The effect of cognition on the visually-induced illusion of self-motion (vection)

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MPI FOR BIOLOGICAL CYBERNETICS

POEMS Perceptually Oriented Ego-Motion Simulation

www.poems-project.info
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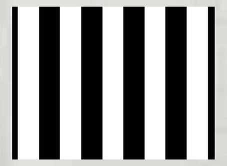
• Introduction

Main question: Do high level cognitive processes like spatial presence influence vection?

Classical vection stimlus

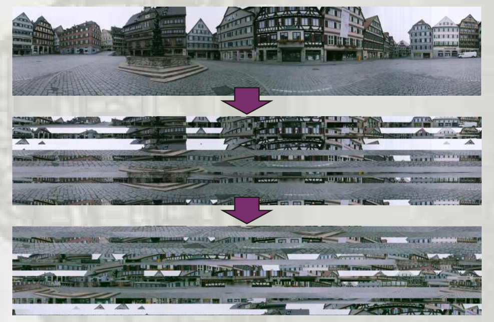


Here: Naturalistic scene inVirtual Reality

The prevailing notion of visually induced illusory self-motion perception (vection) is that the illusion arises from bottom-up perceptual processes. Therefore, past research has focused primarily on examining how physical parameters of the visual stimulus (contrast, number of vertical edges etc.) affect vection.

In this study, we examined the influence of a top-down (i.e., highly cognitive) process: Spatial presence in the simulated scene. Spatial presence was manipulated by presenting either a photorealistic image of the Tübingen market place or scrambled versions of the same stimulus (see Fig. 4-6).

• Methods



Hypothesis: Scene scrambling should decrease spatial presence and thus impair vection

Stimuli: Various scrambled versions of the stimulus were created by either scrambling image parts in a mosaic-like manner (see Fig. 6) or by slicing the original image horizontally and randomly reassembling it (see Fig. 4 & 5).

Hypothesis: We expected scene scrambling to decrease spatial presence and thus impair vection.

Procedure: 12 naive observers viewed rotating stimuli projected onto a curved projection screen (FOV: 54x40.5°, see Fig. 1).

Measurands: We measured vection onset times, vection intensity, and had participants rate the convincingness of the self-motion illusion for each trial using a 0-100% scale. In addition, we assessed spatial presence using standard presence questionnaires (Schubert et al., Presence 2001).

Experimental design: A repeated-measures within-subject design was used with two session on separate days:

	varied between sessions	varied within session				
parameter	method of scene scrambling	number of slices per 45°	vel [°/s]	turning direction	repetitions	number of trials total
values	horizontal or mosaic-like	0 (intact), 2, 8, 32	20, 40	left/right	2 (block a&b)	
number of conditions	2	4	2	2	2	64

