ADAPTIVE VIRTUAL REALITY TRAINING TO OPTIMIZE SURGICAL SKILL LEARNING IN SPACE

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INTRODUCTION

During long-duration spaceflight missions, we expect that maintaining space-related skills over an extended period will be a major challenge. Developing optimized training protocols to reduce skill degradation/attrition and to sustain skill performance could help greatly to meet this need. These solutions are applicable to many procedural skills. We focus on the skills required for minimally invasive surgery (MIS), i.e., laparoscopic surgery, which serves as a particular critical skill for crewmembers during long-duration spaceflight as well as an analog to many other space-related skills. Through MIS, crew can provide certain types of immediate surgical care by using more precise operating tools combined with time efficiency and resource management. However, MIS skills are difficult to acquire and maintain, because of both their technical complexity and the challenging physical environment, characterized by a spatially restricted monocular visual field and a confined working area. Learning MIS thus requires extensive training and also dedicated practice to maintain skills during periods of nonuse.

Although introductory MIS training through simulation is now widespread, it has been primarily limited to novice surgeons practicing on simple psychomotor tasks, such as suturing. MIS training could be useful for training more complex tasks for surgeons with a wider range of experience, and for maintaining skills over periods of disuse. Few studies have examined durability of simulation training generally. Moreover, little attention has been given to learning important cognitive skills or more complex tasks involving sequences of simple tasks. Investigating the optimal design and schedule for learning and retention are important to maintain the readiness of all skills. The trainer that can optimize learning and provide a custom learning schedule can potentially be deployed with astronauts to learn and sustain surgical and other skills efficiently to reduce error and maintain proficiency.

CONCEPT

We are developing an adaptive virtual reality (VR) training system that incorporates an intelligent mechanism for tracking performance using valid, objective measures that would be able to quickly recognize a crewmember's skill deficiencies and generate an optimal adaptive training schedule. Based on a cognitive theory of learning and forgetting, modeling skill learning over time e.g., [1] on a cognitive architecture (e.g., ACT-R) is the foundation of our design. However, MIS teleoperation involves multiple components including a communication interface, control platform, and interactive workspace. Combining the cognitive theory with virtual simulation could provide an optimal training platform for all components of MIS teleoperation. We leveraged our previous success in training program development and incorporated the ACT-R model of the learner into our adaptive VR training system. The goal for this project is to establish the next generation of virtual training environment with adaptability and optimization based on the need of trainees to learn telemedical skills more efficiently. More importantly, the new training environment could be useful for exploring how to sustain space-related skills for human space explorations and teleoperation in the International Space Station.

METHODS

This is an on-going project. A total of 25 subjects will be recruited. Ten subjects will test the training platform and provide feedback for system development. The remaining subjects (5 non-medical control group, 5 medical subjects without MIS experience, and 5 medical subjects with MIS experience) will test the improved training platform. The kinematic measures will include time to task completion, total distance travelled, and speed of movement; physiological measurements include the muscle activation volume; and subjective measurements will include the Presence questionnaire (subjective immersiveness of the virtual training environment) and the NASA Task Load Index to determine the relationship between performance and workload.

RESULTS

Based on our preliminary work, we anticipate that our adaptive VR training system will demonstrate the capability to evaluate the level of skills learning and attrition. Our system will optimize the skill learning and impact the amount of skill maintenance based on the level of surgical experience. As the level of surgical experience increases, the complexity of the given training tasks will increase.

REFERENCE

[1] Kim J.W., Ritter F.E., and Koubek R.J. (2013) *Th Issues in Erg Sci* 14(1), 22-37.