EVALUATING THE SUBJECTIVE STRAIGHT AHEAD BEFORE AND AFTER SPACEFLIGHT

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INTRODUCTION

This joint European Space Agency/NASA pre- and post-flight study investigates the influence of exposure to microgravity on the subjective straight ahead (SSA) in crewmembers returning from long-duration expeditions to the International Space Station (ISS). The SSA is a measure of the internal representation of body orientation and to be influenced by stimulation of sensory systems involved in postural control. The use of a vibrotactile sensory aid to correct the representation of body tilted relative to gravity is also tested as a countermeasure. This study addresses the sensorimotor research gap to "determine the changes in sensorimotor function over the course of a mission and during recovery after landing."

RESEARCH PLANS

The ISS study will involve eight crewmembers who will participate in three pre-flight sessions (between 120 and 60 days before launch) and then three post-flight sessions on R+0/1 day, R+4 days, and R+8 days Sixteen control subjects were also tested during three sessions to evaluate the effects of repeated testing and to establish normative values. The experimental protocol includes measurements of gaze and arm movements during the following tasks:

(1) Near & Far Fixation: The subject is asked to look at actual targets in the true straight-ahead direction or to imagine these targets in the dark. Targets are located at near distance (arm's length) and far distance (beyond 2 m). This task is successively performed with the subject's body aligned with the gravitational vertical, and with the subject's body tilted in pitch relative to the gravitational vertical using a tilt chair. Measures are then compared with and without a vibrotactile sensory aid that indicates how far one has tilted relative to the vertical.

(2) Eye and Arm Movements: The subject is asked to look and point in the SSA direction in darkness and then make horizontal and vertical eye or arm movements, relative to Earth coordinates (allocentric) and to the subject's head/body reference (egocentric). This task is successively performed with the subject's body aligned with the gravitational vertical, and with subject's body tilted in roll using a tilt chair.

(3) Linear Vestibulo-Ocular Reflex: The subject is asked to fixate actual visual targets at near and far distances in the true straight-ahead direction, and to evaluate the distance of these targets. The subject is asked to continue fixating the same imagined targets in darkness while he/she is passively accelerated up and down on a spring-loaded vertical linear accelerator.

RESULTS

In the control subject population, the perceived tilt angles, translations, and distances were remarkably close to the actual values. The pointing tasks indicated that the orientation of arm saccades was influenced by both the gravitational vertical and the body idiotropic vector. Repeating the testing did not reveal any significant changes. Preliminary results obtained in three crewmembers before and after flight will also be presented.

APPLICATIONS

A change in an individual's egocentric reference might have negative consequences on evaluating the direction of an approaching object or on the accuracy of reaching movements or locomotion. Consequently, investigating how microgravity affects the target location will have theoretical, operational, and even clinical implications for future space exploration missions. The use of vibrotactile feedback as a sensorimotor countermeasure is applicable to balance therapy applications for patients with vestibular loss and the elderly to mitigate risks due to loss of spatial orientation.

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