Influence of Gain Factors and Attention on Sensor Fusion in the Perception of Self Rotation

MAX-PLANCK-GESELLSCHAFT

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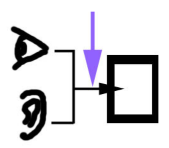
• Motivation

We investigated how optic flow and physical body movements are integrated in the perception of upright self rotation (yaw).



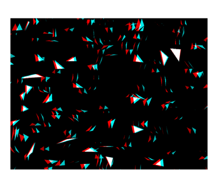
In sensor fusion experiments, large intersensory conflicts often lead to bimodal response distributions (i.e. response is dominated by any one of the input modalities).

The following questions arise:

- **When a visual rotation and a platform rotation are presented together in a cue conflict situation, will the perceived rotation angle be equal to one of the conflicting rotation angles, or will an averaged rotation angle be perceived?**
- **If attention is focused on one of the cues, how will this influence the perceived rotation angle?**

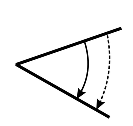
• Methods

- Subjects (14 adult subjects, 7 female, 7 male) were rotated on a Stewart platform with a flat projection screen (see Fig. 1).

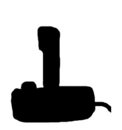


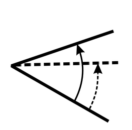
- Visual stimulus was a random 3D triangle field providing optic flow information during rotation; triangles had limited lifetime (1.18 sec) to prevent subjects from using them as an absolute reference during rotations. 3D was provided by anaglyphic red cyan stereo. Simulated depth of field was approximately 2 3 m, depending on the subject's interocular distance. The visual scene always rotated in the opposite direction of the platform, simulating a view through a window on an outside scene.

- Each trial consisted of two phases:



Rotation presentation phase: concurrent rotation with equal rotation angles of both platform and visual scene (varied in six steps between 10° and 30° (see Fig. 2), in three seconds, sinusoidal velocity profile)





Active rotation return phase: Subjects had to actively return either the platform or the visual scene (rotate it back to the previous position) by using a joystick. During active return, a gain factor between the visual and platform rotation was applied (rotation speeds of the visual movement relative to the platform movement varied between 0.35 and 2.84 in nine steps, see Fig. 3).

- Headphones and chair subwoofers were used to cover sound and platform vibrations.

Subjects were informed that the rotation of the platform and the visual scene were unequal during active return. After each trial, they had to press one of three joystick buttons, depending on whether during active return the rotated angle of the ignored modality had appeared to them smaller, equal to or larger than the angle of the returned modality.

Each subject had to complete two experimental blocks of 108 trials each (6 angles x 9 gain factors, 2 measurements each). In one block they always had to return the platform, and in the other they always had to return the visual scene, ignoring the (different) rotation in the other modality (*attentional* conditions).

In the *baseline* conditions, subjects had to return a rotation in one modality only, without any movement of the other modality. For the visual baseline condition, the platform didn't move. For the platform baseline condition, subjects had to turn the platform back in the dark.

