Fostering Virtual Guide in Exhibitions

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21st International Conference on Human-Computer Interaction with Mobile Devices and Services (MobileHCI '19), October 1–4, 2019 Taipei, Taiwan
ACM 978-1-4503-6825-4/19/10.
http://dx.doi.org/10.1145/3338286.3344395

Abstract
Museums are essential to make culture accessible to the mass audience. Human museum guides are important to explain the presented artifacts to the visitors. Recently, museums started to experiment with enhancing exhibitions through mixed reality. It enables cultural exhibitors to provide each visitor with an individualized virtual guide that adapts to the visitor's interests. The effect of the presence and appearance of a virtual museum guide is, however, unclear. In this paper, we compare a real-world guide with a realistic, an abstract, and an audio-only representation of the virtual guide. Participants followed four multimodal presentations while we investigated the effect on comprehension and perceived co-presence. We found that a realistic representation of a virtual guide increases the perceived co-presence and does not adversely affect the comprehension of learning content in mixed reality exhibitions. Insights from our study inform the design of virtual guides for real-world exhibitions.

Author Keywords
Mixed reality; virtual avatar; co-presence; exhibition.

ACM Classification Keywords
H.5.m. [Information Interfaces and Presentation (e.g. HCI)]: Miscellaneous

Figure 1: Composers' busts and the paintings including them were used as the stimuli in the study.

Introduction & Background

Exhibition content can be experienced through a wide variety of media. Visitors traditionally learn through interaction with exhibition guides and other visitors, audio or videos guides, as well as non-interactive media such as exhibition labels. Recently, several museums started using mixed reality (MR) as a new media to enhance visitors' experience in exhibitions [7, 9]. By providing a possibility to view virtual simulations from different perspectives and to interact with them in a real environment, MR creates engaging and motivating learning experience while still enabling social interactions [6, 8, 14].

MR can not only support the augmentation of museum artifacts but also enhance the learning experience through virtual exhibition guides. In a physical museum, narratives can reinforce the visitors learning and understanding of cultural content [17]. As social interaction is the key to strengthen learning [11], virtual guiding avatars are a promising approach to enhance real-world exhibition experiences.

Comparing the human guides to agents, digital models driven by computer algorithms [2], previous work suggests that the latter cannot completely replicate human guides [16]. This is further supported by the fact that human guides can spontaneously respond to visitors' questions and non-verbally communicate through gestures and their body pose, which support verbal explanations [20]. On the other hand, embodied conversational agents [5] being virtual representations of humans through virtual avatars can enhance the social aspect of interaction [13], spontaneously respond in-situ and non-verbally communicate using gestures and body pose. Therefore, though personalized virtual guides using virtual avatars, exhibition visitors can take advantage of time-independent exhibition tours for individuals and groups.

The presence of virtual avatars can have an effect on learning [18], and therefore, it can affect the comprehension of exhibition content presented by a virtual guide. Since avatar realism has a significant impact on presence and co-presence [10, 19], the design of virtual guides can affect the motivation to engage with exhibition content. The motivation and engagement with the learning content can also be enhanced by using a human-like voice with relevant emotional expressions [4]. Enhancing human behavior realism of a virtual avatar (*e.g.*, gaze) can increase co-presence [1]. However, adding visual features of a face can have an adverse effect on mediated communication and cause self-disclosure [21]. It was also shown that the appearance of an avatar as a social model has an essential effect on its success, and it is advantageous to provide a social model from the same in-group as the user [3].

While previous work extensively studied virtual avatars in virtual environments, it is unclear how such avatars should be designed for real-world exhibitions. Therefore, we conducted a study with 16 participants to investigate the effect of realism and presence of a virtual guide on comprehension of the exhibition content and the perception of the guide. We compared a real-world guide with a realistic, an abstract, and an audio-only representation of a virtual guide in a real-world exhibition setting. Results show that the presence and the appearance of a virtual guide do not affect the comprehension of the exhibition content. However, the perceived co-presence is higher for realistic representation than for the abstract or audio-only representations.

