Comparing spatial perception/cognition in real versus immersive virtual environments – it doesn’t compare!

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INTRODUCTION

Immersive virtual environments (IVE) are increasingly used in both fundamental research like experimental psychology and applications such as training, phobia therapy, or entertainment. Ideally, people should be able to perceive and behave in such IVEs as naturally and effectively as in real environments – especially if real-world transfer is desired. Being inherently mobile species, enabling natural spatial orientation and cognition in IVEs is essential.

RESEARCH QUESTION

Here, we investigated whether seeing a virtual environment has a similar effect on our spatial cognition and mental spatial representation as a comparable real-world stimulus does – if it does not, how could we assume real-world transfer?

METHODS

To tackle this question, we closely replicated a real-world study [Riecke and McNamara 2007] in an equivalent virtual environment. In this real-world study, Riecke and McNamara asked participants 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 (α_TBI = 0°, 120°, or 240°). Participants were then blindfolded, disoriented, and wheeled to a different-looking rectangular test room that did not contain any of the target objects. After removing the blindfold, participants were seated to face test orientations (α_TBI = 0°, 120°, or 240°) and performed judgment of relative direction tasks:

(a) imagine being in the learning room;
(b) facing “X” (corresponding to To-Be-Imagined facing directions α_TBI = 0°, 120°, or 240°);
(c) point to “Y” (one of the 15 target objects).

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., α_TBI = 0°;
(b) to-be-imagined orientations matched participants’ learning orientation, i.e., α_TBI = α_LRN; and
(c) to-be-imagined orientations matched participants’ actual orientation in the test room α_TBI = α_LRN. That is, although the test room did not contain any of the learning objects, facing for example α_LRN = 120° in the test room facilitated imagining the corresponding orientation α_TBI = 120° in the learning room, and interfered specifically with imagining the other orientations α_TBI = 240° or α_TBI = 0°.

To test if we would find similar response patterns (a), (b), and (c) in a comparable virtual environment, we closely replicated this procedure, but used a virtual test room presented on a spherical 180°×150° video projection (Eumens vision station), as depicted in Fig. 3.

Twelve naive participants learned the object layout facing α_LRN = 120° in a real learning room (see Fig. 3, left) and were tested with three different orientations α_TBI = 0°, 120°, and 240° with respect to the virtual test room (see Fig. 3, right & Fig. 4).

RESULTS AND DISCUSSION

To test if using different IVE displays and 3D models could help to increase the effectiveness of the virtual reality environment during testing α_TBI, we determined which orientations were easier or harder to imagine (Figure 2), we found no such effect when the test orientation was matched to the learning orientation. While one’s physical orientation in the test room in [Riecke and McNamara 2007] clearly had an effect, our participants were able to perceive and behave in such IVEs as naturally and effectively as in real environments – especially if real-world transfer is desired.

The data are plotted in Figure 5. As expected, hypotheses (a) and (b) were confirmed. Perspective switches were facilitated when (a) the to-be-imagined orientation matched the room reference axis (α_TBI = 0°), and (b) when the to-be-imagined orientation matched the learning orientation (α_TBI = α_LRN) [Riecke, B. E., and McNamara, T. P., 2007]. This highlights the importance of (a) room reference axis and (b) learning orientation in the retrieval of spatial relations from memory.

CONCLUSIONS

In conclusion, despite the immersiveness and large field of view of the current setup, seeing a virtual environment did not have the same effect on our spatial cognition and mental spatial representation as a corresponding real-world stimulus. This suggests that human spatial perception/cognition in real and virtual environments is not necessarily the same. On the one hand, this challenges the often simply assumed effectiveness of current IVE technology. On the other hand, our research can motivate and ideally guide the development of more effective human-computer interfaces that allows for more natural perception and behavior.

REFERENCES