STROBOSCOPIC GOGGLES AS A COUNTERMEASURE FOR DYNAMIC VISUAL ACUITY AND LANDING SICKNESS IN CREWMEMBERS RETURNING FROM LONG-DURATION SPACEFLIGHT

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Long-term exposure to microgravity causes sensorimotor adaptations that result in functional deficits upon returning to a gravitational environment. At landing, the vestibular system and the central nervous system, responsible for coordinating head and eye movements via the vestibulo-occular reflex (VOR), are adapted to microgravity and must re-adapt to the Earth's gravitational environment. This re-adaptation causes decrements in gaze control and dynamic visual acuity, with astronauts reporting oscillopsia and blurred vision. These effects are caused by retinal slip, or the inability to keep an image focused on their retina, which is thought to drive motion sickness symptoms experienced upon landing. Retinal slip can be estimated by dynamic visual acuity (DVA); visual acuity while in motion. Peters et al. (2011) find that DVA is worsened in astronauts by an average of 0.75 eye-chart lines one day after landing. Previously, the use of stroboscopic goggles has shown to be effective in minimizing motion sickness symptoms due to retinal slip (Reschke et al. 2007). In this study, we simulated the decrement in DVA caused by sensorimotor re-adaptation by using minifying lenses and then testing the efficacy of stroboscopic goggles in preventing retinal slip and improving DVA.

Dynamic visual acuity is assessed using an oscillating chair developed in the Neuroscience Laboratory at JSC. This chair is motor-driven and oscillates vertically at 2 Hz with a vertical displacement of +/- 2 cm to simulate the vertical translations that occur while walking. As the subject is being oscillated, they are asked to discern the direction of Landolt-C optotypes of varying sizes and record their direction using a gamepad.

The visual acuity thresholds are determined using an algorithm that alters the size of the optotype based on the previous responses of the subject using a forced-choice best parameter estimation that is able to rapidly converge on the threshold value. Visual acuity thresholds were determined both for static (seated) and dynamic (oscillating) conditions. Dynamic visual acuity is defined as the difference between the dynamic and static conditions.

We found that healthy subjects (n=20) have a significantly impaired DVA while wearing the minifying lenses, demonstrating that the VOR is in an adaptive state and retinal slip is occurring. When subjects' acuity was tested wearing the stroboscopic goggles with the minifying lenses, there was no significant difference in their DVA compared to their baseline DVA. This suggests that stroboscopic goggles are preventing retinal slip and would function as an efficient countermeasure for VOR adaptations and thus help mitigate landing sickness symptoms experienced by long-duration crewmembers. These goggles might also be used to counter blurred vision (caused by retinal slip) experienced by crewmembers during launch where the vehicle vibrations are greatest. The stroboscopic effect could be built into a section of their head mounted displays on the visor of their helmets to be used in these high vibration situation if a mission critical task is necessary.

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