
<b>Division Name:</b>	Human Research		
<b>Program/Discipline:</b>	NSBRI		
<b>Program/Discipline--Element/Subdiscipline:</b>	NSBRI--Sensorimotor Adaptation Team		
<b>Joint Agency Name:</b>	<b>TechPort:</b>	Yes	
<b>Human Research Program Elements:</b>	(1) <b>HHC:</b> Human Health Countermeasures		
<b>Human Research Program Risks:</b>	(1) <b>HSIA:</b> Risk of Adverse Outcomes Due to Inadequate Human Systems Integration Architecture (2) <b>Sensorimotor:</b> Risk of Altered Sensorimotor/Vestibular Function Impacting Critical Mission Tasks		
<b>Space Biology Element:</b>	None		
<b>Space Biology Cross-Element Discipline:</b>	None		
<b>Space Biology Special Category:</b>	None		
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<b>Zip Code:</b>	77058-3607	<b>Congressional District:</b>	36
<b>Comments:</b>			
<b>Project Type:</b>	Ground	<b>Solicitation / Funding Source:</b>	2011 Crew Health NNJ11ZSA002NA
<b>Start Date:</b>	10/01/2012	<b>End Date:</b>	09/30/2015
<b>No. of Post Docs:</b>	0	<b>No. of PhD Degrees:</b>	0
<b>No. of PhD Candidates:</b>	1	<b>No. of Master' Degrees:</b>	0
<b>No. of Master's Candidates:</b>	0	<b>No. of Bachelor's Degrees:</b>	0
<b>No. of Bachelor's Candidates:</b>	0	<b>Monitoring Center:</b>	NSBRI
<b>Contact Monitor:</b>	<b>Contact Phone:</b>		
<b>Contact Email:</b>			
<b>Flight Program:</b>			
<b>Flight Assignment:</b>			
<b>Key Personnel Changes/Previous PI:</b>			
<b>COI Name (Institution):</b>	Buccello-Stout, Regina ( Wyle Integrated Sciences and Engineering Group ) Wood, Scott ( Azusa Pacific University ) Cohen, Helen ( Baylor College of Medicine ) Mulavara, Ajitkumar ( Universities Space Research Association ) Peters, Brian ( Wyle Laboratories, Inc. ) Brady, Rachel ( Wyle Integrated Sciences and Engineering Group ) Seidler, Rachael ( University of Michigan, Ann Arbor )		
<b>Grant/Contract No.:</b>	NCC 9-58-SA02801		
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<b>Performance Goal Text:</b>			

**Task Description:**

Astronauts experience sensorimotor disturbances during the initial exposure to microgravity and during the readaptation phase following a return to a gravitational environment. These alterations may lead to disruption in the ability to perform mission critical functional tasks during and after these gravitational transitions. Astronauts show significant inter-subject variation in adaptive capability following gravitational transitions. The ability to predict the manner and degree to which each individual astronaut will be affected would improve the effectiveness of a countermeasure comprised of a training program designed to enhance sensorimotor adaptability. Due to this inherent individual variability we need to develop predictive measures of sensorimotor adaptability that will allow us to predict, before actual space flight, which crewmember will experience challenges in adaptive capacity. Thus, obtaining this information will allow us to design and implement better sensorimotor adaptability training countermeasures that will be customized for each crewmember's unique adaptive capabilities. Therefore the goals of this project are to: 1) develop a set of predictive measures capable of identifying individual differences in sensorimotor adaptability, and 2) use this information to design sensorimotor adaptability training countermeasures that are customized for each crewmember's individual sensory bias and adaptive capacity.

To achieve these goals we have the following specific aims:

**Specific Aim 1:** Determine whether behavioral metrics of individual sensory bias predicts sensorimotor adaptability. Subjects show individual variation in the degree to which sensory inputs are weighted and reorganized to produce motor output during exposure to discordant sensory conditions. These individual sensory biases may serve as predictors of adaptability. For this aim, subjects will perform tests that will delineate individual sensory biases in tests of visual, vestibular and proprioceptive function. They will then be tested to determine if these metrics predict how quickly they adapt to a novel discordant sensory environment.

**Specific Aim 2:** Determine if individual capability for strategic and plastic-adaptive responses predicts sensorimotor adaptability. The transition from one sensorimotor state to another consists of two main mechanisms: strategic and plastic-adaptive. Strategic modifications represent immediate and transitory changes in control that are employed to deal with short-term changes in the prevailing environment. If these changes are prolonged then plastic-adaptive changes are evoked that modify central nervous system function to automate new behavioral responses. For this aim, each subject's strategic and plastic-adaptive abilities will be assessed using two tests of locomotor function designed specifically to delineate both mechanisms. Subjects will then be tested to determine if these measures predict how quickly they adapt to a novel discordant sensory environment.

**Specific Aim 3:** Develop predictors of sensorimotor adaptability using brain structural and functional metrics. We will measure individual differences in regional brain volumes (structural MRI), white matter integrity (diffusion tensor imaging, or DTI), functional network integrity (resting state functional connectivity MRI), and sensorimotor adaptation task-related functional brain activation (functional MRI). Subjects will then be tested to determine if these metrics predict how quickly they behaviorally adapt to a novel discordant sensory environment.

