Towards Augmented Reality-Based and Social Robot-Based Social Integration of Older Adults: A User Requirements Analysis

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Abstract. Background: Older adults are at risk of social isolation and loneliness. As part of the CO-HUMANICS (Co-Presence of Humans and Interactive Companions for Seniors) project, augmented reality (AR)-based and telepresence robot-based systems are to be developed to support social integration of older adults.

Aim: Following a human-centered approach, this study aims to identify requirements of older adults towards AR-based (RQ1) and telepresence robot-based (RQ2) communication that fosters social integration.

Methods: Semi-structured individual interviews were conducted between May and October 2022 with N = 30 older adults (60–74 years old, 37% women) from Germany. Participants were presented with storyboard illustrations of hypothetical interpersonal communication scenarios involving an AR system and a telepresence robot and gave their detailed evaluations (mean interview duration 43 min).

Results: Older adults had ambivalent and nuanced requirements for an AR system and a telepresence robot. Technology-specific and general requirements emerged from the data and were grouped into four dimensions: 1) technological requirements (ease of use, effortless contact initiation, realistic avatar design, intuitive movement control, anthropomorphism, and robot size), 2) emotional requirements (warmth, intimacy, companionship, and empowerment), 3) social requirements (potential for joint activities, multiparty interaction, and multitasking), and 4) administrative requirements (privacy, data protection, and affordability).

Conclusions: Older adults recognized the potential of AR systems and telepresence robots to support their social integration; however, ease of use, privacy and data protection issues, and affordability remain an obstacle for technology acceptance.

Keywords: Innovative technologies · Ageing · Human-centered design · Telepresence robot · AR

1 Introduction

It is estimated that by 2030, one in six people in the world will be aged 60 years or over [1]. The ageing process can be accompanied by life changes that bring on social isolation or feelings of loneliness among older adults: widowhood, death of friends and relatives,

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retirement, reduced mobility, and health issues, among others [2, 3]. Therefore, several potential solutions aimed at fostering the *social integration* of older adults are being developed and researched. Technology-based interventions carried out by researchers and self-directed behaviors carried out by older adults have shown potential for loneliness and social isolation reduction in old age [4]. In consequence, studies focusing on communication mediated by innovative technologies –such as *augmented reality (AR)* and *telepresence robots*– are increasingly becoming part of the research landscape [5, 6]. However, data show technologies developed for older adults are often discarded due to factors such as stigmatization or lack of adaptiveness to physical and cognitive changes that come with age [7]. To overcome this technology adoption barrier, user-centered design is paramount when creating technologies for the ageing population. Considering individual characteristics of older adults (both physical and psychological) and adapting technologies to their values, has proven effective for technology acceptance [8, 9]. It is against this backdrop that the current study aims at identifying the requirements older adults have towards AR-based and telepresence robot-based interpersonal communication that fosters social integration.

1.1 Augmented Reality for Older Adults

Augmented reality (AR) is a technological system that incorporates virtual objects into the real world in real time as the user experiences them [10]. These objects can range from a simple shape to the real-time rendering of another person ("avatar"), with whom the user can interact socially via an AR headset [11]. Hence, AR systems can enable vivid interpersonal communication over distance.

Recent studies already highlighted potential benefits that AR can provide for the wellbeing of older adults [12], and a number of AR applications have been developed to foster their independence. These applications mostly address the physical [13] and cognitive [14] health of older adults, or they provide assistance in everyday activities such as cooking or cleaning [15]. Social features of AR, however, remain under-researched for this target group, even though experimental studies with younger adults showed AR's overall potential to improve social connectedness among individuals [16]. To address this research gap, the specific requirements of older adults towards AR-based interpersonal communication need to be explored. Therefore, the present study aims at answering the following research question (RQ1):

What requirements do older adults have for innovative interpersonal communication via an augmented reality (AR) system to be developed?

