Fiscal Year:	FY 2018	**Task Last Updated:**	FY 08/22/2018
PI Name:	Reschke, Millard F Ph.D.		
Project Title:	Straight Ahead in Microgravity		
Division Name:	Human Research		
Program/Discipline:			
Program/Discipline--Element/Subdiscipline:	HUMAN RESEARCH--Biomedical countermeasures		
Joint Agency Name:		**TechPort:**	No
Human Research Program Elements:	(1) **HHC**:Human Health Countermeasures		
Human Research Program Risks:	(1) **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:	FLIGHT	**Solicitation / Funding Source:**	OTHER
Start Date:	10/15/2016	**End Date:**	09/30/2020
No. of Post Docs:		**No. of PhD Degrees:**	
No. of PhD Candidates:		**No. of Master' Degrees:**	
No. of Master's Candidates:		**No. of Bachelor's Degrees:**	
No. of Bachelor's Candidates:		**Monitoring Center:**	NASA JSC
Contact Monitor:	Norsk, Peter	**Contact Phone:**	
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Flight Program:	ISS		
Flight Assignment:	ISS NOTE: End date changed to 9/30/2020 per L. Taylor/JSC (Ed., 8/23/18)		
Key Personnel Changes/Previous PI:	October 2016: Dr. Scott Wood is no longer a Co-Investigator due to his new position at NASA. He remains a Collaborator and will be involved only in data analysis and publication.		
COI Name (Institution):	Clement, Gilles Ph.D. (ESA PI: Lyon Neuroscience Research Center)		
Grant/Contract No.:	Not available		
Performance Goal No.:			
Performance Goal Text:			

Task Description:

Dr. Millard Reschke is the U.S. Co-Investigator on this European Space Agency (ESA)-sponsored project; ESA Principal Investigator is Gilles Clément, Ph.D., Lyon Neuroscience Research Center, France. Previous U.S. Co-Investigator was Dr. Scott Wood until October 2016.
The subjective straight-ahead direction is a very basic perceptual reference for spatial orientation, movement, and locomotion. The perceived straight-ahead along the horizontal and vertical meridian is largely determined by both otolith and somatosensory inputs. Otolith and somatosensory inputs are altered in microgravity and will change this reference point. Adaptive processes are taking place within the central nervous system to take into account the new environment and compute new spatial egocentric and world-centered representations or frames of reference. This project will measure and monitor how these frames change over time by investigating eye movements and perceptual reports.

The three specific aims include:

Specific Aim 1: Near & Far Fixation. The first aim is to examine binocular eye movements when subjects fixate on actual targets (normal vision) and then imagine these same targets (occluded vision) in the straight-ahead direction relative to their heading. Initially the subjects' gaze direction and fixation distance will be recorded as they explore the space around them using eye movements in darkness. Next they will be asked to fixate on straight ahead head-fixed targets located at near distance (arm's length, ~0.5 m) and far distance (beyond 2 m). Responses will be compared with different tilt orientations, including pitch tilt forward and backward up to 15 deg. During separate trials, subjects will attempt to maintain fixation on a far Earth-fixed target with and without a vibrotactile sensory aid that indicates how far one has tilted relative to the straight ahead direction.

Specific Aim 2: Eye and Arm Movements. The second aim is to examine directed horizontal and vertical eye and arm movements, relative to Earth coordinates and relative to the subject's head/body reference. This task will be performed with the subject upright and then tilted in roll directions up to 30 deg. The trajectory of directed eye and arm movements made in darkness are expected to reflect perceptual tilt errors.

Specific Aim 3: Near and Far VOR. The third aim is to examine the influence of target distance on the vestibulo-ocular reflex (VOR) during vertical translation movements. Subjects will stare at actual visual targets (normal vision) at various distances (near and far) in the straight-ahead direction while passively translated up and down using a spring-loaded chair. Vision will then be occluded, and the VOR will be recorded as the subject continues to fixate on the same target locations during translation. In addition to these periodic oscillations (~2.0 Hz), eye movements will also be recorded with vision during unpredictable passive head thrusts up and down using the spring-loaded chair.

For each of our specific aims above, our general hypothesis is that responses will be influenced by how accurately subjects perceive their spatial orientation. We will test this hypothesis by comparing responses with and without visual feedback. We also hypothesize for Specific Aim 1 that a vibrotactile sensory aid of tilt position will improve spatial orientation and this reduce gaze fixation errors.

