Moreira Kares, E., Tuomi, A., Caiola, V. *et al.* Social presence in shared virtual reality experience among older adults. *Virtual Reality* 29, 42 (2025). https://doi.org/10.1007/s10055-025-01117-0

Virtual Reality (2025) 29:42
https://doi.org/10.1007/s10055-025-01117-0

ORIGINAL ARTICLE

Social presence in shared virtual reality experience among older adults

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Received: 7 April 2024 / Accepted: 3 February 2025

Abstract
Virtual Reality (VR) has the potential to foster social interaction and improve well-being of older adults. This paper presents two qualitative studies that explore the use of VR to create cultural experiences that enhance the sense of social presence among older adults. Participants ($n = 19$) tested two VR theatre experiences designed to increase social interaction and the feeling of social presence. The study utilised thematic analysis, and the findings highlight the potential of VR as a medium for cultural service producers and the suitability of older adults as a user group for VR experiences. Adding interaction features that foster social presence in virtual experiences can significantly improve the user experience, with social VR experiences potentially reaching a similar level of social presence as live performances. However, the nascent nature of social VR developed for cultural experiences and the specific needs of older adult users necessitate further research, particularly in relation to the social etiquette surrounding VR-based cultural experiences. The paper contributes to the growing research on utilising VR as a medium to foster social interaction and well-being among older adults.

Keywords Older adults · Social presence · Social interaction · User experience · Virtual reality

1 Introduction

Technological advancements continue to enrich the variety of digital service offerings available for users (Buhalis et al. 2019). Spurred by COVID-19, digitalisation has created many novel opportunities for service innovation. For example, in the context of cultural services, the interest in digitizing services has seen a leap in the past years, with technology acting as a bridge between cultural organisations and audiences (Statista 2021; Tuomi et al. 2023). Filimonau et al. (2022) argue that the most significant potential for this sector of services may lie in virtual reality (VR) based digital environments, which they describe to be a network of virtual worlds, commonly nowadays referred to as the metaverse (Hennig-Thureau et al. 2022). Among the different types of individuals who may be interested in these products are older adults, defined in this study as people over 60 years old. Given the ageing population and what e.g. the European Union dubs as the 'silver economy', developing products and services for these users is necessary both from the business point of view and in terms of social sustainability. Older adults constitute a large but currently poorly addressed user segment for digital services, whereby advances in research of VR applications for older adults are relevant from a service development point of view but also for the broader social, cultural, and economic development of societies. One key area of new service development for older adult users is the development of digital cultural services (Tuomi et al. 2023).

Older adults have been one of the fastest-growing user segments in digital services in the past decade (Lian and Yen 2014), but they are still considered vulnerable to digital exclusion (Olphert et al. 2005; Ghasemaghaei et al. 2019). Among the challenges, Charness and Boot (2016) and Meng et al. (2019) identify cognitive, perceptual, and psychomotor decline, the motivation and access to technology (Moore and Hancock 2020), the disparity in digital skills (Hargittai 2002), and the scepticism related to the perceived usefulness of technology (Desai et al. 2022). Slower adoption of new technologies might partially be caused by (product and

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Published online: 19 February 2025

service) design features that are primarily aimed at pleasing the needs of younger generations (Kim et al. 2016).

Myriad of research suggests that partaking in cultural activities supports older adults' well-being. Music experiences, for instance, may promote self-connection, awareness, memory, and self-expression (Elliott et al. 2020). Music may also foster well-being among people with dementia (Sousa et al. 2021), and can reduce sleep disturbances (Petrovsky et al. 2020). Art activities (Tymoszuk et al. 2020) and radio shows (Reuter and Liddle 2020) support social and civic life participation. Studies have also shown positive results from using technology as a mediator between older adults and digital services, for example in virtual museum tours (Beauchet et al. 2022), and in cultural events (Tuomi et al. 2023). Online events can also foster social interaction, which can result in creation of hybrid communities (Simons 2019; Caiola et al. 2023). Especially when talking about older people, engagement in all kinds of cultural activities is associated with lower depression odds (Fancourt and Steptoe 2019), and several recent studies demonstrate the effectiveness of virtual cultural interventions in minimising social isolation and physical frailty among older adults. Digital technologies can increase accessibility to cultural activities, and because of that, provides an exciting avenue to potentially enhance older adult well-being (Lee et al. 2019; Kosti et al. 2023), but it also holds some barriers for successful adoption due to the recognised challenges of older adults as users.

Against this backdrop, the present study explores older adults' social experiences of theatre plays mediated by VR. The paper presents two qualitative studies conducted to test and validate design choices for a social VR concept in the context of cultural events and explore the features supporting social interaction and a feeling of social presence among older adults. Together, the studies make a theoretical contribution by exploring an under-researched user segment, older adults, in the context of VR, particularly in relation to social interaction and social presence as part of VR experiences. Further, the study has practical implications for transferring cultural events into virtual spaces by highlighting the most applicable design features initiating and encouraging social interaction and a feeling of social presence in VR experiences aimed at older adults. The specific research questions (RQs) this study aims to answer are:

RQ1: What are the key design features affecting older adults' user experience during a shared VR experience?

RQ2: What elements enhance or hinder older adults' social interaction and a feeling of social presence during a shared VR experience?

2 Literature review

2.1 Social presence in virtual cultural events

Cultural events are often classified as hedonistic service offerings mostly attended for pleasure (Levy 2010). Cultural events have been found to evoke a strong sense of social presence, and often the social aspect is one of the key motivators for consumers to partake in cultural services (Li and Petrick 2005; Levy 2010; Tuomi et al. 2023). Social presence can be defined as a feeling of being together or in presence of others, either in physical or virtual places, and either with real or artificial entities (Biocca et al. 2003). The manifestation of social presence in events is twofold, whereby individual and communal experiences both influence the user experience (Carlson et al. 2016). There is the aspect of engaging directly with others, e.g. going to an event together with someone or interacting with other participants during an event. The other aspect, sociality, is a sense of a communal experience, where the presence of other users is crucial for creating the event ambiance. In cultural events, social presence can be stimulated through physical settings such as seating areas, allocating time and space for interaction, or atmospherics, e.g., by creating a pleasant ambiance for encounters and conversations (Levy 2010).

