SFU
SIMON FRASER UNIVERSITY
THINKING OF THE WORLD

SCHOOL OF INTERACTIVE ARTS TECHNOLOGY

# Do Virtual and Real Enviroments Influence Spatial Cognition Similarly?


Bernhard E. Riecke & Lonnie Hastings

ber1@sfu.ca | bhasting@sfu.ca


iSPACE
iSpaceLab.com

## Introduction

Immersive Virtual Environments are often used in studies of spatial perception, because they provide the opportunity to observe human behavior under reproducible and clearly defined conditions, affording researchers ecological validity without the compromise of experimental control (Kelly & McNamara, 2008; Waller et al., 1998). Ideally, people should be able to perceive and behave in such virtual environments as naturally and effectively as in real environments – especially if real-world transfer is desired.

## Research Question

This being the case, it is important to evaluate whether people perform similarly in both environments. Here, we examined whether seeing a virtual environment exerts the same influence on our spatial cognition and judgements as a comparable real-world stimulus does.

## Methods

To investigate this question, we replicated a realworld study [Riecke and McNamara 2007] with the exception that we used both a real and a virtual test room instead of a real test room only. In the Riecke and McNamara 2007 study, participants were asked to learn the layout of 15 irregularly arranged target objects in a small rectangular office (see Fig. 1) from one of three different learning orientations ($\alpha_{learn}$ = 0°, 120°, or 240°). Participants were then blindfolded, disoriented, and wheeled to a rectangular test room that did not contain any of the target objects. After removing the blindfold, participants were seated to face test orientations $\alpha_{test}$ = 0°, 120°, or 240° and performed judgement of relative direction tasks:

(1) imagine being in the learning room;
(2) facing "X" (corresponding to To-Be-Imagined directions $\alpha_{TBI}$ = 0°, 120°, or 240°);
(3) point to "Y" (one of the 15 target objects).


Figure 1: Left: Learning room: Office with 15 irregularly spaced target objects. Center: Test room: Similar layout/geometry, but no objects. Right: Top-down schematic of the learning room.

Analysis of response times and pointing errors (see Fig. 2) indicated that perspective switches were significantly facilitated when:

(a) to-be-imagined orientations were aligned with the main reference axis of the to-be-imagined room (0°), i.e., $\alpha_{TBI}$ = 0°, indicating memory-encoding alignment effects

(b) to-beimagined orientations matched participants' learning orientation, i.e., $\alpha_{TBI} = \alpha_{learn}$, indicating memory-encoding alignment effects

(c) to-be-imagined orientations matched participants' actual orientation in the test room $\alpha_{TBI} = \alpha_{test}$. Note that this cannot be explained by traditional sensorimotor interference effects, as perspective-taking was performed in a remote, not the immediate environment.

