Theoretical Background

DeValois and DeValois (1991) have shown that motion behind a stationary window can make this window appear to be locally shifted in the direction of the motion.

Yamagishi, Anderson & Ashida (2001) showed that this error was up to three times greater when subjects had to perform an action task that required quick motor responses in contrast to a pure perception task.

In this study we tested if a motion-induced bias can be found in a motor task that requires the navigation of a motion field in space.

Methods

Twelve participants were asked to manipulate the horizontal position of vertically sliding path using a joystick. The path consisted of smooth curves randomly created by combining sinusoids of different amplitudes (see Fig. 1). Through the steering, this path had to be kept aligned with a motion field (Gabor) that was presented at a constant eccentricity (15 degrees) either left or right of the fixation cross.

For each participant we permutated direction of motion (left/right) and to which side of the fixation cross the Gabor was presented (left/right), so each of them did four blocks of 180 sec (the first 30 sec of each block were later not included in the analysis and considered as practice time). We created four possible orders of the blocks to control for any order effects.

Fig. 1: Stimulus for the experiment - the path is sliding upwards and has to be kept aligned with the motion field

Main question:
- Will the trajectory be misplaced in the direction of the Gabor's motion in this motor task?

Additional questions:
- Are there individual differences in the size of the bias?
- Will a bigger bias lead to generally less accurate steering behaviour?
- Will outwards motion produce a bigger bias?
- Does the bias size change during the experiment (habitation)?
- Is there a learning effect that increases accuracy over time?

Results

Fig. 2: To analyze the data we compared the optimal path (blue) with the real trajectory (red) and calculated the deviation (green). We were interested in the mean of this deviation (a positive value corresponds to a bias in the expected direction) and the SD of the deviation.

Fig. 3 shows that all the participants had a bias in the expected direction (i.e. misplaced the path in direction of the Gabor's motion). We found large inter-individual differences.

Fig. 4 compares for each block (12 participants x 4 blocks = 48 blocks) the mean and its SD. The latter can be taken as an indicator of accuracy (the smaller the SD, the more "stable" is the bias). The lack of relationship between the mean and SD suggest that the size of the bias does not influence the accuracy.

Fig. 5 shows that the tasks in which the Gabors were moving inwards seem to cause a stronger bias in the steering behaviour (this is possibly an artefact; see interpretation).

Fig. 6 compares the different bias values for different positions in the order. There is no order effect.

Fig. 7 shows that the general accuracy (ignoring the size of the bias) does not change over time, which indicates that people did not "learn" to steer better.

Interpretation

As predicted people showed a motion-induced bias in this motor task that demands localization of the motion fields. This bias was found for all the participants - the size of the bias varied among them.

The size of the bias did not decrease accuracy, which indicates that the effect reflects a "general illusion" caused by the motion signals. The SD did not increase proportionally with the size of the bias.

The inwards-motion seems to cause a bigger bias; we believe this to be an artefact, reflecting that participants tended to keep the path closer to the fixation cross, since eccentricity was high.

The order did not have an effect on the size of the bias: it does not have to build up over trials, nor is it diminished through habituation.

Also people don't "learn to steer better", so the bias was equally stable independent from when (which block) it occurred.

Discussion

We showed that the motion-induced bias can also be found in motor tasks that requires navigating an object.

Some remaining questions are:

- What effect would manipulation of eccentricity have?
- If we carry out a purely perceptual experiment with this stimulus, would the biases be smaller/bigger than the ones found here?

References


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