The ongoing attempts to transfer social presence into digital service offerings raise the question of how social presence can be facilitated in the virtual world, as virtual social encounters are seen as profoundly different than their physical counterparts (Osler 2020; Hennig-Thurau et al. 2022). To that end, Hennig- Thurau et al. (2022) and Filimonau et al. (2022) call for more research to study the so-called metaverse to provide multi-sensory and blended social experiences within digital arts and virtual cultural activities. However, fostering social interaction in the virtual world is subject to unique circumstances. Virtual world experiences are often considered disembodied or quasi-embodied experiences, which is why some scholars are pessimistic about virtual world's ability to facilitate social presence to the level of the physical world social encounters (Ekdahl and Ravn 2022). Simons (2019) however argues, that in events, interaction can transform from physical co-presence to virtual co-presence, and vice versa. Osler (2020) further concludes that the virtual aspect and physical distance do not prevent the feeling of being together but that this sense of co-presence can be found through common interests or shared personal history in technologically mediated interaction.

2.2 User experience design in virtual reality applications

The focus in research around human-computer interaction has been shifting from usability to user experiences (UX) in the past decades. Usability has traditionally referred to the aspects such as effectiveness, efficiency, or satisfaction, in which a user can achieve specified goals in a specified context on a given service or platform (Petrie and Bevan 2009). While usability has focused strongly on (system or process) performance, UX emphasizes the holistic experience in using the system. Hassenzahl and Tractinsky (2006) defined UX, in comparison to usability, to consider also the user's subjective experience with their expectations, needs, and motivations, as a factor impacting the overall outcome of interacting with a digital system. UX design aims to develop services and interfaces with optimal and holistic user experience in mind.

VR experiences are often measured by their level of immersion. Immersion refers to a feeling of being transported in terms of how space and time is sensed, often accompanied with strong engagement to current task within the virtual environment and temporarily forgetting the real physical world. In VR, this is often referred to as spatial immersion, which happens when the simulated world seems visually so convincing and real that the user feels as if they were actually there (Freina and Ott 2015). In the context of designing immersive VR experiences, one of the key challenges is the fact that UX design for VR applications works very differently from screen-based interfaces (e.g. TV, laptop, mobile). The main discrepancies are identified in the presence of multiple inputs due to the multisensorial experience, such as hand gesture control, speech command, and head gestures, whereby e.g. tapping and swiping become 3-dimensional and the view range of users widens up. Moreover, the ergonomic aspect must be considered, especially possible fatigue, uncomfortableness, and motion sickness derived from the extended use of VR (Rebelo et al. 2012; Yu et al. 2019; Hillmann 2021).

According to Ijaz et al. (2022), future directions to designing effective, safe, and engaging VR applications for older adults should include a definition of the design process for older adults, a method for evaluating the immersive experience in VR systems, and a report on usability challenges related to older adults. Liang (2016) shows evidence of potential trends for augmented reality (AR) systems to support the elderly (Hughes et al. 2017) but reports that a lack of research on designing AR applications for older people requires a theoretical framework or principles of AR design. Similarly, to maximize the potential of VR in improving the quality of life for older adult users, it is essential to consider the UX of VR holistically. For example, Tcha-Tokey et al. (2018) proposed and validated a user experience model in an immersive virtual environment that consists of 10 components: presence, engagement, immersion, flow, usability, skill, emotion, experience consequence, judgement, and technology adoption. Although the importance of UX design is getting acknowledged more in VR applications and research, the underlying factors and implications, particularly concerning older adult users, require more attention.

2.3 Virtual reality and older adults

In the context of older adults as users of VR, some previous research has been conducted. The research done by Lee et al. (2019) emphasized the potential of VR as a medium to promote older adult well-being. However, they also noted that there is a lack of solutions that are aimed to support especially social and emotional well-being, and that the overall understanding of the needs of older adults as users requires more research. The findings of Kalantari et al. (2022) suggested that social VR applications can promote social engagement among older adults over physical distance, and their sample reported the application both enjoyable and usable. A sense of spatial presence in VR experiences was found to strongly contribute to these outcomes. The study also had some practical implications that could improve user experience for older adults, such as larger controls, and more practice time. The study of Kosti et al. (2023) highlighted the potential of social VR in enhancing older adult well-being especially in addressing loneliness, but recognised challenges regarding usability features that impacted the overall user experience.

Despite a few examples, VR and AR technologies have not often been used to encourage older adults to engage in social activities (Lee et al. 2019). It is possible that people who are unfamiliar with VR, and therefore reluctant to adopt it, might become passive in adopting the technology, and therefore, be unable to engage in social interactions within a virtual environment. Even if technology is designed to promote social interaction among older adults, they can experience a sense of alienation instead (Liang 2016; Seifert and Schlomann 2021). Cyarto et al. (2016) argue that a comparison should be made between the emotions of older adults' experience in a virtual environment versus what they experience in their real-world, to offer experiences similar to those in an actual environment. While online, older adults may feel engaged and become more active if they have a specific activity or a human relationship to participate in. Their fear of using technology could be reduced through a collaborative experience that encourages them to solve difficult problems together (Meng et al. 2019; Vieira et al. 2020). A positive user experience may help in changing the stereotype that older adults struggle to understand how to use modern technology (Cyarto et al. 2016).

