Introduction

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

**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 gravitoinertial cues by applying sideways tilts affects distance estimates.

Method

- Participants (N=17, 11 female) were seated on the MPI Motion simulator² and used a steering wheel to control lateral motions on an arc (diameter = 5.4 m).
- 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.](image)

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.

![Diagram showing lateral acceleration and perceived inertial force](image)

**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.

![Diagram showing enhanced and attenuated gravitoinertial cues](image)

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

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

Results | Experiment 1

- 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

**Enhanced motion cue**

Adding gravitoinertial 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 gravitoinertial 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 gravitoinertial 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 gravitoinertial cues as is often assumed.
- Alternatively, responses might be influenced more by non-directional, sensory information such as the noise and vibrations that accompany almost any motion.

References