Qualitative analysis of user experience in a 3D virtual environment

Dalma Geszten[1] **Balázs Péter Hámornik**[1] **Anita Komlodi**[2] **Károly Hercegfi**[1] **Bálint Szabó**[1] **Alyson Young**[2]

[1] Department of Ergonomics and Psychology, Budapest University of Technology and Economics, Budapest, Hungary

[2] Department of Information Systems, University of Maryland, Baltimore County, Baltimore, United States

geszten.dalma@gmail.com, hamornik@erg.bme.hu, komlodi@umbc.edu, hercegfi@erg.bme.hu, szabobalint@erg.bme.hu, alyson1@umbc.edu

ABSTRACT

This paper describes elements of user experience of a collaborative 3D immersive virtual information management environment. We detail those elements that are seen to both improve and deteriorate user experience, and provide design guidance for researchers and designers. We designed the 3D virtual environment in the Virtual Collaboration Arena (VirCA) collaborative space specifically to study the collaborative information retrieval and management behaviors of users. We conducted 117 interviews and then analyzed the data using a qualitative content analysis to identify the main elements of user experience. While participants generally reacted positively to the environment, they also mentioned a few distracting usability problems. Applying the results in the further development of VirCA can create a higher level of user experience and more effective collaboration.

Keywords

Virtual reality, collaboration, user experience, interviews.

INTRODUCTION

3D representation of document collections and other physical manifestations of abstract information have often been found challenging to navigate and manage on 2D displays due to awkward interaction and disorientation in the space (Robertson, Card, & Mackinlay, 1993; Sebrechts, Cugini, Laskowski, Vasilakis, & Miller, 1999). If we are able to mitigate these challenges of navigation and disorientation, virtual spaces have the potential to effectively support information tasks through spatial displays of information. Virtual spatial displays on large surfaces, such as those allowed by immersive spaces, can mimic physical organization of documents and support complex information problems. We propose an immersive virtual reality environment to overcome the difficulties of navigation and orientation in complex information spaces. In this type of environment the user is fully immersed in the space, which allows them to easily navigate and change perspective by moving around the space. Virtual reality systems also offer the ability for multiple, geographically dispersed users to be present in the same space simultaneously enabling remote collaboration.

We created a 3D virtual space in the Virtual Collaboration Arena (VirCA) environment (http://www.virca.hu/) (Galambos et al., 2015) to allow a pair of users to collaboratively solve an information problem. One participant accessed the space through an immersive cave[1] while the other logged onto the space using a traditional desktop computer. The environment was developed to allow users to take advantage of the spatial layout to manage and use information. Following completion of the collaborative information task, we interviewed the users about their experiences with the space. This poster reports preliminary findings from the qualitative interviews on the participants' user experiences with the system.

RELATED RESEARCH

While immersive 3D environments have their limitations, such as disorientation and fatigue (Sebrechts et al., 1999), they also afford interaction patterns that are similar to shared physical spaces and thus have the potential to effectively support collaborative information tasks. The user interaction methods and information displays afforded by these environments make them more flexible than physical spaces. In addition to physically moving and organizing information items, users can take advantage of digital capabilities, such as full text search, digital annotations, different access levels for different users (some users can edit, while others can only view), and importing and exporting digital formats.

A second advantage is that the number of documents, or information items that can be stored is theoretically limitless. The flexibility of the virtual environment allows

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1 A CAVE (cave automatic virtual environment) is an immersive virtual reality environment where projectors are directed to between three and six of the walls of a room-sized cube to create a virtual environment similar to a physical room.

users to browse, view, move, group, and annotate a large number of documents. While this is a great opportunity for users, designers have to carefully create these environments to ensure that interaction is natural and does not result in disorientation and fatigue.

Shared virtual reality systems also support collaboration among geographically dispersed collaborators. Such environments have been developed for various purposes and support various functions. For example, immersive 3D virtual environments can afford shared viewing and manipulation of digital representations of documents in a common virtual space. VR VIBE is one such system (Benford, Greenhalgh, Rodden, & Pycock, 2001). It is a collaborative virtual reality system that allows users to browse and search web content in a 3D immersive space, while simultaneously viewing other users in the space using the same information. Our virtual space is similar to VR VIBE in its purpose and setup. One fundamental difference, however, is that our environment also supports the interpretation and use of information. Three important elements of our space are: 1) physical representation of information in posters; 2) user actions to manage these posters; 3) collaborative editing surface to create a new document based on the interpretation of the information contained in the posters. Typical actions necessary for interpretation are: reading, structuring and organizing, highlighting, commenting, and creating new content.