2.4 Positioning of the study

For successful adoption of social VR, the special needs of older adults as a user group have to be taken into consideration, especially with regards to design features that support ease of use. The specific needs and design features supporting usability and enjoyability for this user group are still not thoroughly understood, especially concerning social VR applications, and require further examination.

In this context, several studies advocate for the inclusion of older adults in the research and design of VR experiences (Fisk et al. 2018; Weernink et al. 2018; Mannheim et al. 2019; Desai et al. 2022), whereby their exclusion from technology development might cause a stereotypical view of older adults as a homogeneous group (Mannheim et al. 2019). This exclusion can be understood as ageism, which includes bias in knowledge, values, attitudes, and behaviour toward older people. Following Desai et al. (2022), there are three methods for integrating technology into research on older adults. In the first approach, older users participate in creating new technology by producing and designing it. A second method involves older adults modifying existing products and gathering feedback. Using this approach, this specific user group may better understand and accept the technology. Thirdly, existing technology can be adapted to achieve new users and create more value without modifying it. In this study, we followed Desai et al. (2022) and used a combination of all three approaches, whereby we involved older adult participants for testing still in development (Study 1) and existing (Study 2) social VR products. Based on this, the findings can be used to further the current state of understanding older adult needs for successful adaptation of VR more broadly, as well as to modify new or existing VR applications or to develop ancillary service processes built around VR applications to suite better the needs of older adults.

In practice, to better understand the prerequisites and specific needs concerning digitalisation of cultural events that foster social interaction, and serve the needs of older adults, two studies were conducted. Study 1 explores older adults' user experience in a VR experience that simulates a real-life theatre experience, positioning the user as a visitor to a theatre, where they can move around as an avatar in the audience hall whilst viewing a pre-recorded 180-degree theatre performance and with other users' avatars also visible and voice-chat between users enabled. Study 2 tests an immersive VR theatre experience built with a game engine, whereby the users are immersed into the virtual environment, the story, and all that happens around them, simultaneously allowing gesture-based interaction with characters and with other users.

The Fig. 1 showcases the research design.

3 Study 1

3.1 Methods

The first study was conducted in Finland in October 2022, whereby data was collected during a two-phased research setup. In the first data collection phase, participants ($n=7$) watched a 90-minute VR theatre experience with mounted VR headsets (Oculus Quest 2) and external headphones (Bose QC45). In the second phase of data collection, the participants were gathered for a joint focus group discussion. The data collected was a compilation of participant observations during the 90-minute VR experience and the qualitative data derived from the focus group interviews.

3.2 Participants

The study used a convenience sampling method to recruit voluntary participants through an existing volunteer group

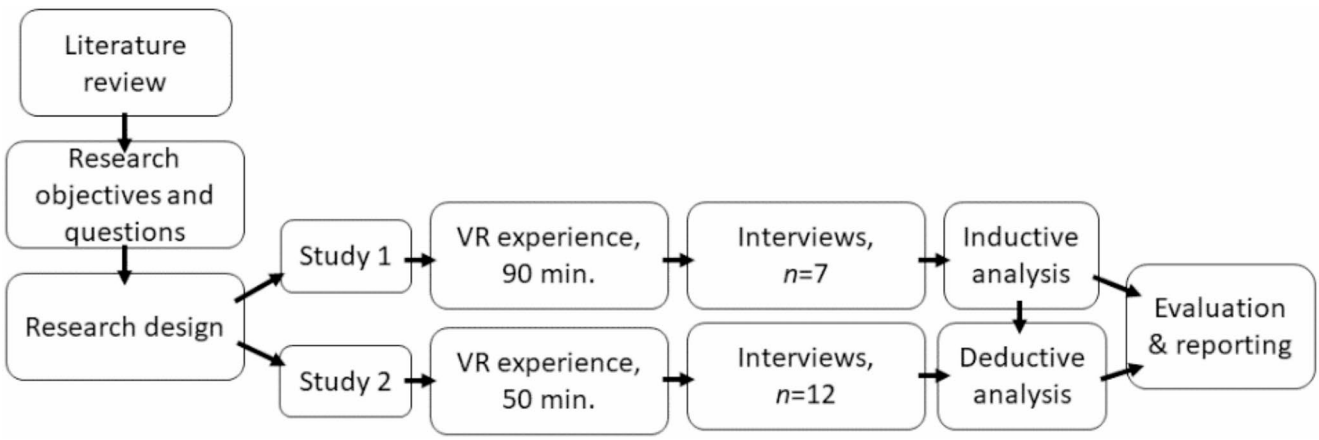

Fig. 1 Research design

of test users. In convenience sampling participants are recruited based on their availability. There were three prerequisites for participating: age (participants had to be over 60), availability on a set date, and having normal or corrected to normal vision. The sample ($n=7$, female $n=6$) were 60-74-year-old socially active older adults living at home in the Helsinki Metropolitan Area. Socially active was defined as regularly engaging in social activities such as meeting friends, family, or participating in social events such as theatre, concerts, etc. All the participants were active consumers of cultural content, such as going to the theatre or opera regularly. The sample was divided into two groups, with the first group having 3 participants and the second group 4 participants. The participants could end their participation at any time without any consequences. The participants were not compensated, but they were provided complimentary snacks and refreshments.

