EVALUATING SENSORY AUGMENTATION AS A NON-PHARMACEUTICAL TOOL TO MITIGATE MOTION SICKNESS AND ENHANCE SENSORIMOTOR TASK PERFORMANCE: A PILOT STUDY USING SIMULATED CAPSULE WAVE MOTION

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Wave motion during capsule recovery operations can result in motion sickness and performance decrements exacerbating reentry sickness following long duration spaceflight. The purpose of this pilot study was (1) to validate a capsule wave motion simulation as a platform to evaluate motion sickness countermeasures and (2) to evaluate a sensory augmentation belt providing vibrotactile feedback of gravitational upright. Ten healthy subjects ages 38.0 ± 10.1 (6M|4F) were exposed to complex wave motions on a six degree-of-freedom platform that included pitch, roll, and heave at provocative stimulus frequencies (0.1-0.25 Hz) while seated in an illuminated cabin deprived of external visual cues. Subjects reported acute symptoms for up to three consecutive 15 min trials or until they reached a motion sickness endpoint of 8 pts on the Pensacola Diagnostic Index (PDI). Five subjects were randomly assigned to the Sensory Augmentation (SA) group while the other five served as controls (CN group). Based on a Motion Sickness Susceptibility Questionnaire, the two groups had similar motion sickness histories (susceptibility percentile ranking of CN group = 27.5 ± 63.6 in the CN group versus 27.5 ± 37.0 in the SA group, median ± IQR). The vibrotactile feedback consisted of a single array of 8 electromechanical tactors positioned around the torso on an adjustable belt (Engineering Acoustics, Inc) that utilized an integrated inertial measurement unit (IMU) to indicate the direction of upright (e.g., subject's back tactor on during forward tilt). During each wave motion trial subjects performed a battery of four different tasks: tracking Earth vertical using a joystick with and without a secondary task (Paced Auditory Serial Addition Test), an eye-hand target acquisition task on a cabin-fixed tablet, and the psychomotor vigilance test (PVT). All ten subjects reported varying levels of motion sickness with 6 of 10 reaching a symptom endpoint. Interestingly, subjects anecdotally reported that engagement in the joystick tracking task was less provocative than tasks involving the cabin-fixed tablet or periods of no activity. Sensory augmentation appeared to delay symptom onset, with 2 of 5 subjects reaching an endpoint within the first 15 min trial in the CN group versus none in the SA group (PDI after 15 min = 6.0 ± 2.5 in the CN group versus 3.4 ± 2.5 in the SA group, mean ±std). Sensory augmentation also improved performance on the joystick tracking task at lower stimulus frequencies (0.1 Hz in roll and 0.2 Hz in pitch). Both CN and SA groups maintained a consistent level of performance on the eye-hand target acquisition and PVT throughout the baseline (no motion) and wave motion periods. Our results validated that the simulated capsule wave motion paradigm provides an effective motion sickness stressor. This paradigm is currently being used to investigate the efficacy of intranasal scopolamine to mitigate motion sickness. Sensory augmentation using vibrotactile feedback appears to improve spatial awareness and delay symptom onset during complex passive motion. One advantage of this portable belt design is that it incorporates all tactor drive and IMU circuitry and therefore could continue to be worn by crewmembers and serve as a balance aid during egress and ambulation with recovery operations.