Visually Induced Linear Vection is Enhanced by Small Physical Accelerations

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• Introduction

"Vection" refers to the illusory feeling of self-motion induced by moving visual (or auditory) stimuli

Main question: Can small physical motions (jerks) accompanying the visual motion onset enhance linear forward vection?

There is a long tradition of investigating self-motion illusions induced by moving visual stimuli ("vection"). The contribution of multi-modal aspects has, however, received only little attention so far.

Wong & Frost (1981) showed that the onset latency of visually induced self-rotation illusions (circular vection) can be reduced by concomitant small physical motions (jerks). Here, we tested whether

(a) such facilitation also occurs for linear vetion, and

(b) whether the strength of the jerk (degree of visuo-vestibular cue conflict) matters.

• Methods

Linear vection was induced using a translating visual stimulus with/without concomitant small physical motions applied using a motion platform

Two factors were varied:
- visual acceleration time (0.5s or 5s)

- platform acceleration (1cm or 3cm jerk)

Stimuli: Fourteen naïve observers viewed linear vection stimuli that were projected onto a flat projection screen (FOV: 75°×58°) using a JVC D-ILA SX21 projector at 1400x1050 pixels resolution (see Figure 1). The visual stimulus consisted of a photorealistic a street of houses from the Virtual Tübingen model (www.kyb.mpg.de/bu/projects.html?prj=41, see Fig. 1&2).

Visual motions: Visual motion started with a linear acceleration of 0.5s or 5s (corresponding to a visual accelerations of 12 m/s^2 and 1.2 m/s^2, respectively), followed by a constant velocity phase (6m/s, 30s) and a smooth final deceleration (3s).

Physical motions: For 2/3 of the trials, brief physical forward accelerations (1 or 3cm jerks applied using a Stewart motion platform) accompanied the visual motion onset. Jerks resulted in an acceleration of about 0.8 and 1.6m/s^2, respectively, at the participants' head, see Figure 3). This gave participants the sensation of a gentle kick from the back, similar to a vehicle start.

All factors were balanced and each combination was presented 4 times, in a random order.

Measurands: We measured vection onset latencies, the time when vection was saturated ("time when maximum vection was first reached"), vection intensity, and had participants rate the convincingness of the self-motion illusion for each trial using a 0-100% scale.

• Results

Platform jerks enhanced vection in terms of onset latency, intensity, and convincingness

