Fiscal Year:	FY 2017	**Task Last Updated:**	FY 01/24/2018
PI Name:	Robinson, Stephen K. Ph.D.		
Project Title:	Customized Refresher and Just-In-Time Training For Long-Duration Spaceflight Crews		
Division Name:	Human Research		
Program/Discipline:	NSBRI		
Program/Discipline--Element/Subdiscipline:	NSBRI--Human Factors and Performance Team		
Joint Agency Name:		**TechPort:**	No
Human Research Program Elements:	(1) **HFBP**:Human Factors & Behavioral Performance (IRP Rev H)		
Human Research Program Risks:	(1) **HSIA**:Risk of Adverse Outcomes Due to Inadequate Human Systems Integration Architecture		
Space Biology Element:	None		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
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Zip Code:	95616-5270	**Congressional District:**	3
Comments:			
Project Type:	GROUND	**Solicitation / Funding Source:**	2013 HERO NNJ13ZSA002N-Crew Health (FLAGSHIP & NSBRI)
Start Date:	06/01/2014	**End Date:**	05/31/2017
No. of Post Docs:	0	**No. of PhD Degrees:**	0
No. of PhD Candidates:	3	**No. of Master' Degrees:**	1
No. of Master's Candidates:	2	**No. of Bachelor's Degrees:**	4
No. of Bachelor's Candidates:	0	**Monitoring Center:**	NSBRI
Contact Monitor:		**Contact Phone:**	
Contact Email:			
Flight Program:			
Flight Assignment:	NOTE: Element change to Human Factors & Behavioral Performance; previously Space Human Factors & Habitability (Ed., 1/19/17)		
Key Personnel Changes/Previous PI:			
COI Name (Institution):	Oman, Charles Ph.D. (Massachusetts Institute of Technology) Liu, Andrew Ph.D. (Massachusetts Institute of Technology) Byrne, Vicky M.S. (Lockheed Martin Astronautics) Mindock, Jennifer Ph.D. (Wyle Laboratories)		
Grant/Contract No.:	NCC 9-58-HFP03801		
Performance Goal No.:			
Performance Goal Text:			

