Fiscal Year:	FY 2004	**Task Last Updated:**	FY 03/30/2006
PI Name:	Young, Laurence R. Sc.D.		
Project Title:	Neurovestibular aspects of short-radius artificial gravity: Toward a comprehensive countermeasure		
Division Name:	Human Research		
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Program/Discipline--Element/Subdiscipline:	NSBRI Teams--Neurovestibular Adaptation Team		
Joint Agency Name:		**TechPort:**	No
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Space Biology Special Category:	None		
PI Email:	lry@mit.edu	**Fax:**	FY 617-258-8111
PI Organization Type:	UNIVERSITY	**Phone:**	617-253-7759
Organization Name:	Massachusetts Institute of Technology		
PI Address 1:	Department of Aeronautics and Astronautics		
PI Address 2:	77 Massachusetts Avenue		
PI Web Page:			
City:	Cambridge	**State:**	MA
Zip Code:	02139-4301	**Congressional District:**	8
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Contact Monitor:		**Contact Phone:**	
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Key Personnel Changes/Previous PI:			
COI Name (Institution):	Hecht, Heiko (Universität Mainz & MIT) Oman, Charles (Massachusetts Institute of Technology, MVL) Cohen, Bernard (Mount Sinai Medical Center) Dai, Mingjia (Mount Sinai Medical Center) DiZio, Paul (Brandeis University) Jarchow, Thomas (Massachusetts Institute of Technology, MVL) Natapoff, Alan (Massachusetts Institute of Technology, MVL) Mast, Fred (Universität Zürich) Newby, Nathaniel (NASA Johnson Space Center)		
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Task Description:	Artificial gravity (AG), produced by centrifugal force on a rotating spacecraft or an on-board centrifuge, is a promising general countermeasure to the debilitating effects of weightlessness. However, high-speed rotation above 180 deg/sec is necessary to produce 1-g or more on a short radius (1.5-3m) centrifuge. Any astronaut head movement not parallel to the plane of rotation can induce strong cross-coupled spatial disorientation, motion sickness, postural disturbance and non-stabilizing compensatory eye movements. This project addresses the issues of adaptation to Coriolis forces and cross-coupled accelerations in accordance with the artificial gravity aim of the NSBRI's Neurovestibular Adaptation Team. The goal of this project is to understand the side effects caused by cross-coupled stimulation that produce motion sickness and could interfere with cognitive and motor function. A further goal is to develop efficient means of adapting astronauts safely to repeated transitions into and out of AG without excessive motion sickness. Basic understanding of the roles played by vestibular and other sensors in adaptation to unusual environments, and the associated disorientation and motion sickness, will contribute to astronaut comfort and safety in all phases of flight. Fundamental studies of the process of sensory-motor adaptation and practical means of controlling motion sickness and sway during rotation are combined in our 5 Specific Aims. 1) Acquisition, Generalization and Retention of Adaptation (MIT). 2) Cognitive Influences on Adaptation, and Effects of AG on Human Performance (JSC and MIT). 3) Spatial Orientation as Influenced by AG (MIT and Brandeis). 4) Adaptation of Postural Sway during AG (Brandeis). 5) Effectiveness of Baclofen in Controlling Motion Sickness by Shortening the Vestibulo-Ocular Reflex Time Constant. Human rotators spinning about an earth vertical axis provide the stimuli for each investigation: a rotating bed at MIT, an on-axis chair at Mt. Sinai, a 3m radius rotating room at Brandeis, and a 1.5m centrifuge at JSC. Measurements are made of compensatory eye movements, dynamic visual acuity, reading comprehension, illusory body motions, subjective motion sickness and postural sway. Cross-coupled canal stimulation and the Coriolis-stimuli on the otoliths during head turns in a rotating environments produce motion sickness and could interfere with cognitive and motor function. The goal of this project is gain an understanding of these side effects that allow us to develop efficient means of adapting astronauts to rotating environments and to allow repeated transitions into and out of AG without excessive motion sickness. Basic understanding of the roles played by vestibular and other sensors in adaptation to unusual environments, and the associated disorientation and motion sickness, will contribute to astronaut comfort and safety in all phases of flight. Spatial disorientation and related spatial illusions are a serious challenge for the astronaut in microgravity, during re-entry, and in the following weeks after return from space (see, e.g. Oman et al., 1986; Mittelstaedt and Glasauer; 1993, Lackner; 1993; Merfeld, 1996; Kornilova, 1997; Young, 2000). Finally, we recognize disorientation and postural disturbances as serious safety problems especially for astronauts returning from long missions, with or without AG. Our studies focus on the vestibular and non-vestibular contributions to orientation and posture in unusual, rotating force fields. They are crucial to the safety issues of emergency egress as well as the effectiveness of EVA on a mission using AG.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	Head movements in a moving or rotating environment, such as in boats, airplanes, and automobiles are often provocative. The ability to control susceptibility to motion sickness by controlling the central time constant of the vestibular system is a major advance and has broad application on Earth.
