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Author: Dr. Aaron Allred
University of Colorado Boulder, United States

GALVANIC VESTIBULAR STIMULATION AS A COUNTERMEASURE TO MOTION SICKNESS FOLLOWING GRAVITY TRANSITIONS IN ASTRONAUTS

Abstract

During spaceflight operations, most astronauts experience motion sickness upon transitioning from Earth to a microgravity environment and upon returning to Earth following extended exposure to microgravity. Resulting symptoms are often severe, and associated risks dictate operations in the first few days following a gravity transition. The most prevailing theory of motion sickness symptom development, sensory conflict theory explains the emergence of motion sickness symptoms as the result of prolonged differences in vestibular sensory information and the brain's expectation of vestibular cues, both for Earth and space motion sickness. In the case of a gravity transition, sensory reinterpretation occurs over the time course of a few days, eventually producing an expectation of vestibular cues that reflect what is sensed in the new environment. Prior to the completion of this process, the central nervous system does not correctly expect/interpret vestibular cues in the new gravity environment, commonly resulting in motion sickness. In recent years, our understanding of how gravity transitions lead to sensory conflict has grown, as well as our understanding of how sensory conflict leads to motion sickness. Today, new computational models of human motion perception have been formulated, which allow us to quantitatively predict motion sickness that is preceded by sensory conflict resulting from gravity transitions.

Leveraging these advanced models, we explore the utility of a technological countermeasure to space motion sickness via the application of galvanic vestibular stimulation (GVS). GVS uses low levels of electrical stimulation to alter vestibular sensory cues, and as a byproduct, augment sensory conflicts. Leveraging our current understanding of GVS and sensory conflict theory, it is possible to reduce motion sickness by designing customized GVS waveforms. Experimentally, we first assessed the effectiveness of GVS as a motion sickness countermeasure in the terrestrial environment. Preliminary results indicate that GVS is able to reduce motion sickness symptoms in the presence of a provocative physical motion stimulus. Here, we extend this work to computationally assess the effectiveness of GVS in the presence of physical motion following gravity transitions. To accomplish this, we combine an observer model of human perception following a gravity transition with a model of vestibular sensory modulation from GVS. The sensory conflicts, intermediaries of perception, are ultimately fed into a validated model of motion sickness symptom dynamics. Using these concatenated models, we produce an evaluation of GVS as a countermeasure following different gravity transitions.