Fiscal Year:	FY 2021	**Task Last Updated:**	FY 04/16/2021
PI Name:	Du, Jing Ph.D.		
Project Title:	Sensory Manipulation as a Countermeasure to Robot Teleoperation Delays		
Division Name:	Human Research		
Program/Discipline:			
Program/Discipline--Element/Subdiscipline:			
Joint Agency Name:		**TechPort:**	Yes
Human Research Program Elements:	(1) **HFBP**:Human Factors & Behavioral Performance (IRP Rev H)		
Human Research Program Risks:	None		
Space Biology Element:	None		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
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Comments:			
Project Type:	GROUND	**Solicitation / Funding Source:**	2020 HERO 80JSC019N0001-HFBP, OMNIBUS3 Crew Health: Human Factors and Behavioral Performance-Appendix E; Omnibus3-Appendix F
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No. of Bachelor's Candidates:		**Monitoring Center:**	NASA JSC
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Flight Program:			
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COI Name (Institution):	Oweiss, Karim Ph.D. (University of Florida, Gainesville)		
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Task Description:	Currently, most interactions with robots in space exploration are achieved through teleoperations. During future space teleoperations, communicating time delays associated with long distances may negatively affect performance if operators do not calibrate to it. The goal of this research is to test if sensory manipulation, especially providing virtual force cues via haptic device-generated feelings of touch and resistance (paired with delayed visual cues), can help mitigate the negative influence of teleoperation delays measured by perceived presence, neural efficiency, and task performance. This research aims to test the following hypothesis: Modifying haptic sensation alleviates the subjective perception of time delays and expedites operator's adaptation to stochastic delays in robot teleoperations. Human sensorimotor controls rely on multimodal sensory feedback, such as the visual, auditory, and tactile cues, to make sense of the consequence of the initiated action. Any latency between the action and the consequence creates a mismatch in motor perception and thus leads to perceptual-motor dysfunction. Literature has already found that sensory manipulation, i.e., providing additional sensory modalities as reinforcement cues, can modulate the effectiveness of motor learning and rehabilitation. The rationale of the proposed approach is that by simulating virtual force of physical interactions on the operator end, the delayed visual cues of teleoperation are reinforced by multimodal sensory feedback, mitigating the perception of time delays and improving performance. The two aims of this project are: Aim 1: Perform human-subject experiments to quantify how modified haptic stimulation expedites operator's adaptation to varying delays in teleoperations. The haptic simulation refers to reproducing the contact dynamics of the remote robotic system for operator via haptic devices. Note, the haptic simulation will be modified (in terms of timing and modes) to search for strategies for minimizing the subjective feeling of delays (primary outcome measure), ensuring accelerated adaptation to delays (secondary outcome measure), and ultimately, improving teleoperation performance (success metrics). Aim 2: Predict the short-term and long-term benefits and risks to the operators' functions based on neurobehavioral evidence. Neuroimaging data based on electroencephalography (EEG) and functional near-infrared spectroscopy (fNIRS), motion data, and performance data will be acquired to build a predictive model of human sensorimotor adaptation and performance with sensory manipulation in teleoperation tasks. The expected deliverables of this research include: (1) proof of concept evidence about the use of sensory manipulation in reducing the sense of time delays and expediting human adaptation to time-delayed robot teleoperations; (2) multimodal sensory feedback system design suggestions for human-robot interaction (HRI) in time-delayed teleoperations; and (3) quantitative models of functional and performance improvements in a variety of delay scenarios. This research proposes an innovative sensory manipulation approach to help reduce risks related to teleoperation delays. The neural, perception, and performance evidence contributes to the formulation of effective space teleoperation designs. The quantitative human models of perceptual and performance provide predictive models for NASA to perform risk and opportunity assessment for yet-to start missions that involve robot teleoperations. Lessons learned in this research will also inform a new training paradigm for both crewmembers and ground supports as for adapting to the changing environments in future deep space exploration with adaptive and assistive sensory augmentation. The data can also be transferred to other domains such as aviation and manufacturing industry with automation controls.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	
Task Progress:	New project for FY2021.
Bibliography Type:	Description: (Last Updated: 04/20/2023)