Task Description:	Astronauts on long-duration missions are certain to be faced with critical and complex tasks for which the crewmember has either not recently trained, or has never been trained. This research project addresses the question of how best to bring an inflight astronaut up to evaluated readiness to perform a complex and critical task, after a significant period since final ground-training. Our overall objective is to address both on-board refresher training (for re-acquisition of expert performance) and onboard just-in-time training (for tasks that have not been specifically trained previously, but require the integration of existing astronaut skills). To achieve this objective we are experimentally testing the hypothesis that training that is customized for the crewmember can be more efficient than traditional, generic training for the same measured effectiveness. We base our research on two spaceflight-appropriate tasks, one requiring the repair of a complex electro-mechanical system representative of those found aboard spacecraft, and the other requiring manual control of a simulated International Space Station (ISS) robotic arm. This project relies on strong teaming, and is organized with system repair studies taking place at University of California (UC) Davis and robotics studies at Massachusetts Institute of Technology (MIT). At UC Davis, we have completed the Refresher Training (Part A) segment of the proposal, including subject selection, aptitude screening, initial training, and performance evaluation on the complex system repair task, then re-evaluation after a six-month period, refresher training (half the subject group developed their own refresher training), and performance evaluation with a total of 16 subjects. We have also developed and benchmarked quantitative methods for subject performance evaluation. These include assessing subtask timing as subjects work through the repair task, procedure flow, and a detailed taxonomy of error types. Major effort has been made to make these evaluations objective, so that different researchers can analyze the same subject video and produce virtually the same results. We have also instrumented subjects' hands with three-axis accelerometers to gather hand-motion data as they repair the surrogate system. Since we have defined task performance in terms of elapsed time for each sub-task, and also in terms of deviations from procedures (errors), we developed a new and detailed taxonomy of procedural deviations, which allowed us to quantify the type and sequence of errors made by the subjects. Results of the refresher experiment show that use of self-made refresher videos after 6 months since initial training resulted in only a slight improvement in overall performance for subjects in the treatment group, but that the types of errors made are significantly different between the control and treatment groups. At MIT, the manually-commanded robotics version of the proposed refresher training has also been completed. At the end of initial robotics skills and task training, subjects in the experimental group created a short reminder video to be used as a review when they came back in six months. Subjects then completed a hands-on evaluation that incorporated all the skills and theories taught in training. The evaluation performance was assessed with a qualitative rubric based on NASA Johnson Space Center (JSC) robotics training scoring strategies, and with quantitative measurements based on simulator outputs. At the six month evaluation, control subjects only had access to the procedures and a PowerPoint based written skill review, while the experimental group had access to their personalized review video and the procedures. Results showed that metrics of a subject's spatial abilities predicted performance and retention in procedurally complex tasks. Spatial ability had more effect on the control group's retention than those who received customized retraining. Part B of the project was to develop and assess a method of Just-In-Time Training (JITT), such as will be required for long-duration astronauts challenged with critical tasks for which they have not been trained. In this case, ground-learned skills must be integrated into task-capable expertise through JITT. After considering a variety of methods, a self-customization approach was settled upon, in which subjects individually adjust their procedures by selecting from three levels of detail for each sub-task. After selection screening, subjects underwent skills training, and were then presented with a new and complex task to perform with the use of procedures. The control group could not alter their procedures while the treatment group could customize them. UC Davis Part B experiments with complex-system repair tasks are ongoing, while at MIT, early robotics results suggest that provision of customized JITT enables subjects to perform the critical task more quickly than their (non-customized JITT) counterparts. Further, the control group has a markedly higher rate of task errors, as well as a higher response time to the side-task. It is speculated that the customization of JITT reduces subjects' workload and error rate, as they will not spend extraneous attentional resources perusing detailed procedural lists for sub-tasks in which they already demonstrate excellence.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	The results of this project are anticipated to be applicable to many Earth-bound high-risk human activities that require advanced skills and task-training to accomplish critical tasks. Examples include the fields of military field operations, disaster/emergency response, aviation, medical emergencies, nuclear accidents, and undersea/ground operations. Specifically, the assessment techniques and quantitative metrics we have developed during this research serve as tools to measure the efficiency and accuracy of human training to perform any complex task, which can lead to enhanced safety in high-risk environments.
Task Progress:	Part A: Refresher Training - Completed analysis and internal reporting for both complex-system repair at UC Davis and manual-operated robotics at MIT - Developed and benchmarked quantitative methods for subject performance evaluation. These include assessing subtask timing as subjects work through the repair task, procedure flow, and a detailed taxonomy of error types. Major effort has been made to make these evaluations objective, so that different researchers can analyze the same subject video and produce virtually the same results. - Continued development of an instrumentation system for subjects' hands, consisting of three-axis accelerometers to gather hand-motion data as they repair the surrogate system. - Developed a new and detailed taxonomy of procedural deviations, which allowed us to quantify the type and sequence of errors made by the subjects. Part B: Just-In-Time Training - Review and consideration of candidate techniques for Just-In-Time Training resulted in novel concept of

self-customization of procedures by subjects faced with an unfamiliar, complex task.

- Software developed to expand/contract procedures on command, by sub-task, to three levels of increasing detail and multimedia support.

- Completed experiment design for both system repair and robotics studies.

- Recruited subjects and completed training and critical-task evaluation for both control and treatment groups using the Space Station Remote Manipulator System (SSRMS) simulator in the Man Vehicle Lab at MIT.

- Through analysis of surrogate critical repair task, extracted core skills required for pre-training.

- Designed and fabricated a part-task training device for skills-training in complex-systems repair in the Human/Robotics/Vehicle Integration and Performance Lab at UC Davis.

Bibliography Type:	Description: (Last Updated: 01/29/2024)