1.2 Social Robotics for Older Adults

Social robots are robots that interact with ordinary users and have capabilities to assist them in everyday life [17]. Telepresence robots are a subset of social robots that are designed to enable interpersonal communication over distance. Telepresence robots consist of a remotely controllable mobile platform with video conferencing equipment that allows remote users to move around a local environment and interact socially with others [18].

Telepresence robots are being increasingly used to provide support, promote healthy ageing, and foster the social wellbeing of older adults [19, 20]. Robot technology can connect older adults to social networks, such as their relatives, friends, and healthcare workers [17]. Previous studies have tested telepresence robots as tools to help social inclusion of older people with positive results [21–23].

Nevertheless, technology acceptance among the older population is still a challenge [7]. To increase the acceptance of robots, researchers are now employing human-centered approaches that invite older adults into the design and evaluation process [24]. In line with this human-centered approach, the present study aims at answering the following research question (RQ2):

What requirements do older adults have for innovative interpersonal communication via a telepresence robot to be developed?

2 Methods

An interview study with $N = 30$ older adults (60–74 years old, $M_{age} = 67.1$, $SD_{age} = 4.3$, 37% women) living in Germany was conducted between May and October 2022. Participants were active senior citizens without cognitive impairments and all of them signed an informed consent form. The study was granted approval by the ethics committee of Technische Universität Ilmenau, Germany, on July 19, 2021, and was preregistered through the Center of Open Science (https://osf.io/fxp6r/). The individual, semi-structured interviews had an average duration of 43 min.

Participants were asked about their current use of communication technologies and their potential use of innovative communication technologies, namely AR systems and telepresence robots. To familiarize older adults with the innovative technologies, the use of an AR system and a telepresence robot were presented through storyboard illustrations that visually depicted a hypothetical interpersonal communication scenario between a grandparent and an adult grandchild. Each participant viewed 2 storyboards, one from the grandparent's and one from the grandchild's perspective. Women were shown an older female and men an older male character (see Fig. 1).

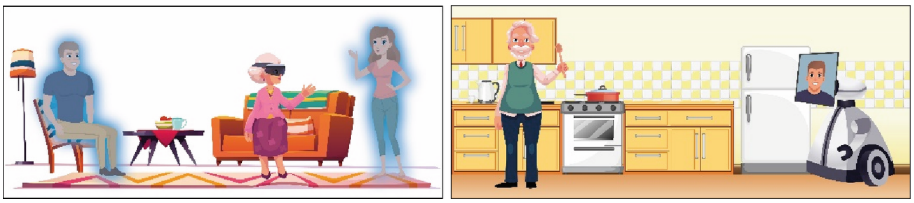

Fig. 1. Excerpts from storyboard illustrations depicting AR-based and telepresence robot-based grandparent-grandchild communication scenarios.

Interviews were audio-recorded, transcribed, and anonymized. Subsequently, several rounds of thematic coding of the transcripts were done with the software MAXQDA.

3 Results

Participants had technology-specific and general requirements for the AR system and the telepresence robot. Four requirement dimensions emerged from the coded interviews: 1) technological, 2) emotional, 3) social, and 4) administrative. A summary of all main requirements included in each dimension can be seen in Table 1.

Table 1. Requirements of older adults for an AR system and a telepresence robot.

Dimension	AR requirements	Telepresence robot requirements
Technological	Ease of use Effortless contact initiation Realistic avatar design	Ease of use Intuitive movement control Anthropomorphic medium-sized
Emotional	Warmth Intimacy	Companionship Empowerment
Social	Joint activities Multiparty interaction	Joint activities Multitasking
Administrative	Privacy/data protection Affordability	Privacy/data protection Affordability

3.1 Technology-Specific Requirements for an AR System

To answer RQ 1, technology-specific requirements related to the AR-system were collected. The very term "augmented reality" was not familiar to older adults, therefore the requirements for the AR-system centered around the emotional response to the presented scenarios. Apart from general concerns regarding wearability of AR headsets and their compatibility with health-related aids (e.g., hearing device or glasses), participants expressed doubts that AR-based communication will fulfill their requirements for intimacy and warmth during mediated communication: *"If I want to have contact, then I want to have contact the way I see you now. The way I can look into your eyes. That would be important to me"* (male participant, 72 years old).