3.3 Materials

The VR theatre experience was a Finnish-language 180 stereoscopic camera recording of a theatre play optimized to be watched with Oculus Quest 2 VR headsets. The participants watched the experience through a social VR platform developed by an external company, whereby the participants, even though physically separated, joined other participants (in this case the other participants from the same study group) to watch the show together in a virtual 3D rendering of a theatre auditorium. The VR auditorium is a replication of a traditional theatre auditorium, having a stage in the front where the play happens and the tiered seating area opposing it with aisles on both sides. The experience was made with Unreal Engine and was custom-built for the study. The VR platform used allows participants to choose an avatar and see each others' avatars in the audience hall, talk with each other via voice chat while watching the recording, and simultaneously pause and resume the show for all users in the same VR 'viewing party'. Participants could also change their seats within the 3D auditorium to change viewing angles and adjust brightness and volume. All the actions except adjusting the brightness and volume could interfere with other participants' experience either directly (e.g. pausing the show) or indirectly (e.g. seeing other participants move around the auditorium).

3.4 Procedure

Before arrival the participants were delivered information of the research and its purposes. Upon arrival the participants were gathered (per group) in a room to receive further instructions and repeat the research procedures (e.g. consent forms) and go through customary information (e.g. that interviews will be recorded). The groups were then split into separate viewing rooms, that each had comfortable chairs and desks. All the participants received help to mount the VR headsets, to adjust them and to optimise clear vision. The participants received further instructions on how to navigate in the VR theatre and how to adjust settings in the software. The participants were instructed to go the audience hall once they were ready to start watching the show, and the show started when all the participants were seated in the virtual environment.

All participants watched the VR experience while being covertly observed by a researcher present in the same room. At any moment, the participants could reach out to a researcher if needing help with anything. One researcher was also online in the VR theatre observing the participants in the virtual environment. After the viewing was over, the participants had a break before they were gathered for the focus group interviews, that lasted between 25 and 30 min. Interviews were recorded, manually transcribed and anonymized. Interview questions explored the ease of use and usefulness of the social VR experience and factors influencing social interaction and social presence in VR experiences. The interview finished with participants' development suggestions: how could social presence in VR experiences be further developed?

3.5 Data analysis

The data were analysed by two researchers employing an inductive thematic analysis to (1) code the data, (2) cluster the data, and (3) categorize the data into themes, and (4) define and refine the themes. Internal consistency of the analysis and relevance to the theoretical framework was checked by the rest of the research team to reach consensus. The analysis followed the thematic analysis principles constructed by Braun and Clarke (2006). In inductive analysis, the occurred themes are formed in a data-driven manner, reflecting the data content provided by the sample.

3.6 Results

Four themes were established in the thematic analysis: (1) social interaction, (2) spatiotemporal immersion, (3) social presence, and (4) older adults' user experience.

With social interaction we refer to findings that describe verbal, auditory, visual, and/or bodily interaction between other users, and/or virtual characters. The theme helps to identify the multisensory factors affecting interaction within VR, as well as to understand how the different design choices influence user satisfaction of interaction.

The second theme, spatiotemporal immersion, refers to findings describing the feeling of being mentally transported

into another place and time, often accompanied by a sense of strong immersion. The theme helps in understanding the features impacting the level of immersion in VR, and the impact of design choices affecting immersion such as the length of the experience.

Third, the theme social presence includes findings that relate to the feeling of presence of others, i.e. other users or virtual characters. The theme helps to understand factors that affect the feeling of sharing the experience, and the impact of such feeling.

Finally, the fourth theme, older adults' user experience, gathers the findings that refer to elements impacting the overall user experience in this particular study, such as user journey, technical aspects, and content. The theme helps to understand how the specific design choices impact the overall evaluation of the VR experience within this user group.

3.6.1 Social interaction

In terms of social interaction, participants commented on the affordances of the different features that the social VR experience facilitated. In particular, participants commented on the use of voice chat feature that allowed verbal communication between users, and the feature that allowed participants to move and change seats within the virtual auditorium. As put by participants:

> "The voice chat worked fine, but I didn't use it much as I didn't feel like the right moment to interrupt someone else's experience ever came" (P1, male, 65–69).

> "When someone [another participant's avatar] moved next to me to watch the show, I almost wanted to grab their hand" (P5, female, 65–69).

> "There was someone [another participant's avatar] sitting in the front row with a tall hat, blocking my view. I wanted to tell them to move or take the hat off" (P7, female, 60–64).

> "We represent the older generation - we are taught to be quiet in the theatre" (P4, female, 65–69).

It is interesting how the VR experience was able to reproduce some characteristic of being "at the theater". For example, having one's vision partially blocked due to stature, hairstyle, or a hat of another participant's avatar, as well as the attention in using voice chat to communicate to avoid disturbing others.

3.6.2 Spatiotemporal immersion

In terms of spatiotemporal immersion, some participants mentioned losing the track of time, as well as strongly immersing themselves in the experience. Even so, the majority of the participants did not mention aspects, neither amplifying nor reducing, relating to immersion.

> "[…] I didn't have any idea of the passing of time" (P2, female, 70–74).

> "I assumed first that I could watch this for max five minutes, but this experiment changed my attitude - I was all in for the experience!" (P1, male, 65–69).

> "I felt that I didn't know in which world I existed. Quite surreal!" (P8, female, 70–74).

Compared to expectations, the relatively long duration of the experience was not evaluated negatively by the participants, who were generally very involved, so much so that they missed the track of time.

3.6.3 Social presence

The participants commented on the design choices that facilitated the feeling of social presence and the importance of sharing the experience: the impact of using cartoon-like avatars and the overall feeling of watching together, including peer pressure, group think, and the emergent social etiquette of 'going to the theatre' in VR. As put by participants:

> "I think it would be important for someone who watches something like this alone at home to share their experience with someone else, virtually" (P2, female, 70–74).

> "Hearing other people [in the same viewing party] quietly laugh at funny moments felt like I was there, in the audience" (P5, female, 65–69).

> "In the beginning, it felt a bit strange to see people [other participant's avatars] move around the auditorium. In a real theatre, people would stay sat where they are" (P7, female, 60–64).

> "I don't see what value the avatars bring. I don't need them" (P8, female, 70–74).