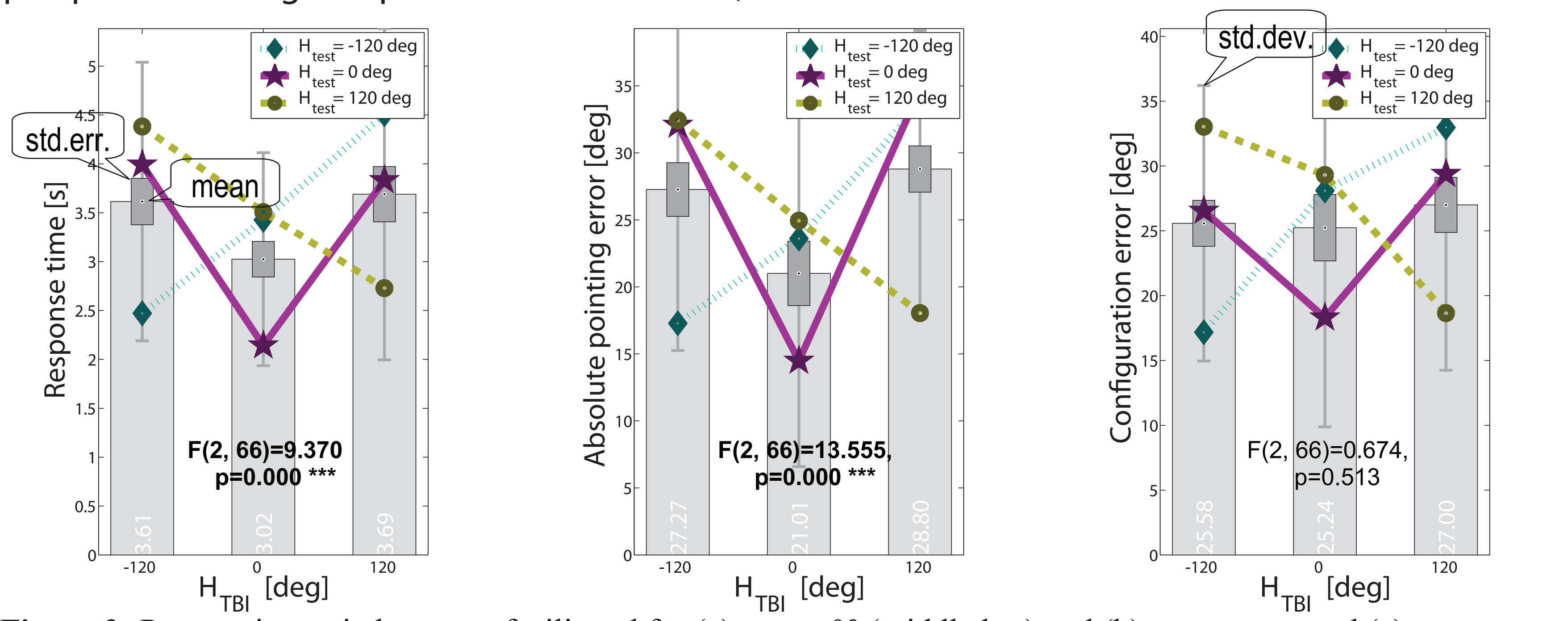


**Figure 2:** Perspective switches were facilitated for (a) $\alpha_{TBI}$ = 0° (middle bar) and (b) $\alpha_{TBI} = \alpha_{learn}$ and (c) $\alpha_{TBI} = \alpha_{test}$.

To test if we would find similar response patterns (a), (b), and (c) in a comparable virtual environment, we replicated this procedure adding a "virtual" test condition in which participant's performed the same JRD task, but in a photorealistic virtual replica of the real test room, displayed using an immersive Wheatstone Stereoscope (2560x1600 pixel/eye) shown in Fig 3.

Fourteen naive participants learned the object layout facing $\alpha_{learn}$ = 120° in a real learning room (see Fig. 3, left) and were then tested in both the real test room and the virtual replica from three different orientations $\alpha_{test}$ = 0°, 120°, and 240°.

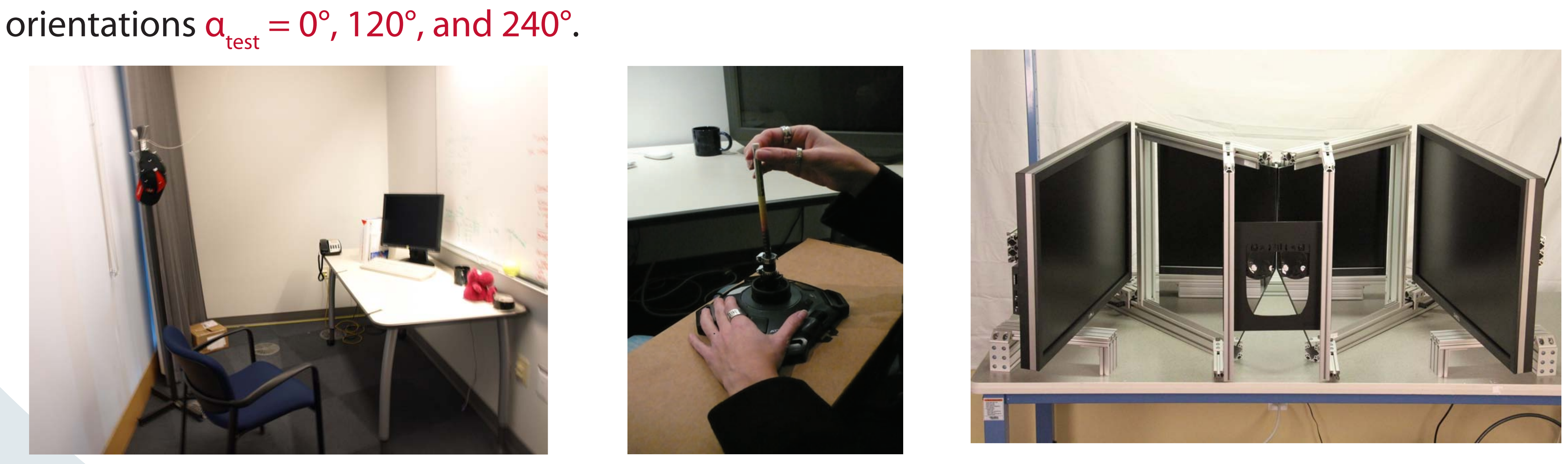

Figure 3: Left: Learning room with objects. Participants learned at $\alpha_{learn}$ = 120° facing the computer. Center: Joystick used to point to the target objects. Right: Wheatstone Stereoscope used to display stereo image pairs of the virtual test room. The display was covered with a large tent and the room was darkened during testing to ensure participants never saw the actual test room.