• Results

As expected, scene scrambling increased vection onset times

In addition, higher rotation velocities decreased vection onset times

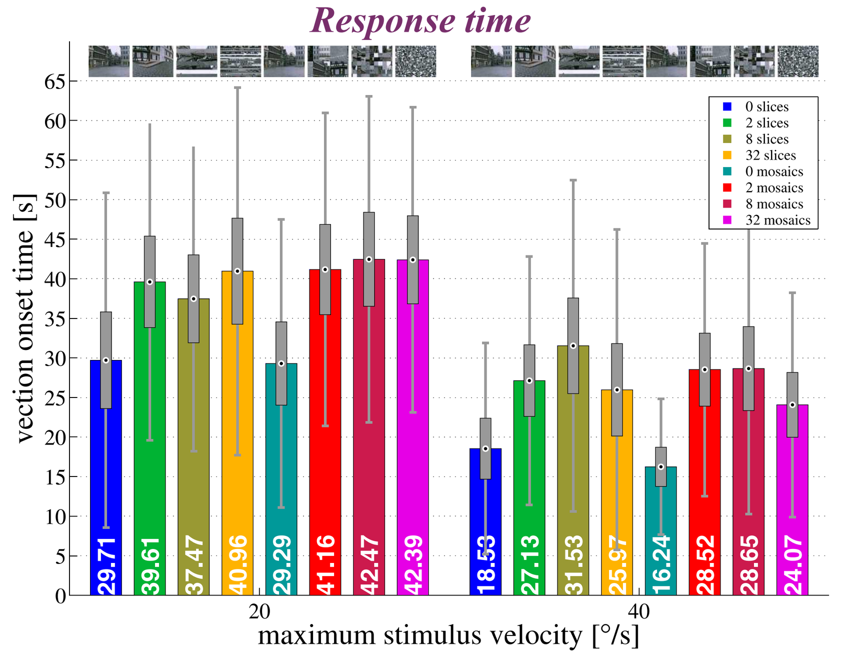


Fig. 7: Vection onset times for each of the 16 experimental conditions. Boxes and whiskers depict one standard error of the mean and one standard deviation, respectively. Note that scene scrambling as well as the lower rotational velocity increased vection onset time.

As expected, scene scrambling impaired vection: Scrambled stimuli yielded significantly longer vection onset times, lower perceived intensity, and lower convincing ness ratings than the intact market scene (see Fig. 7 & 8).

Furthermore, lower rotation velocities increased vection onset times and decreased perceived intensity and convincingness ratings.

Scene scrambling reduced vection intensity and convincingness

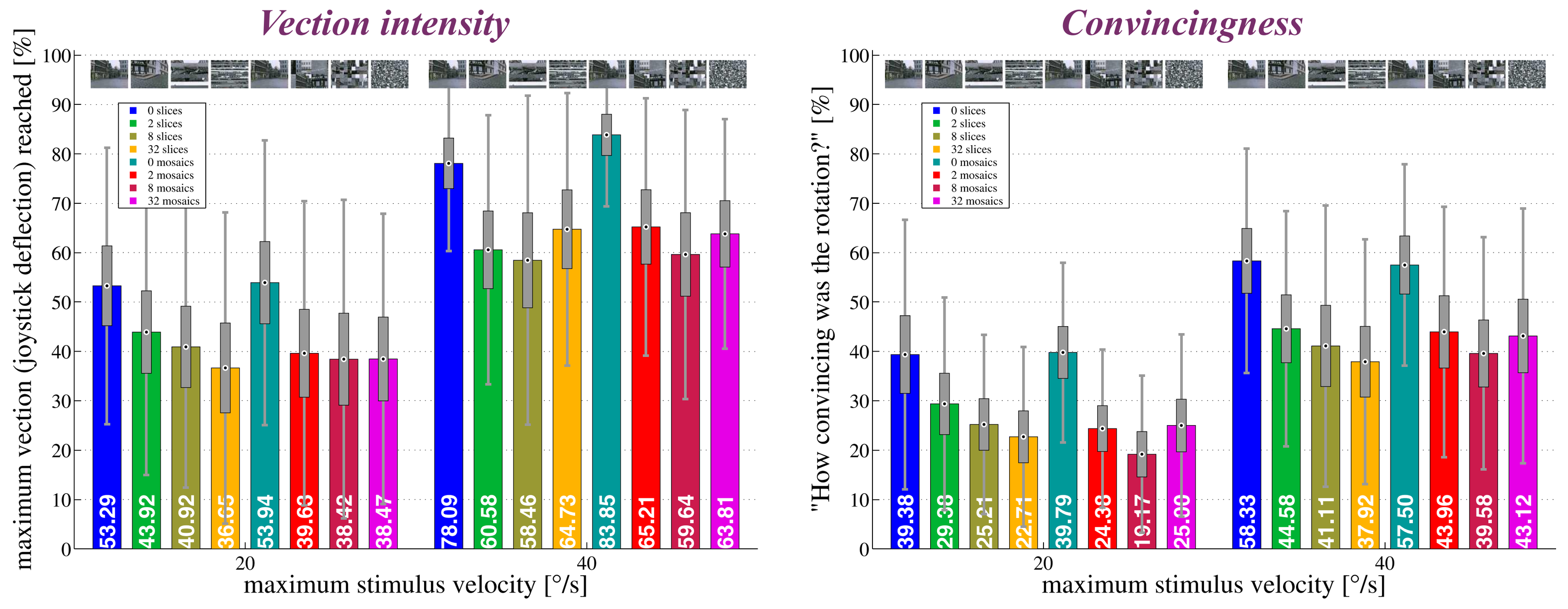


Fig. 8: Vection intensity and convincingness, plotted as in Fig. 7

Scene consistency (implying increased spatial presence & immersion) dominated over low level effects (num. of vertical edges etc.)