Figure 1: The motion platform with projection screen

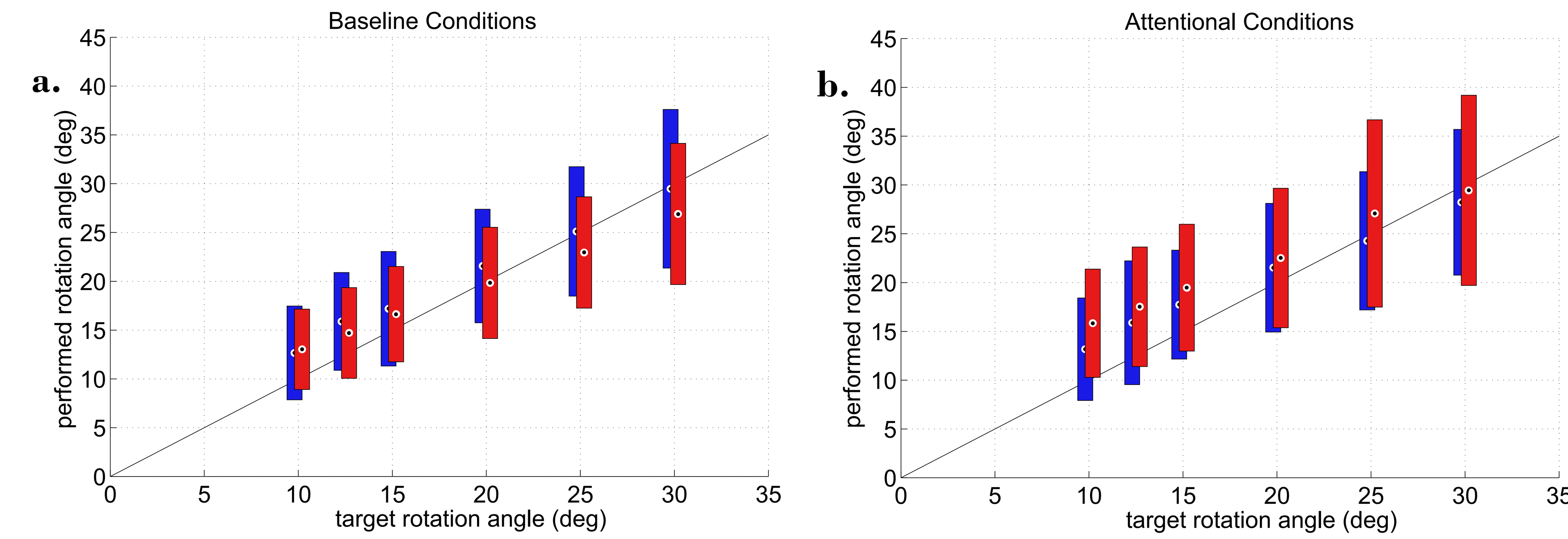


Figure 2: a. Performed rotation angles in the baseline conditions with rotations in the visual scene only (blue) and platform rotations in the dark (red). **b.** Performed rotation angles in the attentional conditions, when the scene (blue) or the platform (red) had to be returned (8 subjects, single trial data)

• Results

Subjects could reproduce platform only rotations and visual only rotations with standard deviations of about 5 degrees (see Fig. 2a). They tended to overshoot small rotations and to undershoot large rotations.

When rotations in both modalities were presented together and gain factors (ratios of visual rotation speed to platform rotation speed) were used, accuracy of manual returns dropped more in the platform attention condition than the visual attention condition (see Fig. 2b). This indicates that the visual cue had a higher influence on returned platform rotations than vice versa. A regression analysis revealed a significant difference in cross influences (p=0.03).

Figure 3 shows the subjects' performance in the two attentional conditions for the different gain factors. Data points were pooled over all target rotation angles by dividing each performed angle by its target angle and averaging all the trials of each gain/attention/subject combination. Note that the performed rotation angles of the platform return condition differ more from their target angles than the visual return angles do.

Figure 4 depicts the significance levels of the differences in visual vs. platform return conditions for the different gain factors, measured by t tests. For gain factors near 1.0, differences are not significant. For extreme gain factors they are significant.

Figure 5 shows that distributions of single responses for the two most extreme gain factors, 0.35 and 2.84, are unimodal. Blue bars show the performed angles when turning back the visual scene, red bars show the performed angles when turning back the platform. The blue and red lines show the respective target rotation angles. The histograms of the responses for the other gain factors also looked unimodal.