Task Progress:	Specific Aim 1: Acquisition, Generalization and Context-Specificity of Adaptation The cross-coupled canal stimulus and the Coriolis-stimuli on the otoliths during head turns in a rotating environment are determined by several parameters: Velocity of the centrifuge (Wc) Velocity of the head turn (Wh) Amount of the head turn (Th) Direction of the head turn (Dh) Position of head relative to axis of rotation (Rh) Axis of the head turns (yaw, pitch, or roll). Within a session the level of motion sickness experienced by the subject increases with the number of head turns (n) that are made in the rotating environment while the VOR time-constant, the VOR amount, tumbling intensity, and other sensations decrease. With an increasing number of sessions all symptoms and all measures decrease. Experiments conducted in 2004: A) Even though the symptoms of pitch head turns are substantially larger, subjects adapt to pitch head turns as well as to yaw head turns. Performing additional yaw head turns within a protocol that adapts subjects to pitch head turns does not interfere with the pitch adaptation. (46 subjects, September 2003 to May 2004) B) Incrementing centrifuge velocity (1.5 rpm to 23 rpm) over 5 days leads to adaptation with far less symptoms and therefore the subjects are less likely to dropout due to excessive motion sickness. (15 subjects, June 2004 to September 2004) C) Cross-coupled stimulation is largely affected by the amount by which the head is turned. A head turn about an angle of 30deg is less provocative and less experienced as less intense as a head turn about an angle of 60deg or 90deg. (21 subjects, April 2004 to September 2004) D) The effects induced by our standard protocol (MIT & JSC) were tested with six subjects between August 2004 to October 2004. E) We ran an explorative test series with six subjects for the 6-month study in November and December 2004 re-testing is planed for May 2005 and June 2005. F) Between September 2004 and December 2004 six subjects were adapted to left yaw head turns (15x to LED and 15xto NU) and tested for right head turns. A preliminary analysis indicates a limited transfer of adaptation from left to right. Several subjects indicated that following the 30 adaptive left head turns, the first 1-2 right head turns were significantly more provocative. At the moment we hypothesize that the initial response to a right head turn -- after being adapted to left head turns -- is high, but decays more rapidly than without the adaptation.

	G) Between September 2004 and December 2004 six subjects were adapted to right yaw head turns off-center. A first data analysis indicates that the off-center adaptation leads to slightly different responses than an on-center adaptation: The transfer of adaptation might be "disturbed" because the GIF and the gravity gradient are different in those two positions. H) Between September 2004 and December 2004 six subjects were adapted to radial movements. No effect on yaw head turns in the right quadrant was found. I) The construction work needed that allows us to spin at 30rpm was finished in December 2004. Safety checks and testing 30rpm protocols are planed for February 2005, and we expect experiments spinning at 30rpm starting in March 2005. J) The direction of the HT is a significant and persistent effect in all our protocols involving yaw HT: A HT to NUP leads to larger responses then a HT to RED. Specific Aim 2: AG and Cognition: Effects of Cross-Coupled Stimulation (CCS) on Performance and Influence of Cognition on Adaptation to AG Planning and preparation of experiments has finished, start of experiments in February March time frame of 2005. Specific Aim 3: Does Cross-Coupled Stimulation (CCS) Interfere with Spatial Orientation? We started first tests of the SVV-device in November and a first series of experiments in December. By now we have run 10 subjects testing for the best type of protocol to be used and their data has been preliminary analyzed. Specific Aim 4: Adaptation of whole-body movements: experiments in a slow rotation room Specific Aim 5: Reduction of the Vestibular Time Constant as a Countermeasure against Motion Sickness. In six subjects the VOR was tested after they have been treated with placebo and 10, 20, and 30mg baclofen. Each subject has been tested seven times in four hours, in total each subject was tested 28 times. To avoid adaptation and effects from the previous test, the test session were about 1 week apart. The test consisted of 2-perrotatory and 2-postrotatory VOR measurements. The analysis for VOR time constants is almost done for all tested subjects and we are still analyzing the data of the VOR gain and the velocity storage coupling gain.

Bibliography Type:	Description: (Last Updated: 02/08/2021)
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