When creating a virtual environment, it is important to pay attention to users' experiences with the system. User experience (UX) is a unique phenomenon. It has several meanings none of which is commonly accepted. Forlizzi and Battarbee (2004), for instance, suggest that user experience includes usability and the hedonic, affective and experiential aspects of technology use. The authors also emphasize the interaction between the user and the product, and user experience is the result of that interaction. In this context experience refers to cognitive, emotional, physical and sensual experiences, everything the user experiences while using the product. According to Hassenzahl and Tractinsky (2006) user experience is traditional Human-Computer Interaction (HCI) usability with aesthetically pleasing design. From this perspective UX is about creating amazing experiences (Hassenzahl & Tractinsky, 2006). Our research adds to the literature on user experience by studying the concept in a 3D virtual environment. We examine the various dimensions that contribute to positive user experience in this space and describe factors that influence this user experience.

METHODS & APPROACH

The research was carried out in three phases. The setting and the tasks were very similar in all three phases, with minor variations in the procedure (described below). After participants arrived at our location, they were introduced to the goals and procedures of the study, and they signed consent documents. They then received a guided tour of the environment in order to become familiar with the space and the functions. They were given the opportunity to ask any questions prior to commencing the study, and detailed instructions were also placed on the wall of the virtual room as a reminder. A connection was then established between the two locations (desktop computer and immersive cave) and the participants were introduced to each other. Participants were represented by an avatar, which consisted of a head and adjustable arm (Figure 1). They could verbally communicate via headphones.

Figure 1. The experimental space in Phase 1 and 2.

Participants were tasked with planning a two-day tour schedule for a foreign student group spending a weekend in Budapest, Hungary. The task and the environment were analogous to a real-life situation in which travelers have to plan a trip from a tourist office (Crabtree, Tolmie, & Rouncefield, 2013). In this setting, information is provided in brochures and posters that are displayed on the office walls. Tourists select, collect, and organize these pieces of information in order to make travel decisions. Similar to a real tourist office, our virtual environment consisted of the following: (1) posters containing information on restaurants, sights, and events, including hours of service and location; (2) a city map annotated with poster numbers denoting the location of the restaurants, sights, and events; (3) text editor windows that function as notes for collaborators to write-on and place within the space; and, (4) a blank schedule from which participants could create their personalized schedule. In phase 1, this feature was a jointly editable document in which participants could record their details. In the latter phases, it was revised to be a calendar-like table where the participants could place their planned program points represented by posters (Figure 1).

Immediately following completion of the task, participants were interviewed about their experiences with virtual reality more generally and with collaboration within a virtual environment. The results of these interviews are reported in this poster. The participants were also asked to complete a number of questionnaires: a mental rotation exercise (Paper Folding Test), demographic and gaming/virtual reality experience, assessment of the quality of the collaboration and the usability of the space, as well as report their familiarity with Budapest and the locations represented in the posters.

122 university students participated in the three phases, 42 per cent of which were female. Their mean age was 22.58 years. Ninety-four interviews were coded and analyzed in ATLAS ti. 6 using content analysis. Four analysis categories were created from the interview questions and the related literature: collaboration, presence, social presence, and awareness. The coding system was developed and refined though several iterative coding phases. In this phase only one coder analyzed the data thus inter-coder reliability has not yet been computed.

Experimental Setting

We used the VirCA platform to create our virtual environment. VirCA was developed by a research team at the Computer and Automation Research Institute of the Hungarian Academy of Sciences to allow users to build, share, and manipulate 3D content (Galambos et al., 2015). VirCA allows collaboration between multiple users located in geographically dispersed locations: *"participating hardware and software devices can be spatially and/or logically distributed and connected together via IP network."* ("Virtual Collaboration Arena," 2014)

In Phase 1, participants who accessed the environment from the 3D cave used an external mouse/keyboard (Lenovo N5902), whereas in phases two and three they used a regular keyboard and mouse as input devices (to write post-it notes in the 3D space, if desired). In the first phase, participants in the cave could also walk around the environment, whereas in the latter phases both participants were seated. This mixed structure of virtual reality interfaces were designed to compare the features of information usage between collaborators, and assess the usability of the interfaces. Phase 1 also differed in that participants were presented with an additional constraint for designing the schedule in the latter phases: the tourist group could only tranfer from Pest to Buda once a day to create a more realistic scenario.

