

# The impact of gravito-inertial cues on the perception of lateral self-motion.

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## Introduction

It is typically assumed that during passive motion in darkness, velocity and traveled distances are indirectly estimated by an integration of inertial signals<sup>1</sup>.

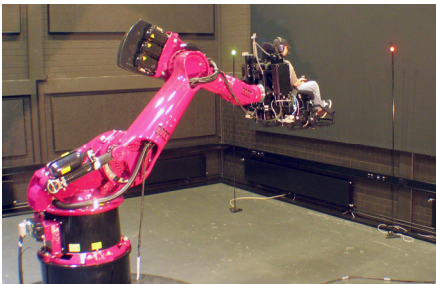
**Objective 1:** Test the robustness of inertial cues to estimate distances under different velocity conditions.

Inertial forces during linear acceleration are, in principle, indistinguishable from comparable gravitational forces during tilted orientations (tilt-translation ambiguity).

**Objective 2:** Evaluate whether adding or subtracting gravito-inertial cues by applying sideways tilts affects distance estimates.

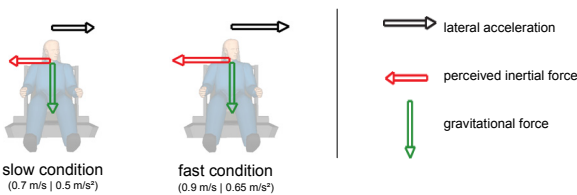
## Method

- Participants (N=17, 11 female) were seated on the MPI Motion Simulator<sup>2</sup> and used a steering wheel to control lateral motions on an arc (diameter = 5.4m).
- The lateral velocity was proportional to the steering wheel angle.
- A target was briefly flashed in total darkness and participants were asked to directly move in front of that target.
- Target distances = 40°, 55° and 70° each to the left and to the right.



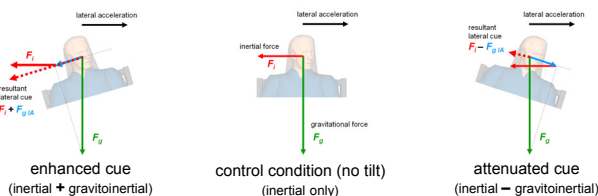
MPI Motion Simulator based on an industrial robot arm. Here, with a subject positioned in front of one target light.

**Experiment 1:** Two motion conditions were used with different gain factors between steering wheel angle and lateral motion. The maximum possible velocity and acceleration was 1.3 times greater in the fast condition than in the slow condition.



**Prediction:** If inertial signals are appropriately integrated, there should be **no differences** observed as a function of different acceleration profiles.

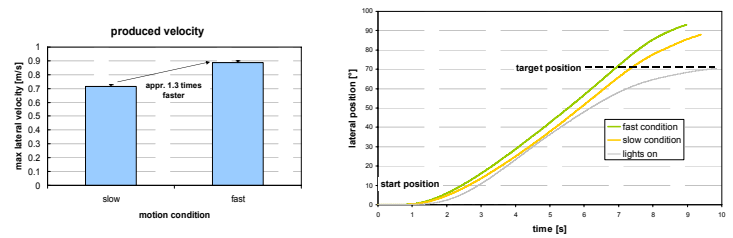
**Experiment 2:** A sideways tilt was applied either in the same or in the opposite direction of lateral movement. The tilt angle was coupled to the lateral acceleration.



**Prediction:** If adding or subtracting gravito-inertial cues by sideways tilting changes the perceived acceleration, it would be expected that:

- adding gravito-inertial cues would **enhance** motion perception (leading to a distance **undershoot**)
- subtracting gravito-inertial cues would **attenuate** motion perception (leading to a distance **overshoot**)

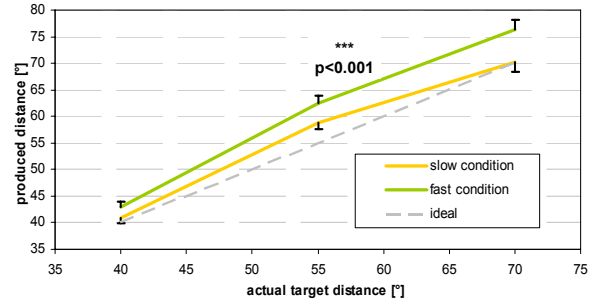
## Results | Experiment 1



Overall produced velocities for both motion conditions. Error bars represent standard error of the mean.

Representative difference between fast and slow condition for one subject and one target distance.

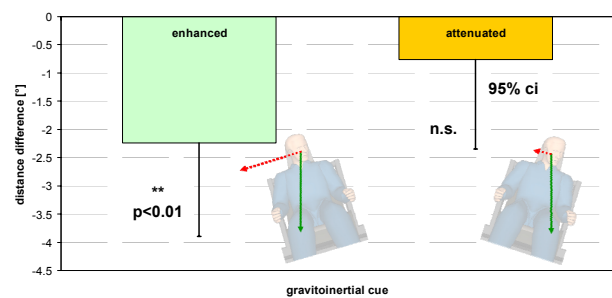
## absolute produced distances



Overall absolute produced distances for both motion conditions. Error bars represent standard error of the mean.

- Different velocities lead to differences in estimates of produced distances.
- Specifically, the faster condition resulted in a significantly larger produced distance compared to the slow condition.

## Results | Experiment 2



Mean produced distance differences for both conditions relative to control condition without tilt.

### Enhanced motion cue

Adding gravito-inertial forces by tilting in the opposite direction of motion resulted in a small, but significant reduction of distances relative to control (no tilt).

### Attenuated motion cue

Subtracting gravito-inertial forces by tilting in the same direction of movement did not affect distance production relative to the control condition (no tilt).

## Conclusions

- In this study, we used different velocities and sideways tilts to systematically alter inertial and gravito-inertial cues as a way of evaluating the associated effects on spatial updating via inertial signals.
- In general, the results indicate that spatial updating in the absence of visual and proprioceptive information is possible.
- However, the lack of compensation for different acceleration profiles and the small and one-sided effect of different tilt directions suggests that such updating might not be as strongly influenced by gravito-inertial cues as is often assumed.
- Alternatively, responses might be influenced more by non-directional, sensory information such as the noise and vibrations<sup>3</sup> that accompany almost any motion.

## References

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- Teufel, H. J., H.-G. Nusseck, K. A. Beykirch, J. S. Butler, M. Kerger and H. H. Bühlhoff: MPI Motion Simulator: Development and Analysis of a Novel Motion Simulator. Proceedings of the AIAA Modeling and Simulation Technologies Conference and Exhibit (AIAA 2007), 1-11, American Institute of Aeronautics and Astronautics, Reston, VA, USA (08 2007)
- Yong, N. Au., G. D. Paige and S. H. Seldman: Multiple Sensory Cues Underlying the Perception of Translation and Path. J Neurophysiol 97:1100-1113, 2007.

Poster presented at IMRF2008