3.6.4 Older adults' user experience

Most participant activity in terms of testing the design features and interacting with the interface was observed while entering the VR theatre and settling in. Once the play was put on, all the participants tended to sit quietly, watching the show. Minor adjustments were made by all during the experience, such as slightly changing one's physical position, fixing VR headsets, or putting the controllers down on the table or on one's lap. Occasionally, few participants laughed out loud or expressed amusement, such as smiling during parts of the experience. No conversations or comments apart from the play's beginning and end happened. After the 90-minute VR experience some participants commented that an in-built intermission would be the best option, as some might feel too shy to pause and interrupt the play for others. This could also facilitate interaction among participants. Otherwise, comfortable seating was mentioned by most to be a must for a pleasant viewing experience.

> "If someone would have suggested, I would have been happy to have a break" (P3, female, 65–69).

> "After an hour my head started to feel heavy and my neck got sore. The seat had armrests but I had to adjust my position to support my head for better comfort" (P4, female, 65–69).

Most participants watched the whole play with the mounted VR headsets without any major problems. At times, most participants changed seats (within the virtual VR environment) or adjusted other settings within the interface. The possibility of changing seats gained multiple positive notions, however, after some experimentation the majority preferred to watch the show from the back row for the best full view on the stage. Some participants were slightly annoyed by the feature that another avatar could move to block their view partially or that the avatar's movement in the seats in front disturbed their focus from the play. The main issues regarding the technical aspects of user interface related to fuzzy vision that many participants reported regardless of using eyeglasses or not. Some new features for enhancing social interaction and social presence participants suggested were the possibility to applaud or share reactions, the option of muting others in your viewing party, and an option to raise your hand or vote to ask the opinion of others for a break, as well as more flexibility for adjusting the viewing angle.

> "I tested different angles and seats just for my own curiosity" (P4, female, 65–69).

> "I liked that I could switch from where I was watching the show. I could follow the actors as they moved on the stage" (P6, female, 65–69).

> "The view was a bit blurry all the time" (P2, female, 70–74).

Participants also noted that the VR experience show should not last for several hours as that might be too exhausting, though most agreed that the 90-minute experience was fine to spend in VR. The content itself was not commented on except for the good acoustics that enhanced the enjoyability of the experience.

> "The plays should not be too long for people to have a pleasant experience" (P8, female, 70–74).

> "I have seen this show live as well, and the audio and acoustics were better now [in the VR]" (P6, female, 65–69).

4 Study 2

4.1 Methods

The second study was conducted in Finland in February 2023, whereby data was again collected during a two-phased research setup, on two separate days. In the first phase participants ($n=12$) watched a 50-minute VR theatre experience with mounted VR headsets (HTC Vive Pro) and external headphones (Bose QC45). Participants were divided into pairs, and as pairs, they could choose two out of three stories they wanted to watch. In the second phase of the study, all the participants were interviewed in pairs after their VR experience.

4.2 Participants

The study used a convenience sampling method to recruit voluntary participants through the same volunteer pool mentioned earlier. However, the participants were not the same as in Study 1. There were three prerequisites for participating, that were age (participant must be over 60), availability on a set date, and having normal or corrected to normal vision. The sample ($n=12$, female $n=6$) were 60-74-year-old socially active older adults living at home in the Helsinki Metropolitan Area. As previously, socially active was defined as regularly engaging in social activities such as meeting friends, family, or participating in social events such as theatre, concerts, etc. The sample was

divided into pairs, having a total of 6 pairs going through the whole research procedure. The participants could end their participation at any time without any consequences. The participants were not compensated, but they were provided complimentary snacks and refreshments.

4.3 Materials

The theatre play and the environment with characters were built using a game engine (Unreal Engine), whereby the participants could move around in an immersive 3D environment. The play was in English with an opportunity to use Finnish subtitles. The play happened around the participants and a narrative voice was directed towards users, guiding them through the story. The story included scenes with virtual/non-player characters, whereby the narrator encouraged participants to interact with virtual characters (e.g. hugging a virtual character) to progress in the story. In two scenes, the participants also encountered the other user (who they were paired up for the study) in the virtual world. The users were represented by abstract human-like shapes that could interact by creating and moving 'virtual energy' or 'stardust' between themselves, by using synchronised hand gestures. All the interaction in the virtual world was bodily interaction, not verbal.

4.4 Procedure

Before arrival the participants were delivered information of the research and its purposes. The participants had signed up as a pair, or they were randomly assigned to a pair if they volunteered to the study alone. Upon arrival, participants received instructions and the research procedures and information was repeated. In the beginning of the actual experience, the pairs received three story options, from which they could choose two to go through. Then they were escorted into separate viewing rooms where the VR headsets were mounted and the majority of the experience took place. All the participants received help to mount the VR headsets, to adjust them and to optimise clear vision. The participants received further instructions on how to move in the VR experience and adjust settings. Participants could choose to watch the VR experience while standing or sitting down; 5 out of 12 participants chose to go through the entire experience sitting down. All the participants were observed via video connection to ensure safety, and at any time they could reach out to a staff member by speaking out loud to receive help.

After the VR experience was over, the participants had a break before they were gathered for pair-wise interviews, that lasted between 25 and 30 min. The interviews were recorded, manually transcribed, and anonymized. Interview questions were the same as in Study 1, whereby the questions explored the ease of use and usefulness of the social VR experience and factors influencing social interaction and presence in VR. The interview finished with participants' development suggestions: how could social presence in VR experiences be further developed?

