







Evaluation of a Concept of Developing Daily Experience Database Using Virtual Proof-of-Concept Experiment in Shopping Use Case

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Abstract

VR offers content reproducibility and precise control for comparison experiments, therefore, the evaluation of user experience of living scenarios in VR may become an appealing methodology in behavioral, cognitive, and social studies. The main features of this study are as follows: (1) We proposed a concept of recording cognitive and behavioral data with environment data as a common database of daily experience using the virtual proof-of-concept experiment. To record cognitive processes, we proposed “time machine interview” method, which involves replaying the recorded data to users and interviewing them about their thoughts during each action. (2) We developed a virtual commercial complex proof-of-concept field and measured the store search behavior among men and women in their 20s, 40s and 60s (N=16) to evaluate our proposing concept. (3) We analyzed the recorded data and subjective reports from questionnaires, and evaluated advantages and disadvantages of recording experience data in VR compared to recording data in real environments. (4) The subjective reality of the experience was significantly higher when the movement was triggered by stepping motion than by a key press.

CCS Concepts

• **Human-centered computing** → **Human computer interaction (HCI); Virtual reality; User studies;**

1. Introduction

Virtual reality (VR) has been used in studies of cognitive behavior by reproducing specific individual living scenarios in virtual space (e.g., shopping [XH21]). VR offers content reproducibility and precise control for comparison experiments, therefore, the evaluation of user experience of living scenarios in VR may become an appealing methodology in behavioral, cognitive, and social studies. To evaluate the effects of environmental changes or assistive technologies, it is necessary to compare the change with the usual daily activities prior to any modifications, referred to as “control conditions.” Therefore, we are conducting research within an industry-academia collaboration consortium “Design Association of Augmented Experience (DAAX)”, aiming to replicate living environments in a VR space and record cognitive behaviors within the space as common control condition data. In this study, we replicated a commercial complex in a VR space as an example of a living environment and recorded and analyzed the cognitive behaviors of users immersed in that environment.

2. Method

2.1. Development of a virtual proof-of-concept field

A virtual commercial complex model (Figure 1) including eight shops was developed based on the recommendations of companies specializing in the design and development of real commercial co-

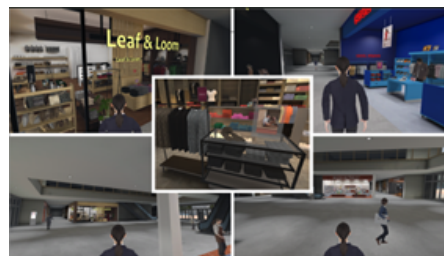


Figure 1: VR commercial complex.

plex, therefore, size of aisles and stores were replicated with the actual facilities. On the contrary, to enhance usability for proof-of-concept experiments, a symmetrical structure was implemented, and the space of each store was standardized. This design ensures compatibility of store locations and facilitates verification processes. By creating this content separately from essential immersive VR functions such as avatar operation and recording, and then implemented it on the general experiment platform Xperigrapher [Ohy21]. Therefore, various other contents could be executed in the same experimental environment.

2.2. Experimental procedure

The experimental procedure commenced with an explanation of the

study and confirmation of informed consent. Participants (N=16) then wore jackets that matched the attire of their avatars. This was followed by a calibration process. Subsequently, participants were explained about the product search task. Target product was a scarf shown by a picture. Then, subjects practiced one of two movement operation conditions (i.e., movement was triggered by stepping motion or a button press). The next task involved touching a table to elicit embodiment. Participants then started the product search task, during which their behaviors were recorded. This was followed by a replay session with the time machine interview to reveal cognitive processes. Finally, participants completed a questionnaire.

3. Results and discussions

3.1. Subjective evaluations of reality

Participants were asked, “How similar do you think your behavior in the experiment is to your normal behavior in a real shopping mall? Please respond on a scale from 0 to 100, where 100 represents identical behavior to the real experience, and 0 represents completely different behavior.” The results indicated an average score of 60.3 (SD = 26.7), with a maximum score of 90 and a minimum score of 10. Participants who scored 10 reported the reason was that their walking speed in VR was slower compared to real life. One who scored 20 mentioned that if she was shopping in real life, she would have spent more time perusing stores unrelated to product exploration. These findings suggest that the perceived differences from real and virtual field were attributed to variations in environmental conditions, such as the method of operation and movement, as well as tasks that participants would not typically perform in real life.

