HEAD-EYE COORDINATION DURING SIMULATED ORBITER LANDINGS

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INTRODUCTION

Up to 90% of crewmembers experience spatial disorientation (SD) during reentry and landing of the Orbiter, with prevalence proportional to the length of the mission. This is a critical issue, as Orbiter landing data shows a decrement in performance following microgravity exposure compared to simulated landings in the Vertical Motion Simulator (VMS) at NASA Ames and the NASA Shuttle Training Aircraft. Despite the potential impact on landing operations, the basis of microgravity-related SD is poorly understood. The aim of this proposal is to obtain basic data on the characteristics of head and eye movements during simulated Orbiter landings. In addition, a Galvanic Vestibular Stimulation (GVS) system will be developed as a model for the effects of microgravity-induced SD. Preliminary results suggest that GVS exposure generates symptoms of SD comparable to space flight. Simulated landings in the VMS will be performed with GVS, to test the hypothesis that SD diminishes head-eye coordination and landing performance. This may serve as a model for the deterioration in pilot performance during reentry, and provide a training regimen to allow commanders and pilots to experience SD in a simulator.

METHODS

We have developed a laptop-based system for tracking eye, head and cabin movements in real time (Fig. 1). Orbiter landings were simulated in a commercial flight simulator (A340-600) using a descending banking turn from 40000 ft to 14000 ft (the HAC maneuver), then a final approach with an 11° glide slope with a flare maneuver at 2000 ft and touchdown at 210 knots. We have recently begun to obtain data from a subject performing high-fidelity simulations in the VMS in the Orbiter configuration.

RESULTS

A340 Simulator: During the 45° banking turn of the HAC maneuver there was a maintained tilt of the head of up to 5° in response to the tilt of the visual horizon. In addition, there was a sustained torsional shift in eye position of 6°, which preceded the head tilt. The combined head and eye tilt acted to orient the eye to the scene-derived visual vertical, with a gain of approximately 25%.

VMS: During final approach the pilot primarily fixated the target cursor on the head up display (HUD) with occasional glances at the primary flight display. With the HUD disabled, the pilot fixated the aim point before the runway (a visual target that indicates correct glide slope) and the start of the runway, and as the altitude for the flare maneuver approached (2000ft) the pilot switched to alternate fixations of the start and end of the runway. Presumably the changing angle subtended by these points provides an estimate of the orientation and speed of the approach. A similar strategy was used in the A340 simulator, which has no HUD.

GVS: Results from 40 subjects (including 7 veteran astronauts) have demonstrated that GVS induces postural, locomotor, gaze and perceptual deficits remarkably similar to that experienced on landing day (Moore et al. Exp Brain Res 2006; MacDougall et al. Exp Brain Res 2006). Furthermore, data from landing simulations during GVS in the A340 and VMS revealed that GVS induced erroneous control inputs, similar to that observed in actual Orbiter landings.

CONCLUSION

Head-eye coordination strategies during simulated shuttle landings have been established using the eye, head and cabin tracker developed by the investigators. In the coming year we will begin to use GVS as a model of SD following space flight, and compare head-eye coordination in the VMS with and without GVS. We expect that head movements will be minimized (the strap-down strategy) to reduce disorientation and the range of ‘eye-only’ gaze fixations will increase. Moreover, pilot performance will be degraded during GVS in a manner analogous to that observed during actual Orbiter landings.