4.5 Data analysis

The data were analysed by two researchers employing a deductive thematic analysis to (1) code the data, (2) cluster the data, and (3) categorize the data into themes, and (4) define the themes. Deductive analysis was used to confirm the themes established in Study 1. Internal consistency of the analysis and relevance to the theoretical framework was checked by the rest of the research team. Again, the analysis followed the thematic analysis principles constructed by Braun and Clarke (2006). In deductive analysis, the analysis is driven by existing concepts, which in this case, where the themes that were discovered in the analysis of Study 1.

4.6 Results

The findings were categorised under the same four themes as in Study 1: (1) social interaction, (2) spatiotemporal immersion, (3) social presence, and (4) older adults' user experience.

4.7 Social interaction

In terms of social interaction, participants commented on the expectations and consequences of bodily interaction. As no prior information about the content of the experience was given, some participants expected that they would be able to communicate verbally with the pair they watched the show with. Most participants were impressed by the possibility of moving around in the virtual 3D environment in the scenes and tried interacting with non-player virtual characters on multiple occasions. However, some felt that the lack of feedback from interacting was discouraging, as there were no clear consequences to it except for few select scenes. The moments where the participants encountered their pair in VR were positively noted, but also many described forgetting that the other character was another human, not just another virtual character.

> "I thought there would have been some verbal interaction" (P15, female, 65–69).

> "[The interaction] was nice, but it would have been better if there would have been clearer consequences - that my choices matter" (P11, male, 60–64).

4.8 Spatiotemporal immersion

In terms of spatiotemporal immersion, majority of participants reported being strongly immersed in the 3D VR world and in the story. Some commented that they lost the sense of time, getting immersed because of the interactive features of the story, or having the urge to spend more time in the virtual world. However, some negative feelings were also reported, such as feeling uncomfortable or even scared because of certain scenes in the story, highlighting a sense of immersion to the story and surrounding VR world.

> "The flames [an interactive feature in the story] helped to break the ice… I felt like I had superpowers" (P10, female, 65–69).

> "Impressive and immersive, I was sucked into another dimension" (P11, male, 60–64).

> "It was so lovely. I could have just paused the show and stayed there [in the VR environment]" (P15, female, 65–69).

4.9 Social presence

The sense of social presence was strong among the majority of the participants. Even though few described the encountering of non-player and player characters in the virtual world being different than in a physical setting, many commented on having emotional reactions to the presence of characters. While some participants reported feeling rather like an observer, some felt truly immersed and part of the scene. The social presence of the virtual characters seemed to have a stronger impact than the co-presence of another participant, as some even commented that it makes no difference to enjoy the experience alone or synchronised with another participant.

> "The dark figure [another participant's avatar] was scary" (P3, female, 65–69).

> "Being together with the character [another participant's avatar] felt a bit different" (P14, female, 60–64).

> "I thought for a moment that the characters [non-player characters] were real people" (P12, female, 65–69).

4.10 Older adults' user experience

The activity of the participants remained relatively constant throughout the experience. Some reported being less enthusiastic to interact with non-player or other participant's characters towards the end of the 50 min experience. Most participants watched the whole show without any issues nor complained of feeling any discomfort or tiredness. Watching the show with a pair made no difference to the experience to any of the participants. Immersion to the experience was described as strong by many, and the immersion seemed to last throughout the experience.

> "I felt more immersed and in the story than in traditional physical theatre play" (P14, female, 60–64).

> "It does not matter if I watch the play alone or with someone" (P11, male, 60–64).

> "I started to fear that the experience was too long because I started to feel a bit nauseous" (P12, female, 65–69).

The main complaint was again the blurriness of the image, which few participants reported. They commented on having issues with fitting the headsets on top of their regular eyeglasses or having from time to time to adjust the headsets for clearer vision. Other issues impacting the user experience related to the limited play area, which has to be set for the VR headsets. The limitation to movement by the HTC Vive Pro power cable, and the warning grid that appears when a participant wanders too far off the play area, were commented on as breaking the immersion. Actual design choices within the VR experience were not commented on.

> "I had to adjust the VR headsets often to keep the view sharp" (P9, female, 65–69).

> "The reality hit when I bumped into the red grid [the VR safety boundary]" (P14, female, 60–64).

> "The goggle's power cable was attached to the ceiling, it limited my movement downwards" (P11, male, 60–64).

The content was described as immersive. Many described the storyline itself as being dark, and raising empathetic feelings and other emotional reactions from participants. Some scenes also raised positive feelings, whereas some features emotionally divided the participants. All in all, the experience raised many emotions among the participants

Table 1 Main findings and comparison of the results between the study 1 and study 2

Results	Study 1	Study 2
Social interaction	Voice chat for verbal interaction was not used by the participants as it might disturb others. The possibility to move in the theatre encouraged bodily interaction, but the moving of others was partially found disturbing.	A possibility for verbal interaction was expected by some participants. The virtual world encouraged bodily interaction with real and virtual characters, but the lack of feedback from the interaction was discouraging for some
Spatio-temporal immersion	Moderate level of immersion for some participants.	Strong immersion for the majority of participants.
Social presence	Sharing the experience can bring added value. Impact of avatars to social presence split opinions. Voice chat increased the feeling of social presence.	Sharing the experience didn't bring additional value. Many participants reported having affective reactions to the presence of virtual characters. For some, the virtual characters felt real.
Older adults' user experience	Participants enjoyed the experience passively. The need for good ergonomics for a pleasant experience was highlighted. Issues with adjusting the headsets and blurry vision. Interface features were moderately used and viewed positively by the majority of the participants. VR theatre should not last for many hours. Technical quality such as acoustics might be better than in the physical venue.	The majority of the participants interacted with VR constantly throughout the experience. No major technical issues or discomfort. Some issues with adjusting the headsets and blurry vision. Content described as immersive. A safety grid limiting the movement can break the immersion. Experience described as eye-opening and ground-breaking (relating to theatre fully in VR)

and was thought to be an eye-opening and ground-breaking new form of doing theatre.