3.2. Behavior data and cognitive processing data

No significant differences were observed in the range or paths of movement trajectory depending on the movement operation condition. However, two different patterns of movement were identified in the central wide area in the complex. One pattern involved moving along the passage or wall (Along in Figure 2), and the other involved cutting across diagonally (Diagonal in Figure 2). No significant correlations with age, gender or personality traits were found, although there were no participants in their 60s who moved in the diagonal pattern.

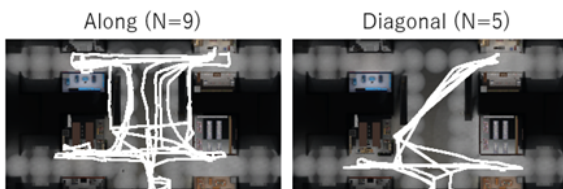


Figure 2: Main trajectory patterns of store search.

Immediately after entering the building, 14 out of 16 participants stopped for an average of 7.3 seconds. This suggests that guidance and assistance at this location could be effective. Although, only one participant paid attention to the map placed in different location. Additionally, from a questionnaire, participants felt that the

experienced VR space was significantly more similar to their everyday living environment when the movement was triggered by stepping motion than by a key press (Mann-Whitney U test; $p < .05$). Cognitive processes were analyzed from the time machine interview, which reveal the reasons and motivations for the behavior. For instance, all participants utilized product category information to locate stores, assuming that a scarf would be found in apparel shop. They cross-referenced this information with their past experiences and memories, estimating whether the store design matched the brand image associated with selling scarves. Participants then approached the store they predicted to be the most relevant based on category proximity. This search process closely aligns with the cognitive behavioral processes observed in previous research on consumer’s navigational search strategies in real-world stores [Tit96]. We will discuss the similarities/differences and advantage/disadvantage between real and virtual field studies.

3.3. Designing daily experience database

To systematically evaluate the impact of environmental and support factors and to accumulate multifaceted insights, it is necessary to compare multiple factors under the same control conditions. Figure 3 shows an example recorded data in design of proposed common experience database that answers the SWIH. This database can be used at any time to refer to and analyze the reproduction of various daily situations.

Where: VR Proof-of-Concept contents data (e.g., commercial complex)		Why: Cognitive process data ("time machine interview")	
When: Date and time of experiment, Time-related aspects depicted in the content (e.g., daytime lighting condition)		An example of the replay of scene ③ in 3rd person perspective	
What: Instructions or tasks given to participants (e.g., product search task)		Participant's utterance at scene ③ "I looked around the clothing store on the left side of the entrance to some extent. I noticed some accessories on the shelf behind the clerk on the right side, so I checked there as well, but couldn't find what I was looking for. Then, I moved further inside and headed to the right side at the back."	
How: Behavior data (Including movement trajectories, posture, facial expression, gaze)		Replayed movie with gaze marker in 1st person perspective	
Who: Personal data man, 20s, student, right-handed			
Personality traits (Big-5)			
extraversion	agreeableness	conscientiousness	neuroticism
3.43	5.14	4.57	2.86
Cognitive styles (EQ-SQ)			
Empathizing factors		Systemizing factors	
I	II	I	II
0.69	0.27	0.67	0.87
		1.43	

Figure 3: Example of the recorded data in proposed design of common database of daily experience.

References

- [Ohy21] OHYAMA J.: Xperigrapher: Social-Lab Experimental Platform to Evaluate Experience in Cyber Physical Society. *Transactions of JSMBE*, Proc (2021), 811–813. doi:10.11239/jsmbe.Annual59.811.1
- [Tit96] TITUS PHILIP A. E. P. B.: Consumer wayfinding tasks, strategies, and errors: An exploratory field study. *Psychology & Marketing* 13 (1996), 265–290. doi:10.1002/(sici)1520-6793(199605)13:3<265::aid-mar2>3.0.co;2-a.2
- [XH21] XI N., HAMARI J.: Shopping in virtual reality: A literature review and future agenda. *Journal of Business Research* 134 (sep 2021), 37–58. doi:10.1016/j.jbusres.2021.04.075.1