Compared to the horizontally sliced or intact stimulus, The mosaic-like scrambled conditions contained additional vertical high contrast edges which are known to facilitate vection. This predicts that the mosaic-like scrambling should *improve* vection. The results show, however, a tendency towards *reduced* vection for the mosaics. This suggests that the low-level information (more contrast edges in the scrambled stimulus) were dominated by high level information and cognitive factors (consistent reference frame for the intact market scene).

• Results - presence questionnaires

Scene scrambling impaired vection as well as presence ratings

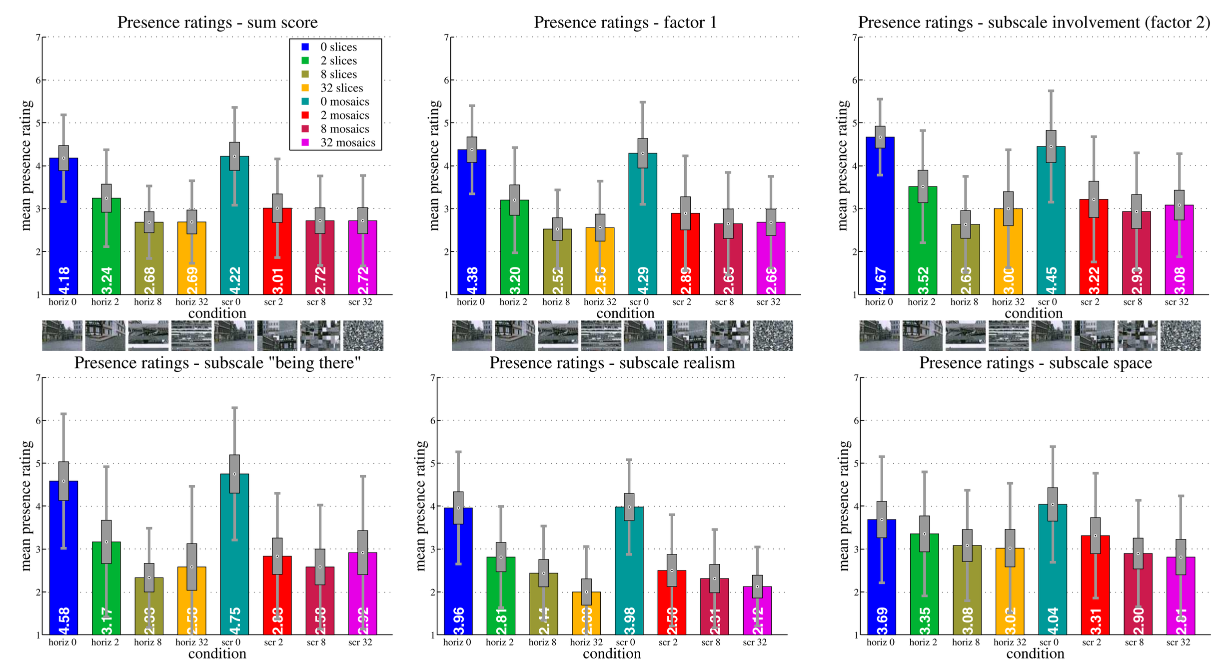


Fig. 9: Presence ratings for the 8 visual stimuli. Plotted are sum score, the 2 main factors of a factor analysis, and 4 subscales. Note that two slices/mosaics were enough to impair presence significantly (p=.003), and no further significant decrease in presence was observed for the 8 and 32 slices/mosaics.

As expected, scene scrambling decreased presence ratings consistently. Interestingly, however, the number of slices or mosaics (2, 8, or 32 per 45° FOV) had no clear influence on either perceived vection or presence; two slices were already enough to impair scene presence.

