Fiscal Year:	FY 2016	**Task Last Updated:**	FY 10/12/2016
PI Name:	Bloomberg, Jacob J. Ph.D.		
Project Title:	Developing Predictive Measures of Sensorimotor Adaptability to Produce Customized Countermeasure Prescriptions		
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) **HSIA**:Risk of Adverse Outcomes Due to Inadequate Human Systems Integration Architecture (2) **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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City:	Houston	**State:**	TX
Zip Code:	77058-3607	**Congressional District:**	36
Comments:			
Project Type:	Ground	**Solicitation / Funding Source:**	2011 Crew Health NNJ11ZSA002NA
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No. of PhD Candidates:	1	**No. of Master' Degrees:**	0
No. of Master's Candidates:	0	**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:	NOTE: End date changed to 5/31/2016 per NSBRI (Ed., 11/5/15)		
Key Personnel Changes/Previous PI:			
COI Name (Institution):	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) Brady, Rachel (Wyle Integrated Sciences and Engineering Group) Seidler, Rachael (University of Michigan)		
Grant/Contract No.:	NCC 9-58-SA02801		
Performance Goal No.:			
Performance Goal Text:			

Task Description:	Astronauts experience sensorimotor disturbances during the initial exposure to microgravity and during the readaptation phase following a return to an Earth-gravitational environment. These alterations may lead to disruption in the ability to perform mission critical functional tasks required during 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. Therefore the goal of this project was to develop a set of predictive measures capable of identifying individual differences in sensorimotor adaptability to aid in the design of sensorimotor adaptability training countermeasures that are customized for each crewmember's individual sensory bias and adaptive capacity. To achieve these goals we pursued the following specific aims: Specific Aim 1: Determine whether behavioral metrics of individual sensory bias predicts strategic responses and sensorimotor adaptability to novel sensory environments. Specific Aim 2: Develop predictors of strategic responses and sensorimotor adaptability using brain structural and functional metrics. Specific Aim 3: Determine whether specific genetic polymorphisms are associated with individual differences in strategic responses and sensorimotor adaptability to novel sensory environments. Subjects performed behavioral tests that delineated individual sensory bias in tests of visual, vestibular, and proprioceptive function. Subjects were also tested for individual differences in brain white matter integrity (using diffusion tensor imaging, or DTI), functional network integrity (using resting state functional connectivity MRI), and functional MRI activation associated with sensorimotor adaptation task performance. We also determined whether specific genotypes were associated with individual differences in sensorimotor adaptability. Three distinct motor learning tests were used to characterize individual behavioral strategic responses and motor learning capability. The Locomotor Balance Test characterized the strategic initial locomotor responses to a novel walking environment. The Adaptive Functional Mobility Test (AFMT) and the Adaptive Manual Control Test represented tasks producing plastic-adaptive response to a novel sensory environment. Subjects performed these tests to determine if behavioral, neuroimaging and genetic metrics predicted individual strategic and motor learning capability. Behavioral metrics related to proprioceptive function, visual dependency, and sensory integration served as the best predictors of individual strategic and motor learning capability. Behavioral results indicated that performance and adaptability are specific to the environment being tested. This study explored relationships between behavioral parameters and performance on three different types of adaptation tasks. Each task had a different combination of significant parameters and no single parameter was significant for all three motor learning tasks. Diffusion Tensor Imaging (DTI) is an MRI technique used to assess white matter quality in the brain. The DTI results indicated that white matter microstructural integrity plays a role in how well individuals are able to respond to novel sensorimotor disturbances. Importantly, the white matter integrity of the corpus callosum was associated with enhanced performance suggesting that intact inter-hemispheric connectivity is an important factor for optimal responsiveness to novel changes in the sensory environment. Resting state functional connectivity MRI (fcMRI) was used to investigate individual differences in large-scale brain networks. These results demonstrated that specific patterns of functional connectivity between resting state networks involved in motor control and cognition are associated with individual differences in sensorimotor adaptation. The fMRI results indicated that a variety of frontal, temporal, and cingulate cortical and subcortical areas in which activation was predictive of individual differences in adaptability during a manual adaptation task. This suggests that some people might be more proficient at recruiting neural areas that allow for efficient adaptation learning. We determined whether genotypes for COMT, DRD2, BDNF, and Alpha 2 adrenergic receptor (DraI) single nucleotide polymorphisms (SNPs) were associated with individual differences in strategic responses and sensorimotor adaptability to novel sensory environments. The DraI and COMT SNPs showed a trend towards distinguishing subjects who exhibit faster or slower responses and adaptation rates on two locomotor tasks. These findings were limited by small sample size, but show promising initial results that may be improved upon by collecting more subject data. In conclusion this study revealed that behavioral, neuroimaging, and genetic metrics can predict individual responses to novel sensory environments and motor learning capability. Predictive power may be enhanced using composite measures composed of a mix of behavioral, neuroimaging, and genetic metrics. Further investigations with astronauts in actual spaceflight conditions will serve to further validate potential predictive metrics of adaptability. These results have important implications for adaptation training programs that facilitate astronaut adaptation to novel environments and for rehabilitation. Specifically, the prospect of identifying people who will likely have difficulty with sensorimotor adaptation would allow for more targeted training programs.