Study Participants: Eight International Space Station (ISS) crewmembers will be recruited to participate in three preflight sessions (between 120 and 60 days before launch) and then three postflight sessions on R+0/1 day, R+4 (±2) days, and R+8 (±2) days. Sixteen ground-based subjects will be recruited to participate in a ground control study for up to 3 sessions. A limited number of subjects will also participate in parabolic flight study as resources permit. This study is being implemented by the European Space Agency and is not carried in the U.S. ISS utilization plans.

Risk Characterization, Quantification\Evidence: This task will contribute to gap closure by providing information regarding any changes in an individual's egocentric reference that might have negative consequences on evaluating the direction of an approaching object or on the accuracy of reaching movements. This information is important for understanding the problems associated with long-term effects of microgravity on astronauts and how they re-adapt to the return of gravitational forces on Earth or other planetary surfaces.

Countermeasure\Prototype Hardware or Software: This task will contribute to gap closure by evaluating how a vibrotactile feedback of reference frames can be used to improve spatial orientation of fixation on space-fixed targets.

Rationale for HRP Directed Research:

Research Impact/Earth Benefits:

This study will address adaptive changes in spatial orientation as assessed by oculomotor and pointing measures related to the subjective straight ahead, and the use of a vibrotactile sensory aid to reduce perceptual errors. On Earth, there is evidence that patients with vestibular or cerebral lesions present a deviation in their subjective straight-ahead direction. We will test a possible sensory aid countermeasure, vibrotactile stimulation, to improve spatial awareness. This countermeasure may be useful for both astronauts and clinical populations. The results of our flight study also have practical implications in the design of man-machine interfaces. Changes in line of sight in reduced gravity affect crew posture and reach, display orientation, and other visual cues, which should be considered in hardware and operations design.

Task Progress:

TASK PROGRESS
Flight Study

Eight International Space Station (ISS) crewmembers will be recruited to participate in three preflight sessions (between 120 and 60 days before launch) and then three post-flight sessions on R+0/1 day, R+4 (± 2) days, and R+8 (± 2) days. Preflight data was initiated in 2015 following approval for this study to be implemented for pre- and post-flight testing only. To date, five ISS crewmembers have completed pre- and post-flight data collection. Preflight data collection has been obtained from two other crewmembers, although one of these subjects was withdrawn from the study due to changes in post-flight test plans.

Preliminary analysis of the perception data indicates that the amplitude of perceived tilt and translation during passive roll tilt decreased on R+1 compared to preflight. However, the amplitude of perceived tilt and translation during passive pitch tilt was unchanged on R+1 compared to preflight. The perception of distances ranging from 0.5 m to 4 m was not affected by spaceflight.

The eye movement data are being analyzed using a method that has been recently published (Reschke et al. 2018). The amplitude of ocular counter-rolling reflex during roll tilt was reduced for several days after return from long-duration spaceflight. This decrease in amplitude was not accompanied by changes in the asymmetry of OCR between right and left head tilt (Reschke et al. 2018).

Ground Control Studies

A preliminary analysis comparing the responses of 16 healthy non-astronaut subjects across three sessions separated by about one month indicates that there is no learning effect induced by the repetition of the tests (Clément et al. 2018). In addition, the responses of the seven crewmembers tested preflight so far are within the range of those measured with the 16 non-astronaut subjects.

[Ed. note: see below Bibliography section for references]

Bibliography Type:	Description: (Last Updated: 06/28/2023)
Abstracts for Journals and Proceedings	Clément G, Campbell D, Reschke MF. "Evaluating the subjective straight ahead before and after spaceflight." 2018 NASA Human Research Program Investigators' Workshop, Galveston, TX, January 22-25, 2018. 2018 NASA Human Research Program Investigators' Workshop, Galveston, TX, January 22-25, 2018. , Jan-2018
Articles in Peer-reviewed Journals	Reschke MF, Wood SJ, Clément G. "Effect of spaceflight on the spatial orientation of the vestibulo-ocular reflex during eccentric roll rotation: A case report." J Vestib Res. 2018;27(5-6):243-9. https://doi.org/10.3233/VES-170631 ; PubMed PMID: 29400689 , Feb-2018
Articles in Peer-reviewed Journals	Reschke MF, Wood SJ, Clément G. "Ocular counter rolling in astronauts after short- and long-duration spaceflight." Scientific Reports. In press as of March 2018. , Mar-2018