Exploring Mediated Communication with Older Adults: Comparing AR Avatars, Telepresence Robots, and Face-to-Face Interaction

Stephanie Arevalo Arboleda
Birmingham City University
Birmingham, United Kingdom
stephanie.arboleda@bcu.ac.uk

Jakob Hartbrich
RWTH Aachen University
Aachen, Germany
hartbrich@ient.rwth-aachen.de

Florian Weidner
Glasgow University
Glasgow, United Kingdom
fweidner@sigchi.org

Melisa Conde
Media Psychology and Media Design
Technische Universität Ilmenau
Ilmenau, Thüringen, Germany
melisa.conde@tu-ilmenau.de

Veronika Mikhailova
Media Psychology and Media Design Group
Technische Universität Ilmenau
Ilmenau, Germany
veronika.mikhailova@tu-ilmenau.de

Felix Immohr
RWTH Aachen University
Aachen, Germany
immohr@ient.rwth-aachen.de

Söhnke Benedikt Fischedick
Neuroinformatics and Cognitive Robotics
Technische Universität Ilmenau
Ilmenau, Germany
soehnke.fischedick@tu-ilmenau.de

Bea Vorhof
Virtual Worlds and Digital Games Group
Technische Universität Ilmenau
Ilmenau, Germany
bea.vorhof@tu-ilmenau.de

Christoph Gerhardt
Virtual Worlds and Digital Games Group
Technische Universität Ilmenau
Ilmenau, Germany
christoph.gerhardt@tu-ilmenau.de

Kay Richter
Neuroinformatics and Cognitive Robotics
Technische Universität Ilmenau
Ilmenau, Germany
kay.richter@tu-ilmenau.de

Christian Kunert
Virtual Worlds and Digital Games Group
Technische Universität Ilmenau
Ilmenau, Germany
christian.kunert@tu-ilmenau.de

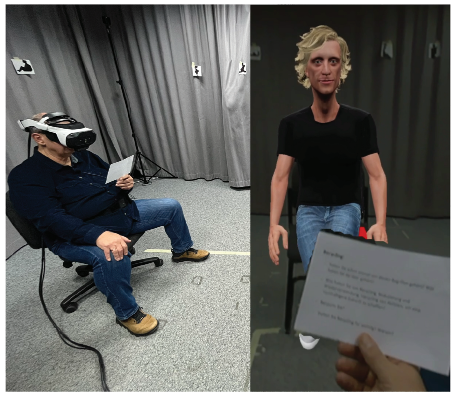
Nicola Döring
Media Psychology and Media Design Group
Technische Universität Ilmenau
Ilmenau, Germany
nicola.doering@tu-ilmenau.de

Horst-Michael Gross
Neuroinformatics and Cognitive Robotics
Technische Universität Ilmenau
Ilmenau, Germany
horst-michael.gross@tu-ilmenau.de

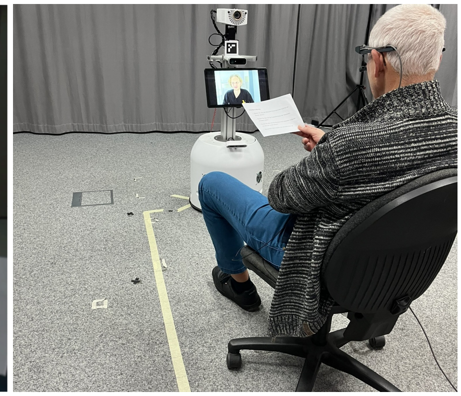
Wolfgang Broll
Virtual Worlds and Digital Games Group
Ilmenau University of Technology
Ilmenau, Germany
wolfgang.broll@tu-ilmenau.de

Alexander Raake
RWTH Aachen University
Aachen, Germany
raake@ient.rwth-aachen.de

(a) Conversation in F2F



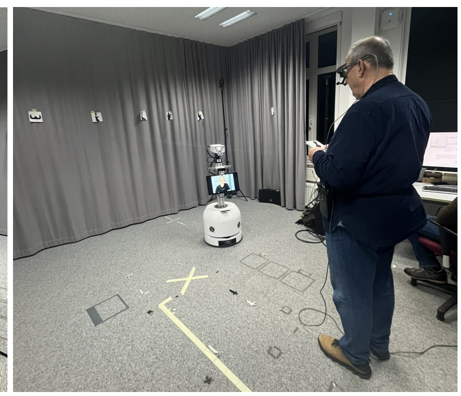
(b) Conversation in AMC



(c) Conversation in RMC

(d) Collaboration in F2F

(e) Collaboration in AMC



(f) Collaboration in RMC

Figure 1: Conversation (a–c) and collaboration tasks (d–e) with the confederate represented in face-to-face (a, d) as an avatar (b, e) or using a telepresence robot (c, f).

Abstract

Older adults, a growing demographic, face an increased risk of experiencing loneliness and are less exposed to emerging communication technologies. Augmented reality (AR) avatars and telepresence robots have been proposed as tools to foster social connection, yet their suitability for older users remains underexplored. We present an exploratory study with ten healthy older adults who engaged in both conversational and spatial collaboration tasks using AR avatar-mediated communication, robot-mediated communication, and face-to-face interaction. We collected self-reported measures of co-presence, social presence, closeness, uncanny valley, preferences, and open feedback. Our findings suggest that telepresence robots enhanced co-presence, while avatars were valued for their expressivity and humanlike qualities. Task type influenced co-presence in spatial collaboration only during communication using the telepresence robot. Other measures, such as social presence and closeness, were unaffected by task type or representation. While neither technology outperformed face-to-face interaction, both were positively received, underscoring their potential to address the social needs of older adults and highlighting the importance of enhancing nonverbal expressivity, particularly nonverbal cues in mediated communication. Ultimately, our results contribute to the fundamental understanding of mediated communication with older adults, motivating further empirical work to confirm and extend these findings.

