Indoor Wayfinding in Real-world Environments and Virtual Reality: A Comparison

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Abstract. Wayfinding has been widely studied in fields of location-based service and geospatial cognition. It is currently unclear how wayfinding behaviour and spatial knowledge acquisition in immersive virtual reality (iVR) differ from those in real-world environments (REs). To investigate this question, we conducted the wayfinding experiment in RE with twenty-five participants and in iVR with forty participants. Participants' eye movements, verbal reports and questionnaires were recorded. The results revealed that participants processed visual information more efficiently in RE but searched visual information more efficiently in iVR. For spatial learning, participants' distance estimation was more accurate in iVR. This empirical study proves the ecological validity of iVR and encourages further studies to use VR techniques in wayfinding research.

Keywords. Indoor wayfinding, Spatial learning, Immersive virtual realty

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1. Introduction

Elucidating wayfinding behaviours can improve our understanding of spatial knowledge acquisition in an unfamiliar environment, and better provide location-based service. The rapid development of Virtual environment (VE) technologies, with a range of setups from desktop to fully immersive, provides new experimental approaches for investigating wayfinding behaviours and spatial knowledge acquisition (Darken et al., 1998; Ehinger et al., 2014). Immersive Virtual Reality (iVR) offers more naturalistic sensory information, which might reduce the gap between laboratory and the real-world environment (RE) (Ruddle et al., 2011). No matter how realistic a virtual environment, however, differences between REs and VEs are inevitable. The ecological validity (Schmuckler, 2001) of the iVR in the indoor wayfinding field is still poorly understood, it remains unclear whether people who navigate in iVR and RE settings exhibit the same wayfinding behaviours and acquire equivalent spatial knowledge.

Therefore, we here hypothesize that pedestrians exhibit the different wayfinding behaviours and obtain varying levels of spatial knowledge between iVR and RE experiments. To test this hypothesis, we conducted indoor wayfinding experiments in two different setups. We measured their behavioural (verbal report protocol and questionnaire) and physiological (eye movement) metrics and tested them difference by statistics, to verify the ecological validity of the iVR from multiple perspectives.

2. Methodology

We recruited 65 participants (25 in the group RE and 40 in the group iVR) to conduct eye-tracking wayfinding experiments. The experiment tasks are the same in both two environments: participants were first required to complete the first set of tasks including one free viewing and three wayfinding tasks. Subsequently, participants finished the spatial knowledge measurements. After data pre-processing, we did statistical tests to validate our hypothesis.

3. Results and Discussion

Results include their wayfinding performance, visual attention, and spatial knowledge acquisition (Figure 1). Behavioural results show that indoor wayfinding efficiency and effectiveness might be closer between two environments with increasing experimental time in the iVR. Eye movement reflects that it is more difficult to process visual information in the iVR. Conversely, they perform better in visual searching with a wider range.

However, the distribution of fixation locates in landmarks is similar in both environments. The flexibility of participants and the landmark salience in different experimental settings (Dong et al., 2020; Lessels and Ruddle, 2005) might cause these findings. For their spatial learning results, we don't detect the distinguish in their direction estimation and sketch map between two environments. To our surprise, participants in the iVR estimate distance more accurately than in the RE. Our study provides evidence for the ecological validity of the iVR in wayfinding research. Confirming these interesting results will require further research into the detailed mechanisms of spatial coding at the level of brain activation and response.

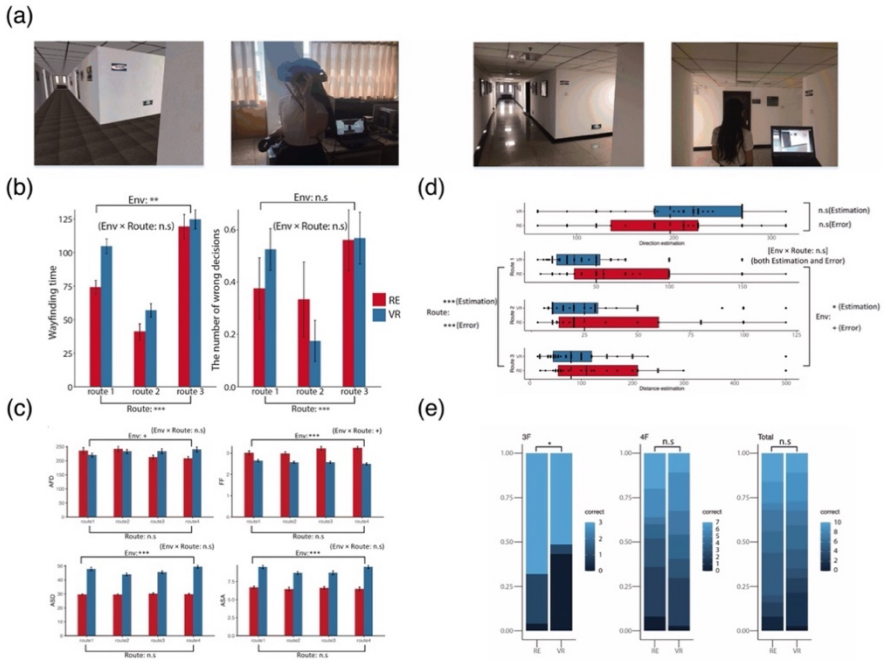

Figure 1. Overall results include wayfinding performance, visual attention, and spatial knowledge. (a) Experimental setups, two left pictures are in the iVR and right pictures are in the RE; (b) Wayfinding performance; (c) Visual attention; (d) Direction and distance estimation; (e) Sketch mapping distribution.

Notice: This extended abstract is based on the following paper:

Dong, W., Qin, T., Yang, T., Liao, H., Liu, B., Meng, L., & Liu, Y. (2021). Wayfinding Behavior and Spatial Knowledge Acquisition: Are They the Same in Virtual Reality and in Real-World Environments? *Annals of the American Association of Geographers, 1-21.*

References

Darken, R. P., T. Allard, and L. B. Achille (1998) Spatial orientation and wayfinding in large-scale. Virtual spaces: An introduction. Presence: Teleoperators and Virtual Environments 7 (2):101–7.

Dong, W., T. Qin, H. Liao, Y. Liu, and J. Liu (2020) Comparing the roles of landmark visual. salience and semantic salience in visual guidance during indoor wayfinding. Cartography and Geographic Information Science 47 (3):229–43.

Ehinger, B. V., P. Fischer, A. L. Gert, L. Kaufhold, F. Weber, G. Pipa, and P. Konig (2014) Kinesthetic and vestibular information modulate alpha activity during spatial navigation: A mobile EEG study. Frontiers in Human Neuroscience 8:71. Di Dio C, Macaluso E, Rizzolatti G (2007) The Golden Beauty: Brain Response to Classical and Renaissance Sculptures. PLoS ONE 2(11): e1201. doi: 10.1371/journal.pone.0001201

Lessels, S., and R. A. Ruddle (2005) Movement around real and virtual cluttered. environments. Presence: Teleoperators and Virtual Environments 14 (5):580–96.

Ruddle, R. A., E. Volkova, and H. H. Bulthoff (2011) Walking improves your cognitive map in. environments that are large-scale and large in extent. ACM Transactions on Computer–Human Interaction 18 (2):1–20.

Schmuckler, M. A (2001) What is ecological validity? A dimensional analysis. Infancy: The. Official Journal of the International Society on Infant Studies 2 (4):419–36.