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PERCEPTION OF UPRIGHT: INFLUENCE OF GENDER, VISION, GRAVITY AND PROPRIOCEPTIVE CUES

Abstract

How much gravity is sufficient to provide an adequate perception of "upright" for astronauts and are there gender biases in the relative contributions of vision, gravity and the internal representation of the body to the perception of upright?

In order to find answers to the above questions, we used the European Space Agency's short-arm human centrifuge to simulate gravity levels along the body's long-axis here on Earth. A total of 26 participants (13 female) was tested in two experiments (10 in experiment 1 and 16 in experiment 2) while lying supine on the centrifuge. The perception of upright was measured using the Oriented Character Recognition Test (OCHART). OCHART uses the ambiguous symbol "p" shown in different roll orientations to probe the perceptual upright (PU). Participants decided whether the ambiguous symbol was either a "p" or a "d" and the perceptual upright (PU) was calculated based on the points of maximum ambiguity of the p-to-d and d-to-p transitions. The relative contribution of vision, gravity and the internal representation of the body were then calculated for each polarized visual background and simulated gravity state. Control experiments were done off the centrifuge (upright, supine and lying left side down).

In the first experiment the centrifuge was rotated so as to provide g-levels of $0.2g$–$1g$ along the long axis of the body measured at ear level. In the second experiment the range of logarithmically spaced g-levels was $0.04g$–$0.5g$).

Our data suggest that a gravitational field of at least $0.15g$ is necessary to provide effective orientation information for the perception of upright, which is close to the gravitational force found on the Moon of $0.17g$. For whole-body linear acceleration, the vestibular threshold is around $0.1\frac{m}{s^2}$ (although studies have reported values ranging from $0.014\frac{m}{s^2}$ to $0.25\frac{m}{s^2}$) and so the lunar value of $1.6\frac{m}{s^2}$ is clearly well above threshold.