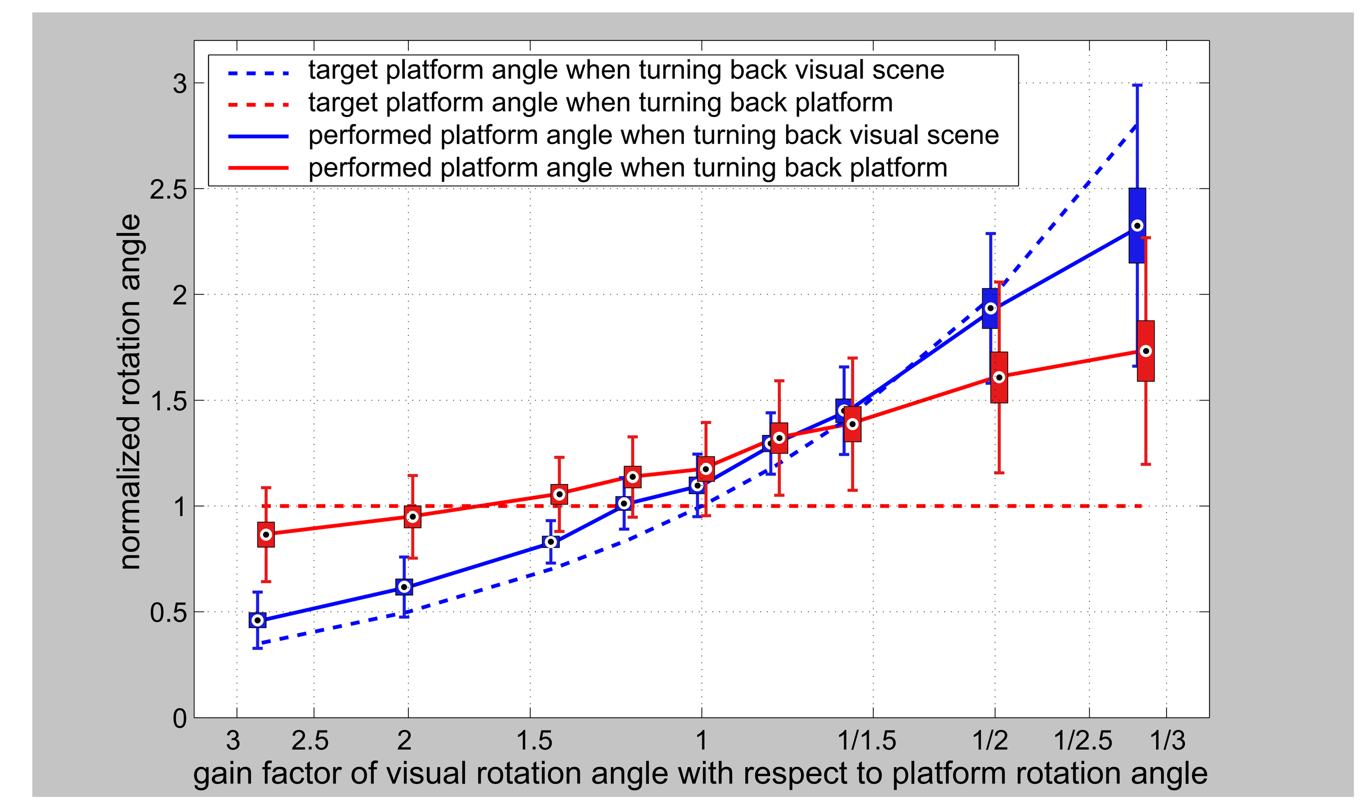


Figure 3: Performance of all 14 subjects in the attentional conditions

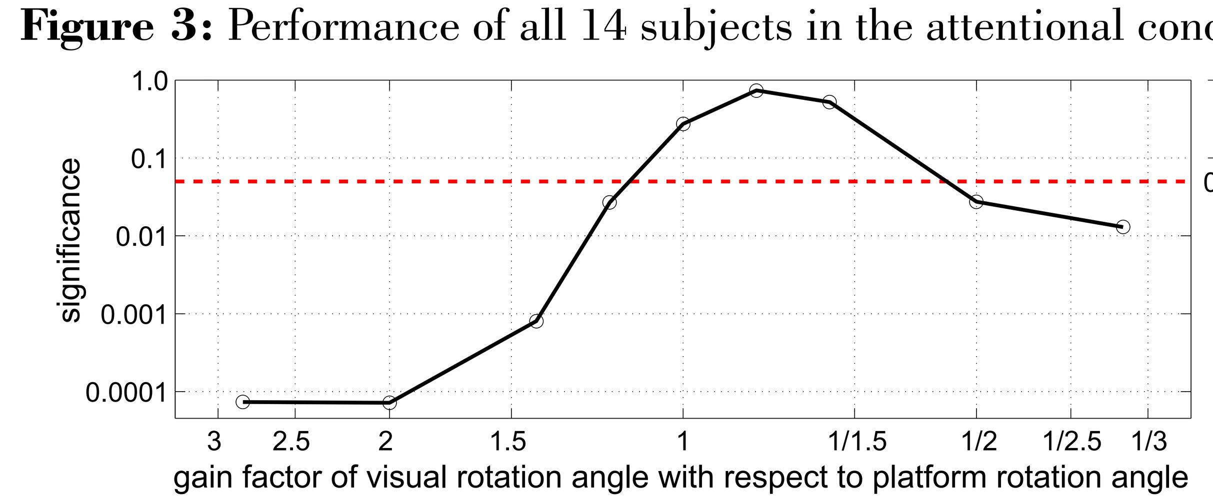


Figure 4: T test significance levels of response differences between the two attentional conditions for the different gain factors

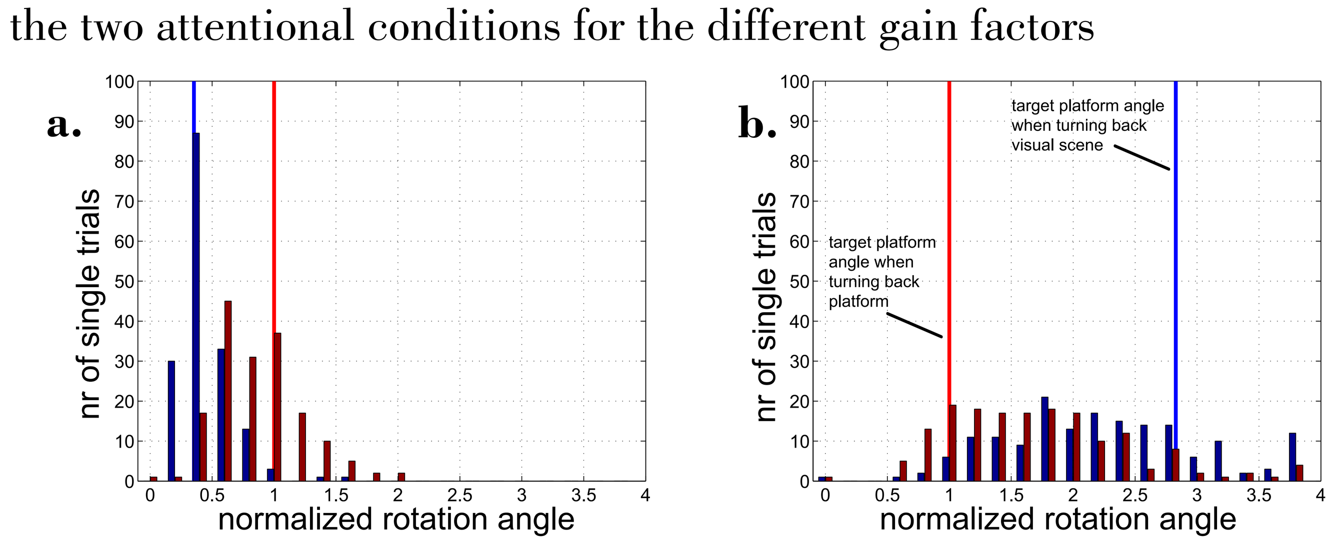


Figure 5: Single response histograms for visual (blue) and platform returns (red), for the most extreme gain factors 0.35 (**a.**) and 2.84 (**b.**)

• Conclusions

The experiment showed that for extreme difference between visual and platform rotation angles, response distributions for each of the two attentional conditions were unimodal. The means of the distributions of these two conditions differed significantly from each other.

• This shows that perception of self rotations in these cue conflict situations is a fused, unimodal perception of a rotation rather than one which is alternating between the two presented rotation angles.

• This unimodal percept can be shifted by an attentional bias toward the attended cue.

The amount of crossmodal influences varied greatly across subjects. The crossmodal influence of the visual rotation when turning back the platform was usually larger than vice versa.

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