Method

To assess the effect of the presence and the appearance of an exhibition guide in the MR environment, we conducted a controlled experiment. We prepared a real-world exhibition room in our lab. Furthermore, we prepared four short pre-

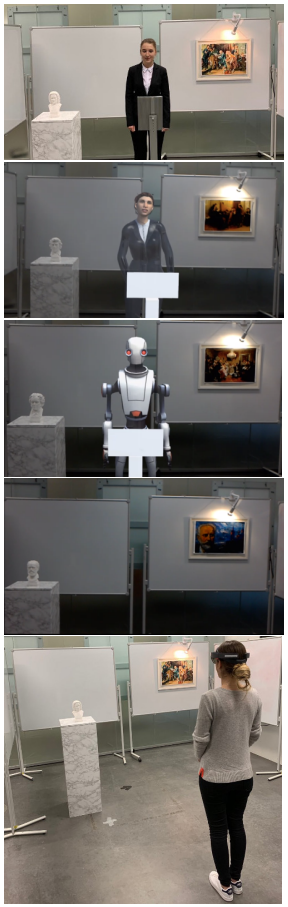

Figure 2: The figure shows *Real*, *MR-Realistic*, *MR-Abstract*, and *MR-Audio* conditions and a participant in the MR exhibition.

sentations, which were conceptually similar but presented different content. For presentations, we selected four classical music composers: Johann Sebastian Bach, Frédéric François Chopin, Franz Peter Schubert, and Pyotr Ilyich Tchaikovsky. To create multimodal presentations, we used a bust and a painting of the composer, and a short piece of music by the composer ("Gottes Zeit ist die allerbeste Zeit (Actus tragicus)", "Polonaise in G minor", "Der Erlkönig", and "Symphony No. 1 Winter Dreams", respectively) (see Figure 1). Furthermore, for the guide, we prepared a speech explaining the life and work of each composer. The texts of the speeches were on average 461 (SD = 5.09) words long. For the study, the guide was presented as a human (*Real*), a realistic avatar (*MR-Realistic*), an abstract robot (*MR-Abstract*), or only by audio (*MR-Audio*).

We systematically varied the presence and the appearance of the guide resulting in a within-subject design with an independent variable GUIDE with four levels: *Real*, *MR-Realistic*, *MR-Abstract*, and *MR-Audio*. As a dependent variable, we measured comprehension of each guide's speech using ten multiple-choice questions with four possible answers. Furthermore, we measured the social presence and the affinity to the guide using the co-presence questionnaire by Poeschl and Doering [15]. We recorded the same human guide's voice for the speeches of the realistic avatar, the abstract robot and the audio representations of the guide. Furthermore, we ensured that the comprehension questions had a similar complexity through a pilot study with six participants. The item difficulty for questions of all presentations was similarly distributed and was ranging between 0.33 and 0.66, which is considered as an acceptable difficulty [12].

We recruited 16 participants (8 female) through our university's mailing lists. Their average age was M = 22.75 (SD = 3.38) years. Most participants had a background in IT, and all were university students. 31.25% of the participants reported having experience with MR. Participants received 10EUR for taking part in the study.

As an apparatus, we used a Microsoft HoloLens mixed reality glasses. For the study, we prepared an exhibition room and used whiteboards to give a feeling of a room with white walls. We put a pedestal, a bust and a painting in the room as seen in figure 2. As an exhibition guide, a research assistant wearing a black jacket and pants was coached to present the artifacts. To create a human-like avatar, we generated the realistic 3D representation from photos of her by using FaceGen Pro [1] and DAZ3D [2]. Both the model and skeleton are based on the Genesis 8 model in DAZ3D. The animated model of a robot [3] was used for the abstract robot representation. To create a realistic body pose and gestures of a virtual guide, we recorded the research assistant's motion for each presentation using OptiTrack's full-body tracking system. In the real world condition, the research assistant played the guide herself.

