DETERMINE OPTIMAL STIMULUS AMPLITUDE FOR USING VESTIBULAR STOCHASTIC STIMULATION TO IMPROVE BALANCE FUNCTION

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Sensorimotor changes such as postural and gait instabilities can affect the functional performance of astronauts when they transition across different gravity environments. We are developing a method, based on stochastic resonance (SR), to enhance information transfer by applying non-zero levels of external noise on the vestibular system (vestibular stochastic resonance, VSR). Our previous work has shown the advantageous effects of VSR in a balance task of standing on an unstable surface [1]. This technique to improve detection of vestibular signals uses a stimulus delivery system that provides imperceptibly low levels of white noise-based binaural bipolar electrical stimulation of the vestibular system. The goal of this project is to determine optimal levels of stimulation for SR applications by using a defined vestibular threshold of motion detection.

A series of experiments were carried out to determine a robust paradigm to identify a vestibular threshold that can then be used to recommend optimal stimulation levels for sensorimotor adaptability (SA) training applications customized to each crewmember. The amplitude of stimulation to be used in the VSR application has varied across studies in the literature such as 60% of nociceptive stimulus thresholds [2]. We compared subjects' perceptual threshold with that obtained from two measures of body sway. Each test session was 463s long and consisted of several 15s long sinusoidal stimuli, at different current amplitudes (0-2 mA), interspersed with 20-20.5s periods of no stimulation. Subjects sat on a chair with their eyes closed and had to report their perception of motion through a joystick. A force plate underneath the chair recorded medio-lateral shear forces and roll moments. Comparison of threshold of motion detection obtained from joystick data versus body sway suggests that perceptual thresholds were significantly lower. In the balance task, subjects stood on an unstable surface and had to maintain balance, and the stimulation was administered from 20-400% of subjects' vestibular threshold. Optimal stimulation amplitude was determined at which the balance performance was best compared to control (no stimulation). Preliminary results show that, in general, using stimulation amplitudes at 40-60% of perceptual motion threshold significantly improved the balance performance. We hypothesize that VSR stimulation will act synergistically with SA training to improve adaptability by increasing utilization of vestibular information and therefore will help us to optimize and personalize a SA countermeasure prescription. This combination may help to significantly reduce the number of days required to recover functional performance to preflight levels after long-duration spaceflight.

[1] Mulavara A.P. et al (2011) *Exp Brain Res* 210, 303-312. [2] Yamamoto Y. et al. (2005) *Ann Neurol* 58, 175-181.

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