Proceedings of the IEA 2000/HFES 2000 Congress

COGNITIVE PERFORMANCE OF ASTRONAUTS DURING TWO SPACE SHUTTLE MISSIONS

Randa L. Shehab, Robert E. Schlegel, Byeong-cheol Hwang
School of Industrial Engineering, University of Oklahoma
Norman, Oklahoma

INTRODUCTION

The National Aeronautics and Space Administration (NASA) conducted a series of space shuttle missions to investigate the effects of microgravity on human performance. This paper presents the results of a combined analysis of data collected from two space shuttle missions. Astronaut cognitive performance data were collected from three flight-crew astronauts aboard STS-65, the Second International Microgravity Laboratory (IML-2) and from four payload-crew astronauts aboard STS-78, the Life and Microgravity Spacelab (LMS).

A computer-based task battery, the Performance Assessment Workstation (PAWS), was used to measure cognitive performance. PAWS contains six performance tasks and two subjective scales (Schlegel, Gilliland, and Shehab, 1993). For the current analysis, three PAWS tasks were examined. The Critical Tracking (TRK) task requires subjects to manipulate a trackball to maintain an unstable cursor in the center of a horizontal target. An instability parameter (lambda) represents the level of difficulty attained. The Dual (DUL) task combines tracking with Sternberg memory search. Root mean square error (RMSE) is a tracking measure of cursor deviation from target. The Directed Attention task simultaneously presents a spatial manikin (MAN) task and a mathematical processing (MTH) task. A cursor directs subjects to perform one of the two subtasks. Throughput integrates reaction time and accuracy into a single performance metric.

METHOD

The methodology followed in each mission was as similar as possible. Subjects were trained for eight PAWS sessions (T1 to T8) and then completed 16 practice sessions (P1 to P16) prior to launch. During the mission, IML-2 subjects performed one PAWS session each day while LMS subjects performed one PAWS session every other day. Recovery sessions were completed immediately after shuttle landing and periodically throughout the following week.

The data from the separate missions were combined to provide a database of 7 subjects and 268 sessions and the data collection sessions were aligned to capture performance during distinct mission phases. Practice was represented by performance averaged across sessions P12, P13, and P14. These trials were selected as "practice" because they demonstrated a stable performance level (using the methods described in Hwang, Schlegel, and Shehab, 1998) that was not evident in the immediate pre-launch trials. On-orbit sessions were separated into early (first two), middle (middle three), and late (last two) flight and recovery was categorized as early (first session) and late (session 4 or 5).

RESULTS

A repeated measures analysis of variance was performed with mission phase as the independent variable. All three tasks reflected significant differences among phases. Performance improvement due to learning continued throughout the on-orbit sessions. For TRK lambda (p=0.0002), a performance decrement was noted from practice to early flight and from late flight to early recovery. DUL RMSE (p=0.0270) reflected a similar performance pattern. Improvements in MAN throughput (p=0.0188) were attributed to the continued learning on-orbit.

DISCUSSION

The results of this study indicated that changing gravitational environments might impact the performance of visual-motor tasks. Performance on both tracking tasks suffered initially under a change in gravity (both in early flight and in early recovery) although the decrements were quickly recovered. The continued improvement on the Directed Attention task indicates that sufficient learning had not been accomplished pre-mission. Although this study investigated the effects of space flight on highly trained synthetic tasks, the results suggest that astronauts might have difficulty compensating for changes in gravitational environment during the performance of operational tasks requiring similar skills. For example, a task analysis of the use of the Remote Manipulator Arm has indicated that it requires visual-motor operator skills. Another interpretation of the results might suggest that the impaired performance represents gravitational effects on learning as opposed to performance. The issue of long-duration space flight and the inability to sufficiently train pre-mission for delayed operational tasks, suggest that this issue is critical. However, these findings are preliminary and higher fidelity tasks should be examined to determine if the results translate into operational task decrements.

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