

STROBOSCOPIC VISION AS A TREATMENT FOR RETINAL SLIP INDUCED MOTION SICKNESS

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INTRODUCTION

Motion sickness in the general population is a significant problem driven by the increasingly more sophisticated modes of transportation, visual displays, and virtual reality environments. It is important to investigate non-pharmacological alternatives for the prevention of motion sickness for individuals who cannot tolerate the available anti-motion sickness drugs, or who are precluded from medication because of different operational environments. Based on the initial work of Melvill Jones, in which post hoc results indicated that motion sickness symptoms were prevented during visual reversal testing when stroboscopic vision was used to prevent retinal slip, we have evaluated stroboscopic vision as a method of preventing motion sickness in a number of different environments. Specifically, we have undertaken a five part study that was designed to investigate the effect of stroboscopic vision (either with a strobe light or LCD shutter glasses) on motion sickness while: (1) using visual field reversal, (2) reading while riding in a car (with or without external vision present), (3) making large pitch head movements during parabolic flight, (4) during exposure to rough seas in a small boat, and (5) seated and reading in the cabin area of a UH60 Black Hawk Helicopter during 20 min of provocative flight patterns.

METHODS

Visual Field Reversal Testing. Nineteen subjects read text while making $\pm 20^\circ$ head movements in the horizontal plane at 0.2 Hz while wearing left-right reversing prisms during exposure to 4 Hz stroboscopic or normal room illumination. In a simple crossover design, testing was repeated using LCD shutter glasses as the stroboscopic light source with an additional 13 subjects and 6 subjects from the first condition (for a total of 19 subjects). *Car Reading.* The protocol for motion sickness provoked in a moving car with the subject reading an adapted version of *Treasure Island* was conducted in two phases: (1) outside view occluded (9 subjects), and (2) normal outside view (10 subjects). In both phases subjects were tested with the glasses either flashing or not flashing with a minimum of 1 week between tests. *Parabolic Flight.* Nine subjects made whole upper body pitch movements and viewed the surrounding plane's interior during the μg portion of the parabola (subjects were seated and stationary during all other phases of flight). Subjects were tested with the glasses flashing or not flashing with at least 5 weeks between each flight. *Helicopter.* Stroboscopic glasses were worn by 6 volunteers who were required to read the text of an Army aircraft manual while seated in the cabin area of a UH60 Black Hawk Helicopter during 20 min of provocative flight patterns (rapidly changing turns, climbs and descents). Each participant experienced two flights; wearing the glasses on the first and not on the second. *Sea Sickness.* Three subjects volunteered to wear the glasses on NASA's aquatic, short duration NEEMO study. Subjects wore the glasses once while clear and once while flashing on a boat to the destination for ~30 minutes of travel time, and for approximately 30 min while the boat was anchored above the NEEMO platform. *Scoring.* In all testing, except that used during the helicopter testing, motion sickness was scored using a modified Pensacola Diagnostic Index (PDI) and subjective self-ratings. For the helicopter testing, motion sickness was scored with a questionnaire that rated symptoms on a 0 to 3 point severity scale. During final analysis of the helicopter data, only the nausea sickness scores were totaled for both groups (glasses Vs. no glasses).

RESULTS

Visual Field Reversal Testing. During the experiment with a strobe light, motion sickness scores were significantly lower than in the control condition where normal room illumination was used. Results with the LCD shutter glasses were analogous to those observed when the environment was strobed in an otherwise dark room. In both test environments all subjects (total of 38) completed the 30 min end criteria under both stroboscopic conditions, while only half of the subjects (total of 19) completed the full 30 minutes of testing under the control condition. *Car Reading.* Three of the 9 subjects in the outside view-occluded condition completed the 30 min car ride during both the treatment and control test sessions. Of the remaining 6 subjects, all but one showed an increase in tolerance time to motion while reading under stroboscopic illumination. For testing in which the outside view was not occluded, two of the 10 subjects completed the 30 min testing session during both the control and treatment sessions. Another two subjects were susceptible regardless of the treatment (terminated the test within 6 to 7 min), one subject performed worse under strobe, and the remaining 5 subjects demonstrated a significant increase in tolerance time while reading under stroboscopic light. *Parabolic Flight.* Under stroboscopic illumination, four of the 9 subjects showed no change in susceptibility, one subject completed fewer parabolas while under stroboscopic illumination (32 parabolas vs. 35), and the remaining four subjects demonstrated an increased tolerance to the μg portion of the flight. It is interesting to note that more motion sickness may have be attributable to the hyper-g phase of flight where the subject sat with eyes closed and made no pitch head movements, than to the μg phase when the subjects were actually moving relative to the plane. *Helicopter.* Nausea scores with the glasses reached a total of two, while the scores without glasses reached a level of 5. *Sea Sickness.* All three subjects never reached a motion sickness PDI score beyond mild awareness while wearing the glasses. Without the glasses all subjects vomited a minimum of one time.

CONCLUSION

Stroboscopic illumination reduces the severity of motion sickness symptoms, and shutter glasses with a flash frequency of 4 or 8 Hz with a short dwell time are as effective as a strobe light. Stroboscopic illumination appears to be an effective countermeasure where retinal slip is a significant factor in eliciting motion sickness. Furthermore, the results suggest the possibility of producing functionally useful adaptation via stroboscopic illumination during either self or surround motion without the penalty of using disabling motion sickness drugs by controlling the rate of the adaptive process.