Table 1 presents the main findings of both studies under the four recognised themes.

5 Discussion, conclusion and future research

5.1 Design choices for social VR: theoretical implications

The results of this study provide further support on the potential of older adults as a user group for immersive VR experiences in general, and in the context of cultural events in particular (see e.g. Tuomi et al. 2023). The findings highlight the possibilities that VR based spaces as a stage hold for cultural service producers and are in line with Filimonau et al.'s (2022) arguments on the potential of these technologies for the event sector. As the results suggest, longer experiences such as theatre plays can be transformed into VR and watched through mounted VR headsets without severely risking the comfort of watching. However, aspects such as fatigue and motion sickness highlighted by previous research as possible comfort issues in using VR (Rebelo et al. 2012; Yu et al. 2019; Hillmann 2021), were also mentioned in some of our participant's responses. There is a general need for developing VR headsets further for more pleasing watching experience, especially considering a clear visual input, as blurry vision was mentioned as a source of discomfort with or without eyeglasses. This aspect of the user experience seems to be one of the key features affecting older adults, as perceptual decline, that is more common among older adults, have been recognised as a possible challenge for technology adoption for older adults (Charness and Boot 2016; Meng et al. 2019). Another possible explanation for the commonness of this issue could lie in the access to technology (Moore and Hancock 2020), as not many of the participants were familiar with VR technology, and so might have faced technical difficulties for correctly adjusting the vision within the VR headsets. If the perceptual decline among with other special needs and cognitive challenges of older adults as users of digital services (see e.g. Charness and Boot (2016) are not addressed, it might further negatively impact the motivation to use these technologies, and thus, engaging with such services (Moore and Hancock 2020; Desai et al. 2022).

In Study 1, the shared viewing environment and presence of other participants' avatars were able to create the feeling of co-presence among participants– for better and for worse. While participants generally viewed the ability to move around the virtual environment and the ability to see & hear other participants' presence, excessive movement from other participants also created unwanted disturbances and thus negatively impacted the experience. Further research should explore how player autonomy and social interaction can be combined to create optimal user experiences.

In Study 2, the strong immersion seemed to be mostly contributing to the feeling of social presence, regardless of with whom, i.e. the co-viewer or a virtual character, the user was interacting. Interestingly, the presence of another human participant simultaneously going through the same experience did not seem to contribute to the feeling of social presence. Based on these results and in response to the previous questions raised in research (Osler 2020; Hennig-Thurau et al. 2022), it could be argued that the mere existence of virtual characters might be enough to facilitate a feeling of

social presence, as long as there is some level of interaction between the user and different characters (human or computer controlled), combined with clear sensory cues that highlight the user input and its influence on the surrounding virtual world.

The biggest difference between the two experiences with regards of social presence seemed to be that the knowledge of other human users did not add value in Study 2. However, it should be noted that we did not test what would have been the implication to the feeling of social presence in Study 1, if computer-controlled avatars would have been present. Based on the results of our studies, it seems that a higher immersion level reported in Study 2 could perhaps have replaced some of the need for other human participants, and that this engagement to the experience itself fulfilled needs for social interaction.

To expand Osler's (2020) view on virtual togetherness, based on the results, a sense of togetherness could be reached also through shared initiative, as in doing something together with other participants or even with just a virtual character. In particular, the design choices promoting bodily interaction encouraged most of the participants to actively participate in the experience. Even though the lack of feedback from the interaction was described to decrease the enthusiasm to interact with the characters, most participants still reported continuing the interaction, as well as having a sense of enjoyment as being actively part of the experience. Even though VR has not been commonly used to promote sociality among older adults (Lee et al. 2019), the results of this study provide clear evidence of its potential for it.

As much of VR technology and its applications are designed for a younger audience (Kim et al. 2016) opening up more VR development to an older user segment could, based on our findings, bring significant benefits. There is an ongoing stream of research which targets older people as users of digital cultural experiences, because they are already more likely to be potential consumers of cultural products (Tuomi et al. 2023). Research has also shown that participation in cultural events brings significant physical and mental benefits (see e.g. Fancourt and Steptoe 2019; Elliott et al. 2020). As a result, at a social level, these benefits could translate into reducing mortality, improving general health indicators, and decreasing health care costs among older adults, if successfully integrated into compelling digital services.

5.2 Design choices for social VR: practical implications

Overall, the two empirical studies presented here explore successful design features for social & cultural VR experiences for older adults, via directly engaging them in the research and design process, as suggested by previous studies (see e.g. Fisk et al. 2018; Mannheim et al. 2019; Desai et al. 2022). In doing so, the aim of our work was to offer guidance for product development for social & cultural VR applications for the elderly. In this respect, the study brings many aspects of novelty into play, and contributes to the current knowledge of UX design in VR studies focusing on older adult users.

Most importantly, the two examples of social & cultural VR experiences described here involve active enjoyment, where the virtual world can be experienced in first person, with a possibility for movement and interaction, that creates an illusion of being there, and having a sense of co-presence through other viewers or virtual characters. The aspect of being able to move, physically or by simulation, and seeing or hearing others, seemed to contribute to the experience the most, making it similar to real-world experiences and thus evoking the feeling of social presence.

Among the aspects to be evaluated positively, we identify the design of media in which it is possible to customise the conditions of participation (e.g. choosing an avatar) and simultaneously have synchronous social interactions (e.g. interacting with other users via gestures or voice chat). This aspect could be further deepened and expanded in many other applications. In addition, the perception of each other's presence is valued as positive. The virtual proxemic interaction could contribute to the social support of those older adults who tend to be more isolated. Through the adoption of an avatar, one's and others' virtual presence becomes part of the performance, and the general acceptance of avatar-use opens up an essential discourse on digital identity in the context of older adults.

