Fiscal Year:	FY 2008	**Task Last Updated:**	FY 06/09/2008
PI Name:	Aoki, Hirofumi Ph.D.		
Project Title:	Virtual Reality-Based Pre-Flight Astronaut 3D Navigation Training		
Division Name:	Human Research		
Program/Discipline:	NSBRI Teams		
Program/Discipline--Element/Subdiscipline:	NSBRI Teams--Sensorimotor Adaptation Team		
Joint Agency Name:		**TechPort:**	No
Human Research Program Elements:	None		
Human Research Program Risks:	None		
Space Biology Element:	None		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
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Zip Code:	02139	**Congressional District:**	8
Comments:			
Project Type:	GROUND	**Solicitation / Funding Source:**	2005 NSBRI-RFP-05-01 Postdoctoral Fellowships
Start Date:	10/01/2005	**End Date:**	10/01/2007
No. of Post Docs:	1	**No. of PhD Degrees:**	0
No. of PhD Candidates:	0	**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: changed end date to accommodate NSBRI final report submission (jp 5/08)		
Key Personnel Changes/Previous PI:			
COI Name (Institution):	Oman, Charles (MENTOR: Massachusetts Institute of Technology)		
Grant/Contract No.:	NCC 9-58-PF00902		
Performance Goal No.:			
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	POSTDOCTORAL FELLOWSHIP. The goal of this sensorimotor/human factors project was to develop a virtual reality (VR) based training method for astronauts aboard International Space Station (ISS) or a Mars mission vehicle as a countermeasure of inflight spatial disorientation and navigation. These problems have been frequently reported by crews of Space Shuttle, Mir, and ISS as complicating responses to emergencies. The three-dimensional (3D) architecture and inconsistency of the visual vertical of adjacent quarters and modules, combined with the limited visual experience of crewmembers is the major cause of the problem, identified as a significant risk by NASA. Astronauts normally see the interior of a spacecraft from a variety of body orientations and viewpoints that cannot be simulated on the ground. It requires cognitive skills to interrelate cues perceived in a body centered (egocentric) frame of reference built up directly through navigation and		

Task Description:	also in an overall (allocentric) frame of reference defined by the spacecraft. Astronauts can either learn this interrelationship inflight, or develop the required cognitive knowledge prior to flight via VR simulation. As a member of NSBRI's Sensorimotor team led by Dr. Oman, we have conducted a series of experiments of 3D spatial orientation and navigation performance in a virtual space station using simulated emergency egress tasks. In the first experiment in a fully immersive virtual environment with a head mounted display, we showed that individual 3D spatial abilities (e.g. mental rotation and perspective taking skills), relative orientation to the environment, and the configuration of the environment influence performance. Subjects trained locally visually upright developed landmark and route knowledge, whereas those who maintained a constant orientation with respect to the entire station during training enhanced sense of direction and 3D cognitive map, and therefore performance in low visibility in a simulated smoke condition. This result suggests that training initially should be performed locally upright, followed training in a constant station orientation, and then trainees should be challenged by trials in randomized orientation. This could be customized based on individual spatial ability and task performance. This study, published in the Aviation, Space and Environmental Medicine, was awarded the 2007 ASMA Space Medicine Branch Young Investigator Award among 177 nominees. In the second experiment, it was shown that most 3D navigation performance measures for this egress task were similar in the immersive and non-immersive VR systems. Subjects pointed out that this egress task was mainly "done in your head", and that vestibular cues were not critical. This finding is important, since it suggests that laptop trainers (analogous to DOUG for EVA training) could be used for preflight (or even inflight) emergency egress navigation training. Based on these results, this project intended to clarify whether VR training can help to develop cognitive skills and to learn retention, improvement, and limitation of 3D human spatial orientation and navigation for long-term training. In the experiment, we demonstrated that "see-through walls" and a miniature 3D model of the environment by VR technology features were useful. Subjects trained with those VR tools showed better performance than those without at the training day, but same in both groups in one month later. This result showed the effectiveness of preflight spatial orientation and navigation training, especially in early stage of learning. Taken together, these studies provide solid laboratory validation for a preflight VR based navigation training countermeasure at the CRL 7 level. The next step is CRL 8 validation with human subjects in spaceflight to demonstrate operational feasibility and efficacy.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	Results of this project help develop crew safety by understanding 3D spatial orientation, navigation, and spatial memory, establishing training method, and providing implications for future spacecraft design including Orion, Lunar Lander, and Mars Transit Hab. By gaining better cognitive map of the environment, motion sickness and Visual Reorientation Illusions could be reduced. The simulation tool could be used to train other profession such as firefighters and submariners, as well as occupants of high-story buildings. Results also support deep understanding in human from the viewpoint of brain and cognitive science. Our results also pertain to environmental and architectural design and pre/post-occupancy evaluation of buildings, underground, and cities.
Task Progress:	Using the 3D spacecraft interior navigation training tool with "see-through wall" and virtual spacecraft miniature model features, which was developed over the last two years, an experiment was conducted to study retention, improvement, and limitation in 3D human spatial orientation and navigation during long term training. Results showed that subjects trained with those VR features showed better performance than those without at the training day, but same in both groups in one month later. The result showed the effectiveness of preflight spatial orientation and navigation training, especially in early stage of learning. We also continued an experiment to compare 3D spatial orientation and navigation performance with immersive and non-immersive VR simulation tools. Although immersive displays probably better simulate the vestibular and haptic cues required for spatial orientation, the subjects showed almost same performance using non-immersive desktop display.
Bibliography Type:	Description: (Last Updated: 09/11/2017)
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