IMPROVING SENSORIMOTOR FUNCTION AND ADAPTATION USING STOCHASTIC VESTIBULAR STIMULATION

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Astronauts experience sensorimotor changes during adaption to G-transitions that occur when entering and exiting microgravity. Post space flight, these sensorimotor disturbances can include postural and gait instability, visual performance changes, manual control disruptions, spatial disorientation, and motion sickness, all of which can hinder the operational capabilities of the astronauts. Crewmember safety would be significantly increased if sensorimotor changes brought on by gravitational changes could be mitigated and adaptation could be facilitated. The goal of this research is to investigate and develop the use of electrical stochastic vestibular stimulation (SVS) as a countermeasure to augment sensorimotor function and facilitate adaptation. For this project, SVS will be applied via electrodes on the mastoid processes at imperceptible amplitude levels. We hypothesize that SVS will improve sensorimotor performance through the phenomena of stochastic resonance, which occurs when the response of a nonlinear system to a weak input signal is optimized by the application of a particular nonzero level of noise. In line with the theory of stochastic resonance, a specific optimal level of SVS will be found and tested for each subject [1]. Three experiments are planned to investigate the use of SVS in sensory-dependent tasks and performance. The first experiment will aim to demonstrate stochastic resonance in the vestibular system through perception based motion recognition thresholds obtained using a 6-degree of freedom Stewart platform in the Jenks Vestibular Laboratory at Massachusetts Eye and Ear Infirmary. A range of SVS amplitudes will be applied to each subject and the subject-specific optimal SVS level will be identified as that which results in the lowest motion recognition threshold, through previously established, well developed methods [2,3,4]. The second experiment will investigate the use of optimal SVS in facilitating sensorimotor adaptation to system disturbances. Subjects will adapt to wearing minifying glasses, resulting in decreased vestibular ocular reflex (VOR) gain. The VOR gain will then be intermittently measured while the subject readapts to normal vision, with and without optimal SVS. We expect that optimal SVS will cause a steepening of the adaptation curve. The third experiment will test the use of optimal SVS in an operationally relevant aerospace task, using the tilt translation sled at NASA Johnson Space Center, a test platform capable of recreating the tilt-gain and tilt-translation illusions associated with landing of a spacecraft post-space flight. In this experiment, a perception based manual control measure will be used to compare performance with and without optimal SVS. We expect performance to improve in this task when optimal SVS is applied. The ultimate goal of this work is to systematically investigate and further understand the potential benefits of stochastic vestibular stimulation in the context of human space flight so that it may be used in the future as a component of a comprehensive countermeasure plan for adaptation to G-transitions.

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