BIMANUAL COORDINATION IN ALTERED GRAVITY DURING PARABOLIC FLIGHT

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ABSTRACT

Sensorimotor function is altered during gravitational transitions, such as those that occur during spaceflight. Astronauts must remain functional during the critical mission phases that occur during or temporally close to gravity transitions, particularly for vehicle control and landing tasks. Sensorimotor adaptation to altered-gravity (or G-adaptation) can be assessed using a variety of metrics, including manual control performance metrics, which have a direct application to human performance in the space environment. Thus, in the present investigation, we propose to investigate sensorimotor G-adaptation in the context of bimanual coordination tasks during parabolic flight.

This project presents an experimental approach aimed at quantifying performance decrements in bimanual coordination tasks due to G-transitions, as well as adaptation to new altered-gravity environments, if it exists. We aim to quantify the effect of partial G-levels on bimanual coordination tasks during parabolic flight. NASA HRP is planning a parabolic flight campaign where multiple G-levels (0, 0.25, 0.50, 0.75, 1, and 1.8G) will be delivered for about ~ 20sec. This provides a unique scenario to generate gravitational dose-response curves on sensorimotor function, as well as investigate the effect of transitions between G-levels. Subjects will conduct two different but complementary bimanual coordination tasks at all G-levels delivered. The first task is based on bimanual movement coordination [1], and will require individuals to coordinate left and right limb movements together in a continuous pattern that changes from 0° to 180° relative phase in 30° increments. The second task is based on bimanual force coordination [2], and will require participants to produce and coordinate two bimanual force patterns (in-phase and 1:2 multi-frequency). Both of these tasks are important skills in any space operational scenario (e.g. landing a spacecraft or piloting a rover). Each task will be conducted continuously during 5 parabolas in a row, which will also allow us to investigate potential performance decrements during gravitational transitions and subsequent adaptation.

Additionally, we propose to account for motion sickness medication, which is extremely common in this type of parabolic flight investigation. An equal number of subjects with and without medication will be selected. We will use promethazine, a motion sickness drug commonly used in space and that has been shown to cause decrements in roll-tilt perception (i.e. increase of 31% in vestibular perceptual thresholds) [3]. While our investigation does not focus specifically on roll-tilt perception, these previous findings highlight the potential risk of functional decrements in sensorimotor tasks caused by promethazine. These potential decrements remain to be determined and we attempt to address them in the context of bimanual coordination tasks.

Our specific aims are summarized below:

- Generate dose-response relationships between bimanual coordination operational variables as a function of G-levels.
- Determine the G-thresholds associated to decrements in performance in bimanual coordination tasks.
- Test whether bimanual coordination adaptation to altered-gravity occurs by repetitive exposure to altered-gravity levels in the context of parabolic flight.
- Test whether promethazine affects operational performance in bimanual coordination tasks during various G-levels and during the rapid G-level transitions during parabolic flight.

Results will provide critical information for current and future countermeasure development and in-flight prescriptions.

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