During the study, each participant experienced four presentations. We counterbalanced the order of GUIDEs and presentations using a Latin square design. After introducing the purpose of the study, participants signed a consent form and responded questions about demographic data and experience with MR. Afterward, we introduced the Microsoft HoloLens to the participants, helped them to wear it and instructed them to stand in front of the exhibition (see Figure 2). We informed participants about the comprehension tests after each presentation and asked them to pay attention to the guide's speech. At the beginning and middle of

[1] https://facegen.com
[2] https://www.daz3d.com
[3] https://assetstore.unity.com/packages/3d/characters/robots/space-robot-kyle-4696

	Md	M	SD
MR-Abstract	6	6.19	1.97
MR-Audio	6.5	6.69	1.7
MR-Realistic	7	6.13	2.06
Real	7	6.81	1.64

Table 1: Comprehension measures for all conditions.

each presentation with a visual guide, the guide showed the bust and the painting with a hand gesture to arouse the participant's attention. During the presentations, participants could observe the exhibition, listen to the guide's speech and a piece of music while standing two meters away from the exhibition artifacts. After each presentation, participants took off the Microsoft HoloLens, answered comprehension questions and filled the co-presence questionnaire. During this time, the research assistant changed the bust and the painting of the composer to the next ones. Afterward, participants continued with the remaining conditions. Each presentation took on average four minutes containing 15 seconds of a piece of music by the corresponding composer in the middle of the presentation.

Results

Each participant experienced four presentations, one with each condition. Table 1 summarizes the participants' comprehension results. A Friedman Test revealed no significant effect on comprehension, $\chi^2(3)$=2.364, p=.501. A repeated measures ANOVA using Greenhouse-Geisser correction showed a statistically significant main effect of the GUIDE on co-presence ($F(2.493, 37.392) = 62.821, p < .001$). Post hoc tests using Bonferroni correction revealed statistically significant differences between all but not between the *MR-Abstract* and the *MR-Audio* conditions (see Table 2).

		M	SD	sig.
1	MR-Abstract	2.483	.843	3*, 4***
2	MR-Audio	1.875	.977	3**, 4***
3	MR-Realistic	3.213	.928	1*, 2**, 4***
4	Real	5.025	.991	1***, 2***, 3***

Table 2: Co-presence measures for all conditions. The mean difference is significant at the * p<.05, ** p<.005, *** p<.0005 levels.

Discussion & Limitations

In this paper, we investigated the effect of a virtual guide on the experience of a real-world exhibition. On average, *MR-Realistic* and *Real* conditions resulted in the highest comprehension. However, we found no statistically significant difference among the conditions. The results suggest that the appearance of the guide might have a negligible effect on learning outcome. It implies that an abstract and a realistic representation of a virtual guide might not distract from paying attention to the guide's explanations. Our results showed that the co-presence is higher using a realistic avatar compared to an abstract avatar or an audio-only representation. Due to the missing photorealistic appearance, *MR-Abstract* resulted in lower co-presence than *MR-Realistic*. Previous work showed that the visual presence of an avatar provides higher motivational and affective outcomes in learning activities than the audio-only case [3]. Therefore, we can conclude that a realistic representation of guides can be used in exhibitions to increase engagement with the content without an adverse effect on learning.

We recognize that our approach has limitations. We conducted the study in the lab without distractions from the environment. However, a real exhibition might be crowded and noisy. Future work should investigate the effects of

such influences. Future work should also investigate the appearance and placement of virtual guides when there are multiple other people around. Moreover, as mixed reality glasses, we used a HoloLens which has a limited field of view and resolution. Since in the study, the virtual guides had the same size as the real guide (the research assistant), it was only possible to see part of the virtual guide at the same time. Despite this limitation, participants could perceive the presence of realistic and abstract virtual guides. However, future research with mixed reality glasses with a wider field of view is needed to determine the effect of this limitation.

Conclusion

We investigated the presence and appearance of a guide in a mixed reality exhibition. We studied how the representation of a guide (human guide, realistic virtual guide, abstract virtual guide, and audio guide) affect comprehension of the guide's speech and the perceived co-presence. We found that realistic representation of a virtual guide results in higher co-presence than the abstract or audio guide, and does not distract from the learning activity. The findings can be used as design recommendations for developing guides for mixed reality exhibitions.

Acknowledgements

This work is supported by the German Ministry of Education and Research (BMBF) within the GEVAKUB project (01JKD1701A).

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