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). Personalized medicine has become an important research topic. Many brain stimulation, physical therapy, and pharmacological approaches to movement disorders are efficacious for some individuals but not others. The ability to predict ahead of time which patients would be most responsive to differing types of treatments would clearly save time and costs, and increase patients' quality of life by providing targeted rehabilitation interventions targeted at individual sensory biases and ability to process sensory information. 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 and maximize the predictive power of our measures we collected data for Specific Aims 1 and 2 simultaneously on the same subjects. This involved behavioral testing in our labs at NASA/Johnson Space Center and neuroimaging at the University of Texas Medical Branch Victory Lakes Facility, which is located offsite. This approach had a number of benefits including increased data capture. By having the same subject perform both specific aims we were able to enhance our ability to detect how a wider range factors and their groupings 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. Dr. Mulavara is currently conducting a complementary National Space Biomedical Research Institute (NSBRI) study titled Developing Personalized Countermeasures for Sensorimotor Adaptability: A Bed Rest Study. This study will recall subjects who participated in the recent bed rest CFT70 campaign and spaceflight subjects (Functional Task Test) to investigate if predictive metrics based on behavioral, brain, and genetic markers can be used to retrospectively predict sensorimotor adaptability in post bed rest and spaceflight subjects. To aid this effort and to develop a complete set of predictive metrics we added several new behavioral measures. We also added genetic tests previously used to detect sensorimotor adaptability as possible metrics of adaptability. We called back our original subjects and tested them on these new metrics, which were added to the original set of potential predictive metrics obtained previously. During this reporting period data collection analysis was completed. Data Collection at Azusa Pacific University (APU): The focus of the data collection at Dr. Wood's APU laboratory was to expand the set of behavioral predictive measures capable of identifying individual differences in the ability to adapt to novel discordant sensory environments. In the APU study the inter-subject variability during adaption to visual distortion lenses was measured in 27 subjects over 3 sessions. During this reporting period data collection analysis for the studies at APU was completed. During this reporting period the following manuscripts were published: Seidler RD, Mulavara AP, Bloomberg JJ, Peters BT. Individual predictors of sensorimotor adaptability. Front. Syst. Neurosci. 9:100. doi: 10.3389/fnsys.2015.00100, 2015. Bloomberg JJ, Peters BT, Cohen HS and Mulavara AP. Enhancing astronaut performance using sensorimotor adaptability training. Front. Syst. Neurosci. 9:129.doi: 10.3389/fnsys.2015.00129, 2015. In addition, during this reporting period 17 presentations at meetings were completed. See also Bibliography section below.
Bibliography Type:	Description: (Last Updated: 06/03/2025)
Articles in Other Journals or Periodicals	Eikema DA, Chien JH, Scott-Pandorf M, Peters BT, Bloomberg JJ, Myers S, Stergiou N, Mukherjee M. "Locomotor adaptation to support surface roll oscillations: reductions in postural coupling with the environment is enhanced by noisy plantar tactile stimulation." Experimental Brain Research, submitted as of October 2016. [Ed. note: recategorized as Other Journals since not yet published as of 8/28/2018] , Oct-2016
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Articles in Peer-reviewed Journals	Cohen HS, Stitz J, Sangi-Haghpeykar H, Williams SP, Mulavara AP, Peters BT, Bloomberg JJ. "Tandem walking as a quick screening test for vestibular disorders." Laryngoscope. 2018 Jul;128(7):1687-91. Epub 2017 Dec 11. https://doi.org/10.1002/lary.27022 ; PubMed PMID: 29226324 ; PubMed Central PMCID: PMC5995610 , Jul-2018
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