Interestingly, the social etiquette of 'going to the theatre' seems to persist even in VR theatre experiences, whereby the context and its implicit rules prevail over the possibilities offered by technology, e.g. voice chat, whereby participants were somewhat reluctant to disturb other participants' experience, despite reporting how hearing other participants' laughter via voice chat enhanced the experience. Perhaps older adults - or perhaps only for this specific type of experience - do not tend to transcend the limits of the physical world but rather, stick to the digital translation of the physical experience to which they are accustomed to. Furthermore, a suitable level of user autonomy has to be considered, if elements such as intermission or polling were to be introduced, as not all users are comfortable pausing the play for everyone else during a shared viewing experience. As in live theatre, breaks in the play are controlled by the production, so an option for a planned intermission could be presented for the users prior to the play, to enhance the feeling of going to a theatre by following the traditional protocols in place. Allocating a specific time for interaction,

either pre-, during, or post-experience, could also further enhance the feeling of social presence among participants in virtual events, as it does in physical ones (Levy 2010), both on an individual and a communal level (Carlson et al. 2016). Another possible future implementation consists of deactivating interactions (voice and proxemics) for users who might not appreciate them or for some specific events, either directly by users themselves or via the use of a dedicated moderator.

The findings of these studies reveal interesting and important insights into the features that impact user experience of older adults in social & cultural VR experiences, while the specific design choices clearly promoted or demoted social interaction and a sense of presence. These findings should be used as a reference point when designing social cultural experiences in VR, especially aimed for older users.

5.3 Conclusion and future research

Immersive technologies such as VR allow for the creation of new types of digital services or other immersive virtual environments for users to try, buy and consume digital products and services (Filimonau et al. 2022). Novel digital environments afford new forms of user-to-content and user-to-user interaction, whereby a key promise of the so-called metaverse is built around fostering new types of social connections. However, there is a lack of research on the mechanisms of social interaction and the formation of social presence in VR experiences (Hennig-Thurau et al. 2022). The experience of older adults in particular is often overlooked in information systems management literature (Ijaz et al. 2022).

To that end, this study qualitatively explored the key features affecting older adults' user experience during a social VR experience, and in particular, how can social interaction and a feeling of social presence be enhanced among this user group. We conclude that promoting the social aspect in virtual experiences can positively affect the watching experience, while furthermore, social VR experiences have the potential to reach a similar level of sociality as in live performances through fulfilling the individual and communal prerequisites, and thus, enhance technology adaption of older adults, and serve as a motivator for using digital cultural services. However, there are also caveats to this, whereby evoking social presence in VR among older adults requires a careful balance of user autonomy and synchronised social interaction. For instance, the spontaneous use of voice chat during a social VR experience may seem alien to older adults, while at the same time hearing other users' laughter or gasps in real time may enhance the feeling of togetherness. Designing cultural VR experiences that include elements of social interaction should take into account the unique needs and requirements of older adults, e.g. perceptual decline (Charness and Boot 2016; Meng et al. 2019) or somewhat stickier social etiquette, e.g. that there should be no moving around or chatting with your neighbour during a theatre performance.

As is always the case, the study has limitations that should be considered. First, given its small sample size and skew towards women, the findings of this qualitative research are not generalizable and would require further validation through, e.g., quantitative or experimental research designs. The content used, i.e., 180-recording of a theatre performance and a game-engine rendered virtual experience might also influence the findings, whereby participants might be less willing to talk over the performance than they would if the content was, e.g., a sitcom, TV show, or sports; or interact with the content differently if it were photorealistic instead of artistic. Future research should therefore study social presence in shared virtual reality experiences where the context and content of the experience are different. Further, the level of active vs. passive participation and the flow of the experience (e.g., breaks, duration) could be explored more, as past research has demonstrated the effects of social presence in more active contexts, e.g., gaming in VR (Liszio et al. 2017).

This study focused on social interaction and the feeling of social interaction as part of the actual VR experience, i.e. the core-experience (Voorhees et al. 2017). However, it should be noted that experiences, e.g. that of going to a theatre, are holistic, formed of multiple touchpoints and the users'/participants' journey through these. As such, future research should look at how social presence enhancing elements of interaction could be added to VR experiences in the pre- or post-experience (Voorhees et al. 2017). For instance, studies could explore the feasibility of pre-performance preparatory and anticipatory VR experiences, e.g. familiarizing with the topic of the performance beforehand, or VR-mediated after-performance discussion sessions with peers or meet & greet sessions with performers to deepen the core-experience.

Finally, the participants in our study were strangers to each other. Prior research has indicated that socialization, particularly meeting friends in VR, influences a feeling of presence, e.g., relatedness and enjoyment (Barreda-Ángeles & Hartmann 2022). Future research could repeat our study with participants with varying levels of familiarity.

Acknowledgements This study was conducted as part of the HomeOpera– Digital Cultural Social Experiences -project, funded by the European Regional Development Fund as part of the EU's COVID-19 recovery actions. Grant ID: A77484.

Author contributions Conceptualisation, E.M.K., A.T., V.C., M.P., and D.S.; methodology, E.M.K. and A.T.; validation, E.M.K. and A.T; formal analysis, E.M.K. and A.T; investigation, E.M.K. and A.T.; resources, E.M.K. and A.T; data curation, E.M.K. and A.T; writ-

ing—original draft preparation, E.M.K., A.T., V.C., M.P., and D.S.; writing—review and editing, E.M.K. and A.T; visualisation, E.M.K.; supervision, A.T. and M.P.; project administration, A.T.; funding acquisition, A.T. All authors have read and agreed to the published version of the manuscript.

Data availability The interview data is not available due to privacy agreements.

Declarations

Conflict of interest The authors declare no competing interests.

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