Magnitude of platform acceleration had no effect, though

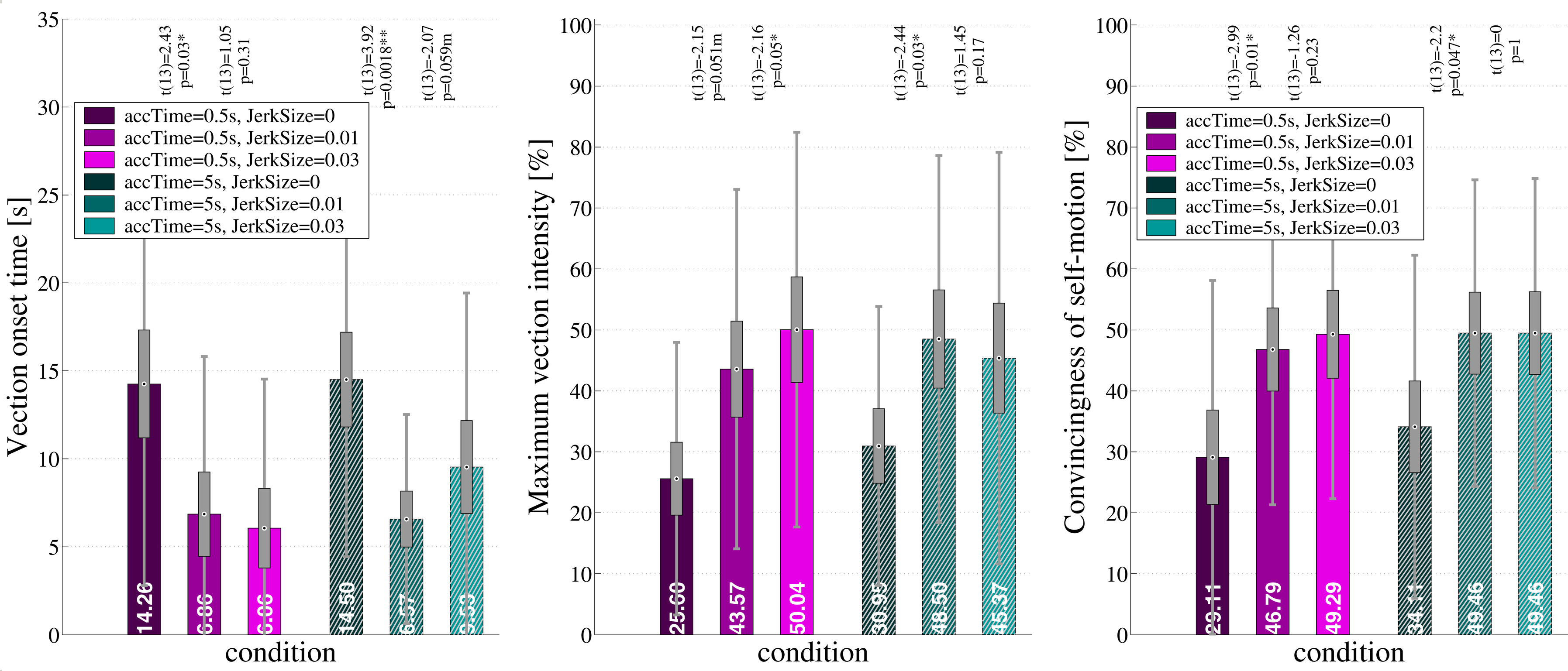
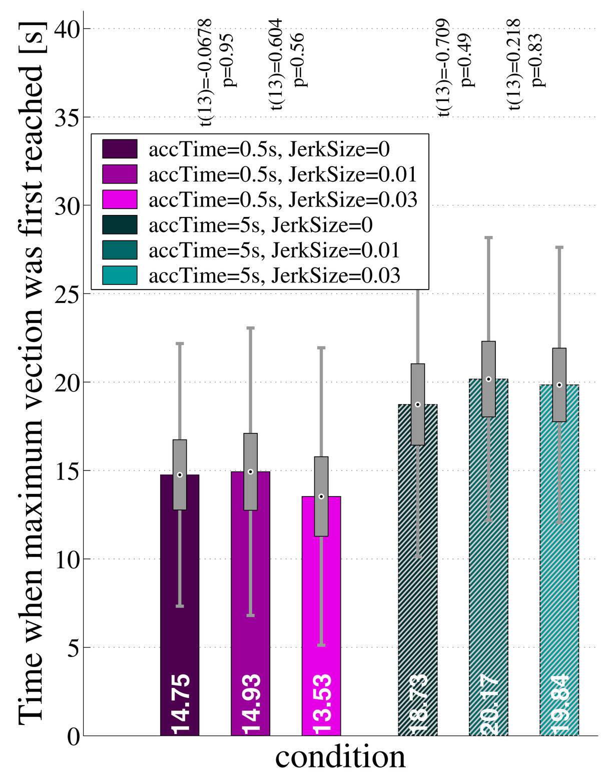


Fig. 4: Mean performance, averaged over the 14 participants. Boxes and whiskers depict on standard error of the mean and one standard deviation, respectively. Note the vection-facilitating effect of the added jerk for three of the four measurands, independent of the size of the jerk and the length of the visual acceleration phase.

Adding jerks enhanced vection significantly for the onset time, intensity, and convincingness of the self-motion illusion (see above, all p's<.05): Onset latency was reduced by 50%, convincingness and intensity ratings increased by more than 60%. Note that the magnitude of the visual acceleration did not matter for these three measurands.

Vection saturated later for longer visual acceleration phases, independent of physical motions



Only the time until vection saturated showed an influence of the visual acceleration time (see left Figure). The presence and strength of the platform jerk failed to show any influence, though.

Unexpectedly, none of the dependent measures showed any effect of the physical acceleration magnitude, at least for the values tested in the current experiment.

• Discussion & Conclusions

Unexpectedly, physical jerks enhanced vection irrespective of the size of the physical/visual acceleration

Vection was facilitated whenever there was physical jerks accompanying the visual motion onset. Interestingly, tough, neither jerk size nor the amplitude of the visual acceleration mattered, and there was no significant interaction between the two factors. This was rather surprising, as one might assume that the higher visual acceleration might better match the higher physical acceleration and thus show a stronger effect.