Presence showed a 2-dim. structure: Factor 1 (spatial presence) correlated mainly with convincingness ratings, whereas factor 2 (involvement) correlated mainly with vection onset time

A factor analysis revealed a two-dimensional structure of presence, namely **spatial presence** (factor 1) and **attention/involvement** (factor 2); While spatial presence was closely related to convincingness of the rotation illusion (r's between .584* and .756**), involvement in the simulation was more closely related to the onset time of the illusion (r's between -.579* and -.779**). This should be taken into consideration when attempting to improve VR simulations. Depending on task requirements, different aspects of presence might be relevant.

• Conclusions

Stimuli depicting a natural scene can produce faster, stronger, and more convincing sensation of illusory self-motion

This might be due to the naturalistic scene providing a stable reference frame one can feel "spatially presence" and involved in

The results of the experiment revealed that a stimulus depicting a natural scene can produce faster, stronger, and more convincing sensation of illusory self-motion. Previous studies have typically used abstract stimuli to induce vection. Here, we show that the illusion can be enhanced if a natural scene is used instead. A possible explanation for why this happens is that natural scenes are less likely to be interpreted as moving because of the assumption of a stable environment (Dichgans & Brandt, 1978).

The similarity between vection and presence measures suggests a direct relation between spatial presence and self-motion perception. We posit that stimuli depicting naturalistic scenes provide observers with a convincing reference frame for the simulated environment which enables them to feel "spatially present". This, in turn, facilitates the self-motion illusion.

This work not only enhances our understanding of ego-motion perception, but also has important implications for motion simulator design and application.

Fig. 1: Participant seated in front of curved projection screen displaying the Tübingen market place. The simulated field of view (FOV) matched the physical FOV of 54x40.5deg.

Fig. 2: Roundshot model of Tübingen market place, wrapped around a virtual cylinder. For the experiments, the simulated viewpoint was centered in the cylinder.

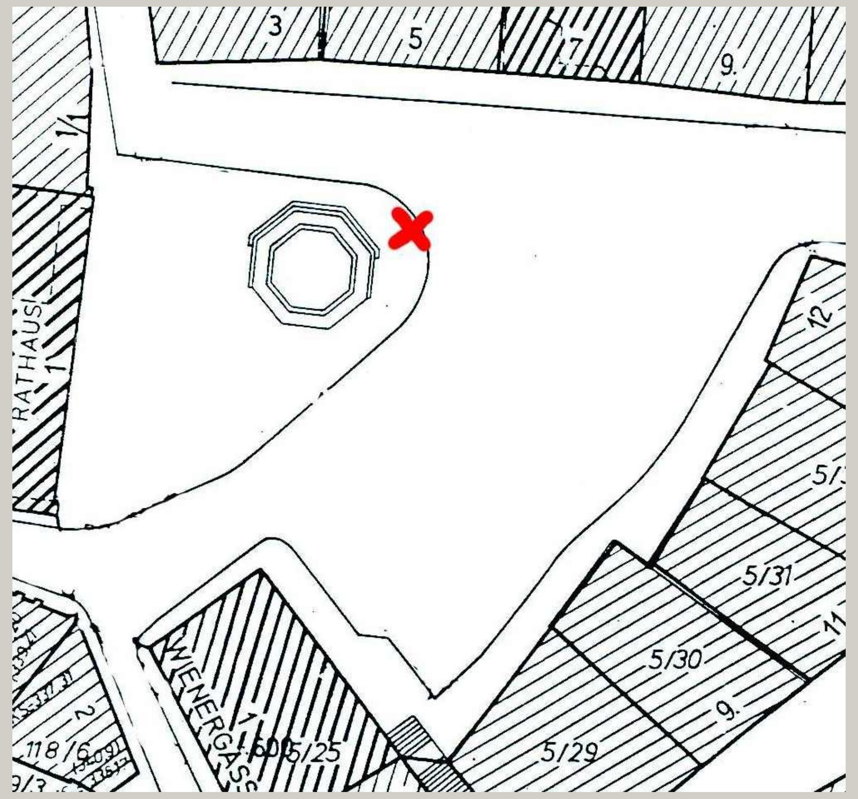


Fig. 3: Bird's eye view of market place illustrating its irregular geometry. The viewpoint is indicated by the red cross.