Figure 4: Stereo image pair of the real test room $\alpha_{test}$ = 0° used for the virtual test room. Image pairs were taken at an offset of 6.3 cm to account for interpupillary distance

## Results and Discussion

As expected, hypothesis (b) was confirmed in both real and virtual test rooms: Perspective switches were facilitated when the to-be-imagined orientation matched the learning orientation ($\alpha_{TBI} = \alpha_{learn}$ = 120°), indicating encoding-memory alignment effects for the learning orientation. (Figure 5). Suprisingly however, hypotheses (a) and (c) were not observed. That is, while alignment of the to-be-imagined orientation with the main reference axis of the room as well as one's physical orientation in the test room clearly determined which orientations were easier to imagine (Figure 2) in [Riecke and McNamara 2007], we found no such effect in either of our test environments.

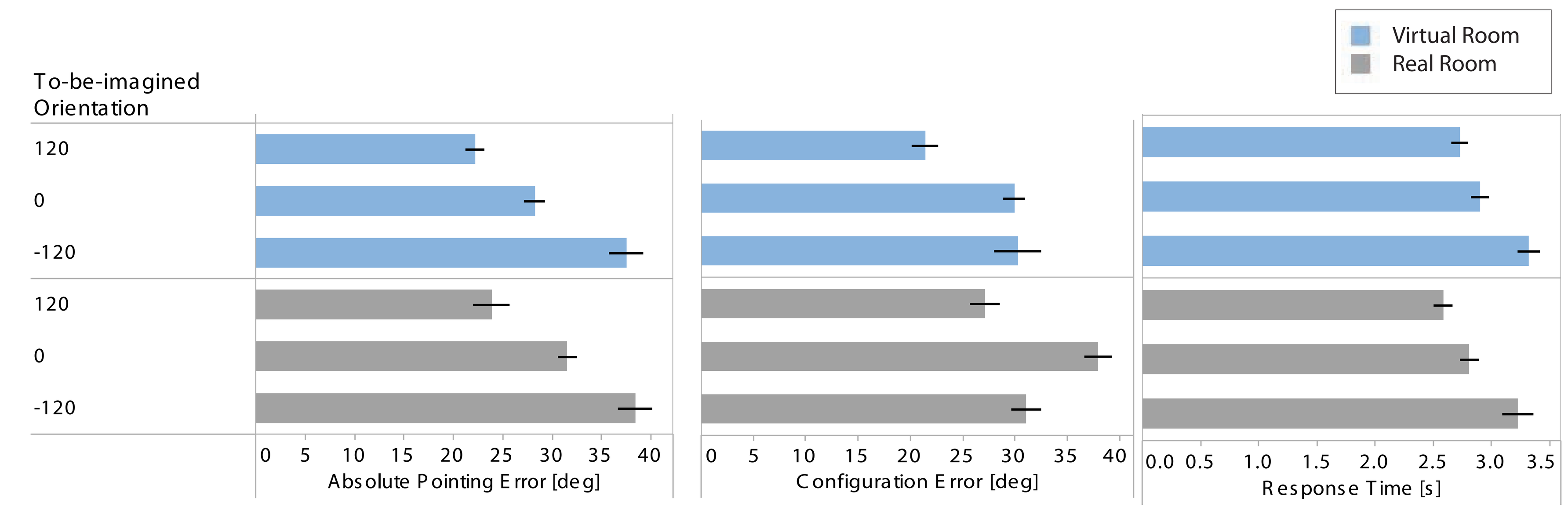


Figure 5: VR Condition: Abs. pointing error: $F[2,123]$= 26.99, p= <.0001; Configuration error: $F[2, 123]$= 7.55, p=.0008; Response time: $F[2,123]$= 10.52, p= <.0001. RR Condition: Abs. pointing error: $F[2,123]$= 16.32, p= <.0001; Configuration error: $F[2,123]$=11.41, p= <.0001; Response Time: $F[2,123]$= 7.68, p= .0007.

