ADAPTIVE CHANGES IN SENSORIMOTOR COORDINATION AND MOTION SICKNESS FOLLOWING REPEATED EXPOSURES TO VIRTUAL ENVIRONMENTS

D.L. HARM[1], L.C. TAYLOR[2] and J.J. Bloomberg[1]
[1]*NASA Johnson Space Center, Houston, TX;* [2]*Wyle Laboratories, Houston TX*

INTRODUCTION

Virtual environments offer unique training opportunities, particularly for training astronauts and preadapting them to the novel sensory conditions of microgravity. Two unresolved human factors issues in virtual reality (VR) systems are: 1) potential "cybersickness", and 2) maladaptive sensorimotor performance following exposure to VR systems. Interestingly, these aftereffects are often quite similar to adaptive sensorimotor responses observed in astronauts during and/or following space flight. Initial interpretation of novel sensory information may be inappropriate and result in perceptual errors. Active exploratory behavior in a new environment, with resulting feedback and the formation of new associations between sensory inputs and response outputs, promotes appropriate perception and motor control in the new environment. Thus, people adapt to consistent, sustained alterations of sensory input such as those produced by microgravity, unilateral labyrinthectomy and experimentally produced stimulus rearrangements. The purpose of this research was to compare disturbances in sensorimotor coordination produced by dome and head-mounted virtual environment displays and to examine the effects of exposure duration, and repeated exposures to VR systems. The first study examined disturbances in balance control, and the second study examined disturbances in eye-head-hand (EHH) and eye-head coordination.

METHODS

Forty-one subjects (21 men, 20 women) participated in the first study, and 11 subjects have participated in the second study to date. One training session was completed in order to achieve stable performance on the posture, eye-head and eye-hand coordination and VR tasks before participating in the experimental sessions. Three experimental sessions were performed each separated by one day. In both studies subjects performed a navigation and “pick and place” task in either a dome or head-mounted display (HMD) VR system for either 30 or 60 min. The environment was a square room with 15 pedestals on two opposite walls. The objects appeared on one set of pedestals and the subject’s objective was to move the objects to the other set of pedestals. After the subject picked up an object, a pathway appeared and they were required to follow the pathway to the other side of the room. The subject was instructed to perform the task as quickly and accurately as possible, avoiding hitting walls and other obstacles and placing the object on the center of the pedestal. Balance control, EHH, and eye-head coordination were measured before, immediately after, and at 1 hr, 2 hr, 4 hr and 6 hr following exposure to VR. Balance control was measured during quiet stance under a variety of sensory conditions using the Equitest CDP balance system (Neurocom, International). EHH coordination was measured as position errors in a pointing task.

RESULTS

Balance control equilibrium scores were normalized using a log transformation, and motion sickness data were normalized using the square root. In general, we found that exposure to VR resulted in decrements in postural stability. The largest decrements were observed in the tests performed immediately following exposure to VR and showed a fairly rapid recovery across the remaining test sessions. In addition, subjects generally showed improvement across days. Although we found no significant main effects for gender (when center of gravity was used as a covariate), we did observe significant ***gender* X *time*** interaction effects for several of the postural control conditions. Women appeared to show larger decrements in postural stability immediately after exposure to VR than men, but recover more quickly than men. Finally, we found no significant main effects for type of VR device or for exposure duration, however, these factors did interact with other factors during some of the SOTs. Subjects exhibited rapid recovery of motion sickness symptoms across time following exposure to VR and significantly less severe symptoms across days. We did not observe main effects for gender, type of device or duration of exposure. **Eye-head and EHH coordination data analysis is currently being conducted for the first 11 subjects, and the preliminary findings of the EHH coordination task will be presented.**

CONCLUSION

Individuals recovered from the detrimental effects of exposure to virtual reality on postural control and motion sickness within one hour. Sickness severity and initial decrements in postural equilibrium decreases over days, which suggests that subjects become dual-adapted over time. These findings provide some direction for developing training schedules for VR users that facilitate adaptation, and support the idea that preflight training of astronauts may serve as useful countermeasure for the sensorimotor effects of space flight.