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A gravity-dose response: Human spatial orientation perception in hypo-gravity

In everyday life humans perceive their own orientation fairly well. However, in altered gravity, humans systematically misperceive their own tilt due to the unusual stimulation of the body's graviceptors, particularly the otoliths of the vestibular system. Previous studies have found an overestimation of one's own roll tilt in hyper-gravity, such as produced on a centrifuge or during a high-G turn in an airplane. Similar misperception would presumably be experienced on a more massive planet. We have modified an existing computational model for human spatial orientation perception that quantitatively captures the overestimation of roll tilt observed in hyper-gravity. Interestingly, the model now predicts that humans will underestimate roll tilt in *hypo*-gravity, such as experienced on a less massive planetary body like the moon or Mars. Furthermore, the model quantitatively predicts more underestimation at lower gravity levels. To validate these model predictions, we aim to experimentally quantify a "gravity-dose response" for human spatial orientation perception (i.e., how does misperception of tilt vary as a function of gravity between 0 and 1 G?). Compared to hyper-gravity, which can readily be produced on the Earth using a centrifuge, it is much more difficult to create a hypo-gravity environment for experimentation. We have used a combination of parabolic flights and a ground-based hypo-gravity analog. In the hypo-gravity analog, the supine subject is centrifuged to create a centripetal acceleration between 0 and 1 G, and then is tilted relative to the centripetal acceleration direction. In nine subjects, centrifuged to 0.5 G, we indeed found roll tilt was perceptual underestimated, comparable to that predicted by our model. Using parabolic flight to create 0.16 G (lunar) and 0.38 G (Martian), in one pilot subject, we also observed underestimation of roll tilt. Building upon these studies, we aim to use parabolic flight to assess spatial orientation perception at 0.25, 0.5, 0.75, and 1 G (as well as 1.6-1.8 G during the pullouts) in a larger group of subjects. In doing so, this will systematically quantify a gravity-dose response curve for human spatial orientation perception. Our findings are relevant for astronauts exploring the moon or Mars, as well as for pilots of high-performance aircraft who briefly experience hypo-gravity environments.