MODELING WORK ON BIMANUAL COORDINATION IN ALTERED GRAVITY

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ABSTRACT

Gravitational transitions, such as those associated with spaceflight, alter sensorimotor function in astronauts [1]. These transitions typically occur at a critical time during spaceflight missions, when errors in vehicle control and landing tasks can represent dire consequences. Thus, successful G-adaptation to altered gravity constitutes a vital aspect of human performance in the spaceflight environment.

To investigate the effects of transitional G-adaptation on bimanual coordination, we have initiated a series of experiments. Preliminary ground studies at Texas A&M University are underway aimed at quantifying effects of altered-gravity environments on performance in two bimanual coordination tasks (i.e., force coordination and movement coordination), and this work will inform development of follow-up studies in other spaceflight analogs: a tilt table paradigm, artificial gravity (AG) delivered via short-radius centrifuge, and parabolic flight. Each analogous environment delivers 0g, 0.25g, 0.50g, 0.75g, 1g, and in the case of parabolic flight, 1.8g effects on bimanual coordination tasks.

Operational constraints of these environments present engineering design challenges. We have developed a novel visualization method to present Lissajous feedback to our subjects via head-mounted display, and validated this method against more classical visualization designs. This was necessary given the tilted and/or rotating position of subjects during the tilt table and centrifuge testing operations. We have developed a modular, independent, testing hardware apparatus to integrate our measurement tools in a transferable fashion between our three paradigms, ensuring maximal precision and validity between environments. In addition, we have developed novel testing software that integrates our measurement tools into a single user interface and records simultaneous digital measurements in real time. Overcoming these challenges will allow us to generate gravitational dose-response curves on sensorimotor function, as well as investigate the effect of transitions between G-levels in all 3 paradigms in an integrative fashion.

Experiments using the tilt table are currently underway, testing both force coordination and movement coordination tasks in separate bimanual tasks. For the force coordination task, subjects must follow a Lissajous plot with 1:1 and 1:2 (left:right) limb frequencies by pressing force transducers at either wrist. The movement coordination task requires subjects to move carbon-fiber arms with embedded potentiometers located at their elbows using a mounted handle grip. Subjects flex and extend their elbows in a continuous pattern that changes from 0° to 180° relative phase in 30° increments. These tasks were chosen as they have been validated in previous work [2] and translate well to spaceflight operational skills (e.g. landing a spacecraft or piloting a rover). Each task will be repeated at each G-level sequentially in ascending order, followed immediately in the descending order. Ascending and descending performance will be averaged for each G-level to offset potential effects of motor learning.

This investigation will ultimately uncover the role of gravity in bimanual coordination as well as provide critical information for current and future countermeasure development and in-flight prescriptions.

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