RESULTS

Participants' experience with the **collaboration was asked in the interview**. Most of the participants felt (in 109 of 117 cases) that they were successfully able to collaborate with their partners, indicating that they could easily solve the task. All of the participants could solve the task therefore every collaboration was successful, because there was no time limit, and the experiment ended when the schedule was planned.

"She was nice and cute. We could easily collaborate." (Phase 2/Cave)

In addition to the overall perceptions of user experience, **presence and social presence** were seen as two components related to successful interactions in virtual spaces. This confirms previous research that has found these characteristics to be indicators of successful interactions in these spaces (Sallnäs, Rassmus-Gröhn, & Sjöström, 2000). Our participants were asked to estimate on a scale from 0-100 how present they felt in the virtual environment. A summary of the results is shown in Table 1. The cave and desktop conditions were not compared statistically, but the trends in the data show that users felt more present in the cave than in the desktop application, which was expected.

Participants also reported factors that contributed to their feelings of presence in the space. The factors that contributed the most were: (1) getting involved in the task, (2) solving the task together, and (3) communication. By contrast, we found that presence was weakened by technical problems (e.g., hard to control the system), and the unrealistic environment (e.g. ability to reach through the posters and the wall). Participants from Phase 1 who used a Desktop also mentioned that seeing the virtual reality on a display interfered with feelings of presence:

"I think it's about 80, I felt that I really touched it and I really felt things in my hand." (Phase 2/Cave)

"I'd say 60-70, because after all this is a monitor, despite I felt being there. But this is like a game, if someone is involved, he feels being there." (Phase 1/Desktop).

These findings are similar to work by Sutcliffe and Alrayes (2012) who found that sensing movement, feeling involved, and perspective (field of view) increased presence, whereas low involvement and unnatural interaction decreased presence.

Social presence refers to the extent to which one person feels they are with another person while located in a different place (Sallnäs et al., 2000). We asked participants in the interviews to judge social presence from a 0-100 scale. We found that communication, particularly hearing their partner's voice, enhanced social presence, while technical problems and limited visual features of the avatars reduced it. The avatar was limited to a head and a hand, and often moved in unnatural ways. Users were also unable to see where the avatar was looking.

"Hmmm. that's a tough one...I heard her voice… and that was the only thing that really helped me feel she was there with me… but imagining where she was or what she was doing… I couldn't do that… so I think it's about 35."(Phase 3/Cave)

"Hm...80. I think I felt it. The virtual movement… with his voice...I felt he was there."(Phase 1/Desktop)

Thus the highly usable parts of the VR environment and the avatar in general increased social presence; however, usability problems and some of the features of the avatar decreased it.

As in Bente and Krämer's research (2002) these results show that nonverbal communication has an important role in creating social presence. Nonverbal communication simultaneously increased (e.g., hearing the partner's voice itself, not the verbal content of the communication) and decreased (e.g., scary avatar, avatar's head is not visible) social presence.Our findings also confirm Cruz et al.

	Phase 1	Phase 2	Phase 3
Desktop Mean score (Std. Deviation)	59.2 (19.68)	63.95 (23.17)	61.31 (25.81)
Cave Mean score (Std. Deviation)	76.6 (22.56)	72.12 (17.49)	70.32 (22.93)

Table 1. The degree of perceived presence in the experimental phases.

(2014), who found that virtual environments and avatars (nonverbal communication, gestures, customization) influence presence and social presence.

The theory of social presence attributes an important role to **awareness** of others in the formation of social presence (Sallnäs et al., 2000). While the head and the hand of the partner's avatar and his/her voice helped awareness, in many cases participants did not know where their partner was looking, and that decreased their awareness of their partner:

"It would help me if I looked her head and she could look back at me… I saw her head, and saw it moving, but I didn't know where she was looking." (Phase 1/Cave)

Participants mentioned the avatar both in connection with helping their attention and in distracting their attention. Avatars are important in interaction (Hendaoui, Limayem, & Thompson, 2008). They have a huge impact on collaboration especially when they are customizable. They also have an important role in maintaining awareness and thereby social presence, especially when they can express gestures and emotions (Cruz et al., 2014).

CONCLUSIONS

The user experience of 3D immersive spaces is slightly different from that of desktop applications. Both the hardware and the avatar representation present very important features of this interaction. As a main practical recommendation based on our results is that the technical equipment should be more comfortable, lighter, and wireless. Our results confirm the importance of presence in user experience. The design of the avatar proved to be extremely important in enabling awareness of others' actions and thus forming social presence. Despite some usability problems and limitations with avatar functionality, the overall positive experiences expressed by participants suggests that 3D immersive spaces can provide a promising environment for collaborative problem solving in information rich environments.

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