In connection to this, participants expressed the requirement of realistic avatar design. Having an avatar that would look as similar to the real person as possible would help them feel more comfortable during AR-based communication, as would the possibility to move around the room freely without any wires attached to the headset and the option to initiate contact in an effortless manner. The potential for interacting with several avatars at once also added value to the AR-based communication in the eyes of older adults: *"It's like a virtual family reunion. That's really cool, I like it"* (male participant, 68 years old).

3.2 Technology-Specific Requirements for a Telepresence Robot

To answer RQ 2, technology-specific requirements related to telepresence robots were collected. All participants had previous knowledge of robots mostly acquired from different fictional and non-fictional media. Furthermore, all of them were acquainted with videoconferencing applications and most of them had first-hand experience with them. Given this familiarity with robots and their functions, older people had very specific requirements related to size and form: anthropomorphic, medium sized robots were preferred: *"It must be a robot that doesn't take up too much space. Not too big, not too small"* (female participant, 61 years old). Additionally, the movement control of the robot was expected to be intuitive as participants associated a sense of empowerment with their ability to control the robot independently.

Related to anthropomorphism was the perception that a telepresence robot that resembles a human could serve as a companion and help against loneliness: "*When a machine like that scurries around in your house […] then you have the feeling that there is someone else. I don't necessarily have to hug it, but you have the feeling […] 'I am not alone here'*" (male participant, 68 years old). The ability to communicate with others while performing daily activities was also perceived by older adults as an attractive function.

3.3 General Technology Requirements

Older adults expressed concerns regarding ease of use and wished for both technologies to be as effortless to operate as possible: *"I know it works when I turn it on and I don't have to do much. There's always a lot of talk about 'it's very simple, you plug it in, and it works', but it's not"* (male participant, 62 years old). Participants also expressed doubts about the safety of innovative technologies in areas such as privacy and data protection: *"Can someone hack into it [the robot]? [Then they] can basically explore my apartment with it"* (female participant, 61 years old). The topic of affordability was also raised, since AR systems and telepresence robots were perceived by older people as very expensive devices beyond the budget of the general population.

Finally, the possibility of engaging in joint activities with loved ones (conversations, meals, virtual celebrations, etc.) was highly valued in both the AR system and the telepresence robot. Older adults saw potential in both technologies to foster social contact and, therefore, social integration in older age: "*[I would use the robot] with my grandchild […] while cooking food, talking about school […]. We do math homework together, maybe it would also be possible to do that*" (female participant, 63 years old).

4 Discussion

Older people have technological, emotional, social, and administrative requirements for AR systems and telepresence robots.

Specific requirements for an AR system were related to the technology fulfilling the need for warmth and intimacy during communication while conveying others through realistic avatars. This is in line with studies by Lee et al. [12] and Puri et al. [25] showing AR can provide older people with an emotionally rich communication experience and stressing older adults' preference of realistic avatars to represent themselves.

Since older adults were already familiar with the type of mediated communication provided by a telepresence robot (videoconferencing) their requirements were connected to the robot's appearance (size and anthropomorphism), the ease to control it, and the feeling of empowerment associated to its use. Accordingly, previous research has determined that the use of technology for communication purposes gives older adults a feeling of empowerment and control over their lives [26].

The most common general requirements were ease of use and social functions: Older people prefer technologies that are intuitive and allow for virtual social activities they can share with loved ones. On the other hand, two obstacles for technology acceptance still remain: privacy and data protection issues as well as affordability.

The scope of the requirements presented in this study confirms the importance of adapting technologies to their users and avoiding "one-size-fits-all" solutions as suggested in previous research [8, 9]. Older people recognize the potential of innovative technologies for social integration, but developers need to include this target group in the early stages of design in order to discover and address issues that can deter technology acceptance in the older generation.

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