

IMPROVING SENSORIMOTOR ADAPTATION FOLLOWING LONG DURATION SPACE FLIGHT BY ENHANCING VESTIBULAR INFORMATION TRANSFER

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Crewmember adapted to the microgravity state may need to egress the vehicle within a few minutes for safety and operational reasons after gravitational transitions. The transition from one sensorimotor state to another consists of two main mechanisms: strategic and plastic-adaptive and have been demonstrated in astronauts returning after long duration space flight. Strategic modifications represent “early adaptation” - immediate and transitory changes in control that are employed to deal with short-term changes in the environment. If these modifications are prolonged then plastic-adaptive changes are evoked that modify central nervous system function, automating new behavioral responses. More importantly, this longer term adaptive recovery mechanism was significantly associated with their strategic ability to recover on the first day after return to Earth G. We are developing a method based on stochastic resonance to enhance information transfer by improving the brain’s ability to detect vestibular signals (Vestibular Stochastic Resonance, VSR) especially when combined with balance training exercises such as sensorimotor adaptability (SA) training for rapid improvement in functional skill, for standing and mobility. This countermeasure to improve detection of vestibular signals is a stimulus delivery system that is wearable/portable providing low imperceptible levels of white noise based binaural bipolar electrical stimulation of the vestibular system (stochastic vestibular stimulation). To determine efficacy of vestibular stimulation on physiological and perceptual responses during otolith-canal conflicts and dynamic perturbations we have conducted a series of studies: We have shown that imperceptible binaural bipolar electrical stimulation of the vestibular system across the mastoids enhances balance performance in the mediolateral (ML) plane while standing on an unstable surface. We have followed up on the previous study showing VSR stimulation improved balance performance in both ML and anteroposterior planes while stimulating in the ML axis only. We have shown the efficacy of VSR stimulations on enhancing physiological and perceptual responses of whole-body orientation during low frequency perturbations (0.1 Hz) on the ocular motor system using a variable radius centrifuge on both physiological (using eye movements) and perceptual responses (using a joystick) to track imposed oscillations. The variable radius centrifuge provides a selective tilting sensation that is detectable only by the otolith organs providing conflicting information from the canal organs of the vestibular system (intra-vestibular conflict). These results indicate that VSR can improve performance in sensory conflict scenarios like that experienced during space flight. We have showed the efficacy of VSR stimulation to improve balance and locomotor control on subjects exposed to continuous, sinusoidal lateral motion of the support surface while walking on a treadmill while viewing perceptually matched linear optic flow. We have shown the safety of short term continuous use of up to 4 hours of VSR stimulation and its efficacy in improving balance and locomotor function in Parkinson’s Disease patients. This technique for improving vestibular signal detection may thus provide additional information to improve strategic abilities. We hypothesize that VSR stimulation will act synergistically with SA training to improve adaptability by increased utilization of vestibular information and therefore serve to optimize and personalize the SA countermeasure prescription. This forms the basis of its usefulness both as a training modality and further help in significantly reducing the number of days required to recover functional performance to preflight levels after long duration space flight.