

Enhancement of Otolith Specific Ocular Responses using Vestibular Stochastic Resonance

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Introduction: Astronauts experience disturbances in sensorimotor function after spaceflight during the initial introduction to a gravitational environment, especially after long-duration missions. Our goal is to develop a countermeasure based on vestibular stochastic resonance (SR) that could improve central interpretation of vestibular input and mitigate these risks. SR is a mechanism by which noise can assist and enhance the response of neural systems to relevant, imperceptible sensory signals. We have previously shown that imperceptible electrical stimulation of the vestibular system enhances balance performance while standing on an unstable surface. **Methods:** Eye movement data were collected from 10 subjects during variable radius centrifugation (VRC). Subjects performed 11 trials of VRC that provided equivalent tilt stimuli from otolith and other graviceptor input without the normal concordant canal cues. Bipolar stochastic electrical stimulation, in the range of 0–1500 microamperes, was applied to the vestibular system using a constant current stimulator through electrodes placed over the mastoid process behind the ears. In the VRC paradigm, subjects were accelerated to 216 °/s. After the subjects no longer sensed rotation, the chair oscillated along a track at 0.1 Hz to provide tilt stimuli of 10°. Eye movements were recorded for 6 cycles while subjects fixated on a target in darkness. Ocular counter roll (OCR) movement was calculated from the eye movement data during periods of chair oscillations. **Results:** Preliminary analysis of the data revealed that 9 of 10 subjects showed an average increase of 28% in the magnitude of OCR responses to the equivalent tilt stimuli while experiencing vestibular SR. The signal amplitude at which performance was maximized was in the range of 100–900 microamperes. **Discussion:** These results indicate that stochastic electrical stimulation of the vestibular system can improve otolith specific responses. This will have a significant impact on development of vestibular SR delivery systems to aid recovery of function in astronauts after long-duration spaceflight or in people with balance disorders.