**Specific Aim 4:** Determine if individualized training prescriptions based on predictive metrics can be used to optimize sensorimotor adaptability training countermeasures. To determine if predictive adaptability metrics can be used to design individualized training programs we will examine a test case focusing on improving adaptive performance of visually dependent subjects. Subjects who are identified in Experiment 1, as being visually dependent with reduced adaptive capability will receive individualized training prescriptions designed to reduce their dependence on vision and increase their ability to use vestibular information for control of movement. The training program will have two components. 1) Subjects will walk on a treadmill-motion base system while viewing discordant visual scenes to reduce dependency on vision along with support-surface motion to challenge gait stability. 2) During this training subjects will receive stimuli (vestibular stochastic resonance) to enhance vestibular signal detection. We anticipate that these two components will act in synergy during training to both reduce visual dependency while increasing dependence on vestibular information. Training efficacy will be assessed by comparing the performance of trained and control visually dependent subjects on how quickly they adapt to a novel discordant sensory environment.

In an effort to increase efficiency and data capture we are currently conducting data collection for Specific Aims 1, 3, and part of 2 simultaneously on the same subjects.

**Rationale for HRP Directed Research:****Research Impact/Earth Benefits:**

Sensorimotor adaptability training programs have Earthbound application in rehabilitation of patients with balance disorders, and for fall prevention training among seniors. We have previously shown that training using variation in visual flow during treadmill exercise improves functional mobility in healthy older adults who were experiencing age-related postural instabilities (Buccello-Stout et al. 2008; 2013). This project will provide measures that will allow individualized training programs that serve to enhance the efficacy of ground-based rehabilitation and training programs.

Buccello-Stout, RR, Bloomberg, JJ, Cohen, HS, Whorton, EB, Weaver, GD, & Cromwell, RL. Effects of sensorimotor adaptation training on functional mobility in older adults. *J Gerontol B Psychol Sci Soc Sci.* 63(5): 295-300. 2008.

Buccello-Stout RR, Cromwell RL, Bloomberg JJ, Whorton EB. Effects of sensorimotor adaptation training on head stability movement control in response to a lateral perturbation in older adults. *The Journal of Aging and Physical Activity.* 21: 272-289. 2013.

**Task Progress:**

In an effort to increase efficiency we decided to complete the data collection for Specific Aims 1, 3, and part of 2 simultaneously on the same subjects. This approach had a number of benefits including: 1) Increased data capture: by having the same subjects perform all three specific aims we can enhance our ability to detect how a wider range factors can predict adaptability in a specific individual. This provides a much richer data base and potentially a better understanding of the predictive power of the selected factors. 2) Minimize prior adaptive experience: Subjects who have previously participated in any of our adaptation experiments were excluded from this study because that prior experience may serve as a training modality and therefore potentially influence our results. To satisfy this requirement we requested that the NASA Test Subject Office only recruit completely naive subjects. Given this constraint it was more efficient to perform Specific Aims 1, 2, and 3 in a single block. 3) Minimize the number of MRI scans: This approach allowed us to leverage on-going scanning activities in the lab and therefore increase efficiency and reduce costs. We are currently in the process of collecting data.

	In order to perform this integrated data collection procedure the following activities were completed: 1) Institutional Review Board approval was obtained. 2) A NASA Test Readiness Review was completed. 3) Pilot experimental dry runs were conducted at the University of Texas Medical Branch (UTMB) Victory Lakes MRI facility to practice and finalize the neuroimaging procedures required for Specific Aim 3. 4) Procedures to measure proprioceptive acuity were developed that were superior to those described in the initial proposal. In collaboration with the NASA-JSC Exercise Physiology Lab a more accurate and repeatable measure of proprioceptive acuity was implemented entailing the use of an isokinetic dynamometer that measures an individual's ability to reproduce a predetermined joint angle after passively moving the limb.
<b>Bibliography Type:</b>	Description: (Last Updated: 06/03/2025)
<b>Abstracts for Journals and Proceedings</b>	Bloomberg JJ, Mulavara AP, Peters BT, Wood SJ, Reschke MF. "Sensorimotor countermeasures: Improving performance during gravitational transitions." 84th Annual Scientific Meeting, Aerospace Medical Association, Chicago, IL, May 12-16, 2013. Aviation, Space, and Environmental Medicine. 2013 Apr;84(4):422. , Apr-2013
<b>Abstracts for Journals and Proceedings</b>	Bloomberg JJ, Peters BT, Mulavara AP, Brady RA, Buccello-Stout R, Miller CA, Batson CD, Wood SJ, Cohen HS, Seidler RD. "Developing predictive measures of sensorimotor adaptability to produce customized countermeasure prescriptions." 2013 NASA Human Research Program Investigators' Workshop, Galveston, TX, February 12-14, 2013. 2013 NASA Human Research Program Investigators' Workshop, Galveston, TX, February 12-14, 2013. , Feb-2013
<b>Articles in Peer-reviewed Journals</b>	Buccello-Stout RR, Cromwell RL, Bloomberg JJ, Whorton EB. "Sensorimotor adaptation training's effect on head stabilization in response to a lateral perturbation in older adults." The Journal of Aging and Physical Activity. 2013 Jul;21(3):272-89. Epub 2012 Sep 18. PubMed <a href="#">PMID: 23006335</a> , Jul-2013
<b>Articles in Peer-reviewed Journals</b>	Peters BT, Brady RA, Batson CD, Guined JR, Ploutz-Snyder RJ, Mulavara AP, Bloomberg JJ. "Adaptation in locomotor stability, cognition, and metabolic cost during sensory discordance." Aviation, Space, and Environmental Medicine. 2013 Jun;84(6):567-72. PubMed <a href="#">PMID: 23745284</a> ; <a href="http://dx.doi.org/10.3357/ASEM.3529.2013">http://dx.doi.org/10.3357/ASEM.3529.2013</a> , Jun-2013
<b>Awards</b>	Bloomberg J. "JSC Group Achievement Award for the Development of the Sensorimotor Adaptability Training System, June 2013." Jun-2013