Even though the difference between the two jerks was clearly above discrimination threshold, none of the participants noticed the difference between the two jerk sizes when asked explicitly after the experiment.

Instead, temporal coherence and qualitative matching of visual and vestibular cues seem essential

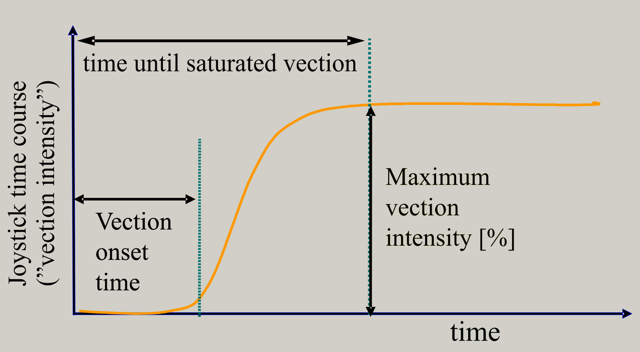
This suggests that it is less critical to match the visual and physical acceleration profiles *quantitatively* than often believed, at least in terms of vection and the parameter range tested. Rather, it seems important that the visual and physical accelerations are matched *qualitatively* and are temporally synchronized. These findings could be employed for improving the convincingness and effectiveness of low-cost simulators without the need for expensive, large motion platforms.

References

Wong, S. C. P., & Frost, B. J. (1981). The effect of visual-vestibular conflict on the latency of steady-state visually induced subjective rotation. *Perception & Psychophysics*, 30(3), 228-236.

Fig. 1: Participant seated at a distance of 1.08m in front of projection screen displaying a view of the road from the Virtual Tübingen model. The simulated FOV matched the physical FOV of 75°×58°.

Fig. 2: A joystick was used to continuously assess the intensity of vection (degree of joystick deflection).



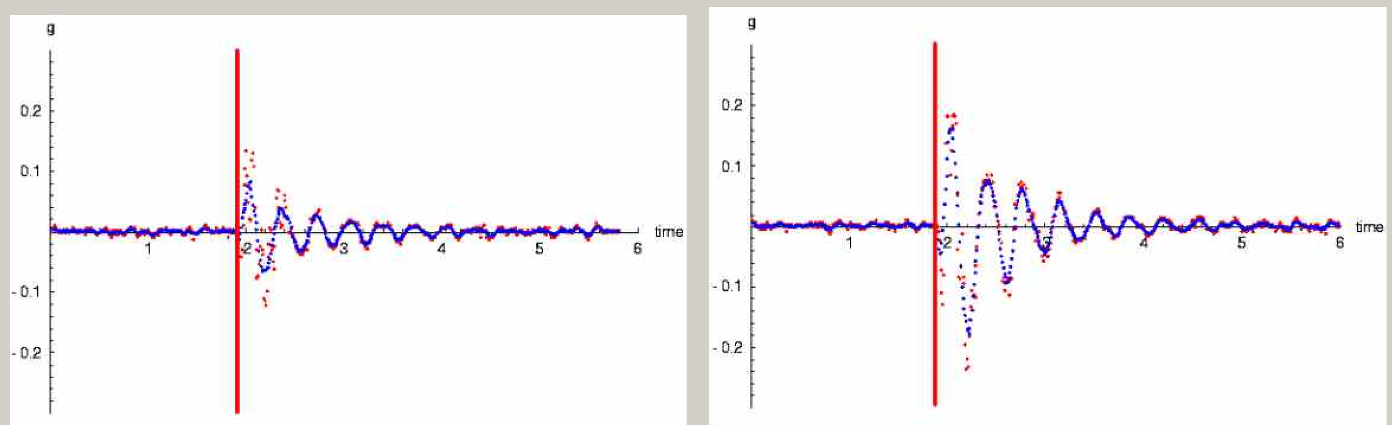


Fig. 3: Physical acceleration profile, recorded using an accelerometer attached to a participant's head. The left profile shows the 1cm platform travel condition and the right one the 3cm platform travel condition. The vertical red line shows the point at which the motion started.

POEMS Perceptually Oriented Ego-Motion Simulation

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