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EFFECTS OF LONG-DURATION SPACEFLIGHT ON OPERATOR PERFORMANCE: IMPLICATIONS FOR FUTURE EXPLORATION CLASS MISSIONS

Abstract

Performance of astronaut pilots during return from the first 100 space shuttle missions was degraded after a few weeks of microgravity exposure, with 20 percent of landings exhibiting off-nominal touchdown parameters. Longer-term microgravity exposure has the potential to impact operator proficiency during critical landing and post-landing operations for exploration-class missions. To assess the impact of long-duration spaceflight on operational performance we conducted full-motion simulations of operationally relevant tasks (driving, Mars rover navigation and docking, and T-38 landings) in a group of 8 astronauts assigned to the International Space Station. In addition, a battery of cognitive and sensorimotor tests were conducted to determine the underlying cause of any post-flight performance decrements. A shadow ground control group (N=12) and a sleep restriction cohort (N=9) were also tested to control for non-spaceflight factors such as lack of practice between pre- and post-flight testing and fatigue. On the day of return after 6 months aboard the space station, astronauts exhibited significant deficits in manual dexterity, dual-tasking and low-frequency (¡0.3 Hz) motion perception in pitch and roll. There was a striking degradation in the ability to operate a vehicle and the majority of test-pilot subjects exhibited degraded performance on the T-38 landing simulation. These deficits were not primarily due to fatigue; performance on the same tasks was unaffected after a 30-h period of sleep restriction. Astronauts experienced a general post-flight malaise in motor function and motion perception, and a lack of cognitive reserve apparent only when faced with dual tasks, which adversely affected operator performance on driving and piloting tasks. Performance on the cognitive/sensorimotor test battery and driving/landing simulations recovered to baseline by four days after landing. These results suggest that astronauts exposed to long-duration microgravity exhibit subtle changes in cognition, motion perception and fine-motor control resulting in operationally significant performance degradation. Spacecraft and task design for future exploration-class missions should allow for these effects by considering limitations on dual-tasking during critical mission operations, audio/visual/tactile cues to assist motion perception, and just-in-time training at the end of extended transits in microgravity.