COUNTERMEASURES TO REDUCE SENSORIMOTOR IMPAIRMENT AND SPACE MOTION SICKNESS RESULTING FROM ALTERED GRAVITY LEVELS

L. R. Young¹, N. W. M. Beckers¹, F. Karmali², and T. K. Clark¹,²

¹Man-Vehicle Laboratory at Massachusetts Institute of Technology, 77 Massachusetts Avenue 37-219, Cambridge, MA 02139, lry@mit.edu,
²Massachusetts Eye and Ear Infirmary, 243 Charles Street, Boston, MA 02114, faisal_karmali@meei.harvard.edu

ABSTRACT

Adaptation to altered gravity levels has been a concern since the dawn of human spaceflight. Sensorimotor function is altered during gravitational transitions, which is frequently accompanied by space motion sickness, and can impact astronaut performance and operation. Astronauts must have accurate orientation perception and control of the vehicle during and after gravitational transitions, which often occur during critical mission phases such as landing or docking. We aim to quantify sensorimotor adaptation during altered-gravity transitions by utilizing a centrifuge to create a hyper-gravity environment. On initial exposure to hyper-gravity, humans tend to overestimate roll tilt, commonly referred to as the G-Excess Illusion, which is followed by an adaption process that reduces errors.

This multi-year project examines sensorimotor adaptation in altered gravity. We are conducting experiments to understand how pre-training and promethazine application may reduce the severity of sensorimotor impairment and space motion sickness during gravitational transitions. There are four specific aims for this project: (1) demonstrate that individual differences exist in the ability to adapt to gravitational transitions, (2) test whether pre-training by adapting to one altered gravity environment can improve sensorimotor adaptation to another novel altered gravity environment, (3) test whether promethazine affects either basic vestibular perceptual function or the adaptation rate to an altered gravity environment and the associated motion sickness symptoms, and (4) develop and test a combined pre-adaptation training and promethazine protocol that can both improve sensorimotor adaptation and reduce the associated motion sickness.

In the novel hyper-gravity environment subjects perform two tasks to quantify sensorimotor performance: a subjective orientation task and a closed-loop manual control task. In the subjective orientation task, subjects indicate their orientation relative to the vertical during passive roll tilts. In the manual control task, subjects actively control their own roll tilt by attempting to keep themselves upright by attempting to null a random disturbance. In addition, motion sickness reports are recorded during both tasks.

This research project was only begun in late 2013. We will conduct five experiments to address the aims of this project. In experiment 1, we are measuring individual differences in adaptation and whether an individual’s adaptation rate in one altered gravity environment can be predicted by the individual’s adaptation in a different gravity environment. In experiment 2, we test the hypothesis whether pre-training by adapting to one altered gravity temporarily enhances an individual’s ability to adapt to another altered gravity level. Experiment 3 tests the impact that promethazine has on basic vestibular function using perceptual thresholds, tilt perception, and manual control measures. We test whether promethazine influences adaptation to altered gravity in experiment 4. In the fifth experiment, we combine the use of promethazine with the pre-training countermeasure. This experiment is the final step in developing a pre-adaptation training and pharmacological protocol to reduce the severity of sensorimotor impairment and space motion sickness during gravitational transitions.

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