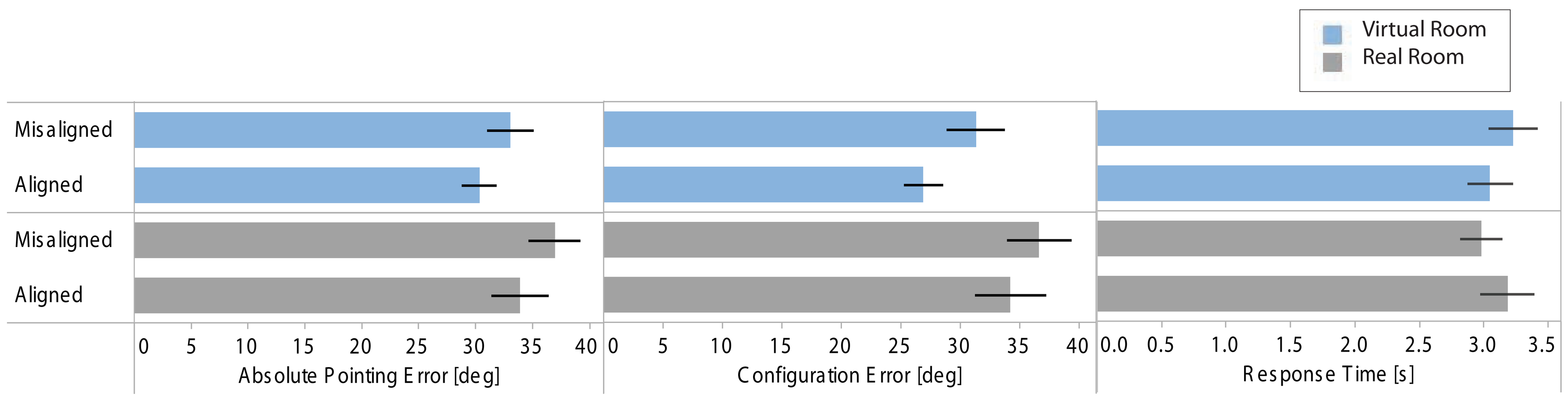


Figure 6: VR condition: Abs. pointing error: $F[1, 54]$= .551, p= .461; Configuration error: $F[1, 54]$= 1.097, p=.300; Response time: $F[1,54]$= .238, p= <.627. RR condition: Abs. pointing error: $F[1, 54]$= .405, p= .527; Configuration error: $F[1, 54]$= .178, p=.675; Response time: $F[1,54]$= .292, p= <.59;

While some participants showed the expected alignment effect between to-be-imagined and test orientation in the real but not virtual environment, unexpectedly we also observed the reverse (Figure 6). We have two hypotheses as to why our results differed so drastically from [Riecke & McNamara 2007].

(1) The dissimilarity could result from minor differences between stimuli in the two studies. Differences include: the shape of the rooms used, the number of target objects (9 vs. 15), and the arrangement of objects (although both studies used an irregular arrangement).

(2) Participants were not monitored during test conditions and may have used self-distraction techniques (eg. closing their eyes) to minimize interference costs from the visual stimuli. Several participants indeed reported either closing their eyes or looking at the ground during debriefing.

Given that Riecke & McNamara replicated their findings in a different-looking test room, we believe the "self distraction hypothesis"(2) to be the most likely explanation. This explanation is further supported by the similarity of our results to those of a "disoriented" condition in another Riecke & McNamara study (forthcoming). In this condition, participants were blindfolded and disoriented before being asked to perform the same JRD task, thus excluding all interference/facilitation effects. We are currently planning control studies to investigate this alternative hypothesis, using webcams to monitor participants (as done by Riecke & McNamara).

## Conclusions

While we were unable to replicate the facilition effects found in the realworld Riecke & Mcnamara study, we believe that the self distraction techniques employed by participants suggest that the visual stimuli were in fact influencing what was easy or hard to imagine in both test conditions (else why would they use self-distraction techniques?)

Furthermore, we did not observe any main effects of test condition (real vs virtual), which suggests that real and virtual environments might in fact influence spatial cognition similarly.

## References


Riecke, B. E., & McNamara, T. P. 2007. Similarity between room layouts causes orientation-specific sensorimotor interference in to-be-imagined perspective switches. In Proceedings of the 48th Annual Meeting of the Psychonomic Society (Psychonomics), 63.