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Is Seeing a Virtual Environment Like Seeing the Real Thing?

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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. 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 from one of three different learning orientations ($\alpha_{learn} = 0°$, $120°$, 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 $\alpha_{test} = 0°$, $120°$, or $240°$ and performed judgement of relative direction tasks: (1) imagine being in the learning room; (2) facing "X" (corresponding to To-Be-Imagined facing directions $\alpha_{TBI} = 0°$, $120°$, or $240°$); (3) point to "Y" (one of the 15 target objects). Analysis of response times and pointing errors 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., $\alpha_{TBI} = 0°$; (b) to-be-imagined orientations matched participants' learning orientation, i.e., $\alpha_{TBI} = \alpha_{learn}$; and (c) to-be-imagined orientations matched participants' actual orientation in the test room $\alpha_{TBI} = \alpha_{test}$. That is, although the test room did not contain any of the learning objects, facing for example $\alpha_{test} = 120°$ in the test room facilitated imagining the corresponding orientation $\alpha_{TBI} = 120°$ in the learning room, and interfered specifically with imagining the other orientations $\alpha_{TBI} = 240°$ or $\alpha_{TBI} = 0°$. 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 $180° \times 150°$ video projection (Elumens vision station), as depicted in Figure 1. Twelve naive participants learned the object layout facing $\alpha_{learn} = 120°$ in a real learning room and were tested with three different orientations $\alpha_{test} = 0°$, $120°$, and $240°$ with respect to the virtual test room.

Results and Discussion The data are plotted in Figure 2. As expected, hypothesis (a) and (b) were confirmed: Perspective switches were facilitated when (a) $\alpha_{TBI} = 0°$ and (b) $\alpha_{TBI} = \alpha_{learn} = 120°$, corroborating the importance of (a) the room reference axis and (b) the learning orientation in the retrieval of spatial relations from memory. Surprisingly, however, while one's physical orientation in the test room in [Riecke and McNamara 2007] clearly determined which orientations were easier or harder to imagine, we found no such effect when the test room was only visually simulated as an IVE. This suggests that a real-world stimulus has a stronger impact on our mental representation and specifically the retrieval of spatial relations from memory than stimuli presented in immersive virtual reality, at least for the current setup and procedure. We are planning further studies to test if using different IVE displays and 3D models could help to increase the effectiveness of the virtual reality stimulus to real-world levels. 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.

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Figure 1: ***Left:*** *Participant facing the spherical projection displaying the test room. The room was darkened during testing.* ***Right:*** *Virtual test room seen from* $\alpha_{test} = 120°$.

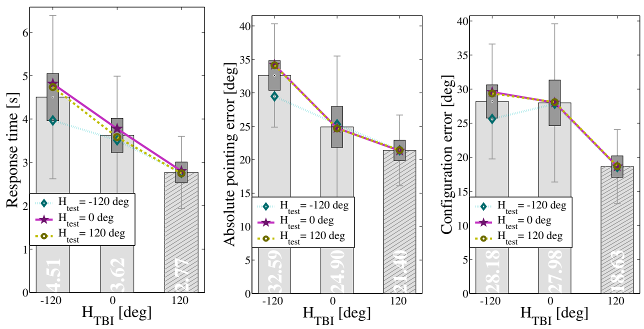

Figure 2: *Means ±1SEM (boxes) and ±1SD (whiskers) for the 3 dependent measures. Note that perspective switches were facilitated for (a)* $\alpha_{TBI} = 0°$ *(middle bar) and (b)* $\alpha_{TBI} = \alpha_{learn} = 120°$ *(right bar), but not for (c)* $\alpha_{TBI} = \alpha_{test}$ *(i.e., no significant interaction between the three separate lines for* $\alpha_{test} = 0°$, $120°$, *or* $240°$.

References

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