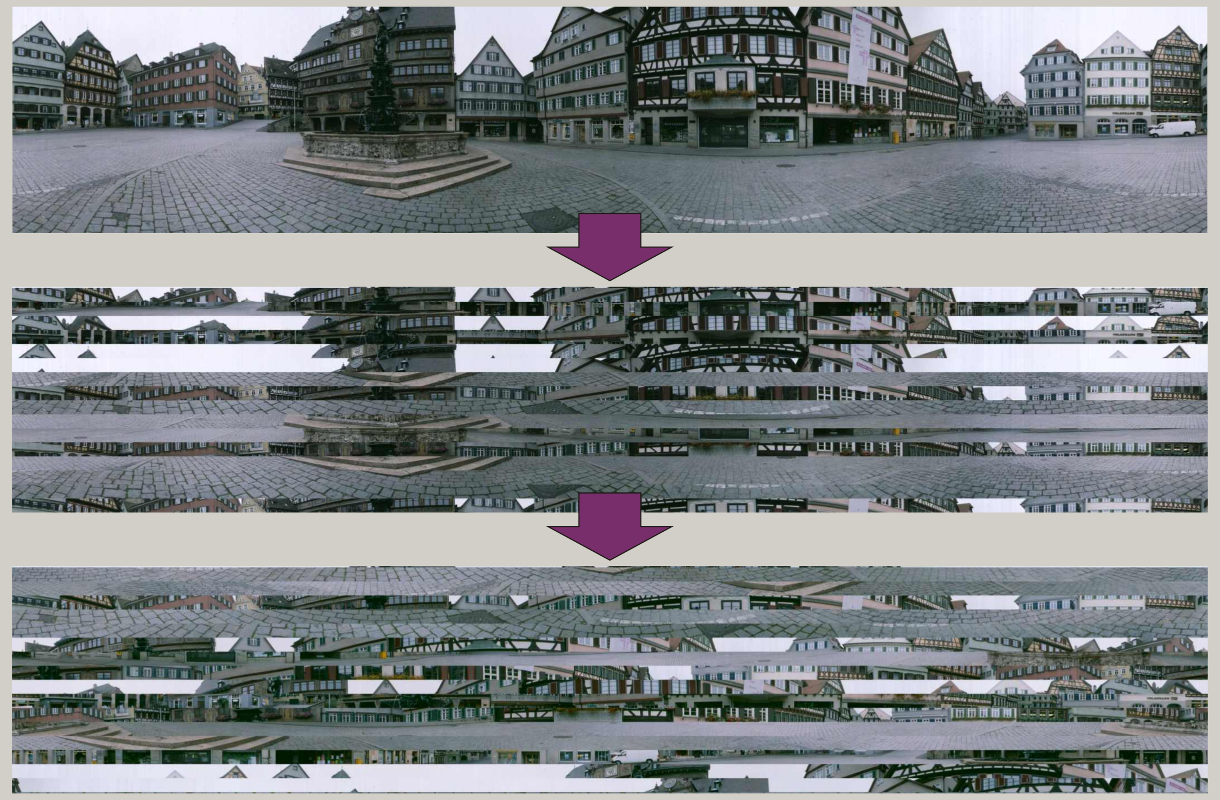


Fig. 4: Top: Original 360 deg. roundshot photograph of the Tübingen Market Place. Below: Scene content and consistency were reduced by slicing the original image horizontally and randomly reassembling it. This was expected to reduce spatial presence while hardly altering image statistics.

Fig. 5: 54x40.5deg view of the 4 stimuli used in session A: original image and 2, 8, and 32 slices per 45deg.

Fig. 6: 54x40.5deg view of the 4 stimuli used in session B: original image and 2x2, 8x8, and 32x32 mosaics per 45x45deg.

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