CCS Concepts

• **Human-centered computing → Mixed / augmented reality**; **User studies**; • **Computer systems organization → Robotics**.

Keywords

Telepresence Robot, Avatar, Augmented Reality, Communication, Co-presence, Social Presence, Uncanny Valley, Nonverbal Behavior, Older Adults

IMX '26, Athlone, Ireland

ACM ISBN 979-8-4007-2448-0/26/06
https://doi.org/10.1145/3788851.3805002

ACM Reference Format:
Stephanie Arevalo Arboleda, Jakob Hartbrich, Florian Weidner, Melisa Conde, Veronika Mikhailova, Felix Immohr, Söhnke Benedikt Fischedick, Bea Vorhof, Christoph Gerhardt, Kay Richter, Christian Kunert, Nicola Döring, Horst-Michael Gross, Wolfgang Broll, and Alexander Raake. 2026. Exploring Mediated Communication with Older Adults: Comparing AR Avatars, Telepresence Robots, and Face-to-Face Interaction. In *ACM International Conference on Interactive Media Experiences (IMX '26), June 09–11, 2026, Athlone, Ireland.* ACM, New York, NY, USA, 13 pages. https://doi.org/10.1145/3788851.3805002

1 Introduction

The global demographic shift toward an aging population presents significant challenges and opportunities for technology design. Older adults represent a large and diverse population group with varying technology usage patterns and distinct requirements [5, 27]. Enriching the lives of this demographic through technology is increasingly important, as it can help address many age-related challenges and enhance quality of life and independent living [22, 56].

Older adults often require assistance with problem-solving and information-finding tasks, which can become more challenging due to age-related changes [15, 56]. As people age, they experience physical and cognitive decline, limited mobility, and shrinking social networks, which collectively increase their risk of loneliness [27]. Thus, exploring technologies beyond video calls, such as telepresence robots and Augmented Reality (AR) that can facilitate connecting older adults with their family and friends and allow easy access to practical support, becomes essential. Especially, as they can help to understand older adults' impressions of using these technologies for communication.

While traditional communication technologies such as phone calls, text messages, and video chats can moderate the effects of experiencing loneliness [13, 68], they offer limited modalities for interaction [43]. Additionally, while offering support via collaboration (working together to achieve a common goal) is possible, efficient joint problem-solving is cumbersome with them. Providing efficient support, including deictic gestures, is hardly possible but often required for solving common household problems (e.g., finding glasses). Here, Avatar-Mediated Communication (AMC) via Augmented Reality (AR) and Robot-Mediated Communication, (RMC) using telepresence robots promise richer communication.

Both AMC and RMC have the potential to bring older adults together with their social ties. Individually, these technologies have been shown to successfully evoke feelings of social presence ("sense of being with another" [11]) and co-presence ("being in the company of others" [11]) for remote conversational partners [3, 51]. However, each approach offers distinct functional advantages and challenges (i.e., physicality, tangibility, and expressivity), and compares differently to Face-to-Face (F2F) communication. For example, telepresence robots can offer physicality, tangibility, and high-resolution video of the face, while AR avatars can provide an expressive humanlike appearance with arm and hand gestures [6].

In this paper, we explore AMC and RMC with older adults. We investigate how these technologies support both conversational interaction and collaboration (working together and offering support through referential communication via a Tangram task [20]) and compare them with F2F interaction. Focusing on the perception of older adults, we are guided by the research question (RQ): *How do older adults perceive the communication experience in terms of social presence, co-presence, closeness, and uncanniness, during avatar- and robot-mediated communication compared to F2F experiences?* To answer this question, we collected self-reported measures of co-presence, social presence, closeness, uncanny valley, general preferences, and the physical distance to the conversational partner (proximity).

Our exploratory study represents the first direct comparison between F2F, AMC, and RMC for older adults, a significantly underrepresented user group in technology research, despite constituting a large portion of the population. Furthermore, we provide the first investigation of how different communication tasks perform across these modalities, investigating their strengths and weaknesses. While previous research has explored older adults' preferences regarding robot anthropomorphism [47, 71] and avatar realism [9, 60], limited efforts [6, 59] have investigated how these technologies compare and perform when evaluated against each other and traditional F2F interaction. This comparison is crucial, as it directly addresses the relationship between the practical needs of our aging society and the rapid advancement of communication technologies, which, if left unaddressed, risk further marginalization of older adults and widen the already existing digital divide [73].

Our core contributions and main findings can be summarized as follows:

- Our findings suggest that both AMC and RMC are well-perceived by older adults across tasks; co-presence with telepresence robots is more variable, requiring careful design to maintain consistency.
- Older adults slightly favor AMC and consider transmission of nonverbal behaviors in both AMC and RMC essential, especially body movements and gestures.

The results highlight the importance of inclusive technology design for older adults by addressing their unique needs in digital communication, and they motivate further empirical work with larger samples to confirm and extend these findings.

2 Related Work

2.1 Avatar-Mediated Communication (among Older Adults)

Avatars, digital representations of individuals in virtual environments, have been widely researched across application domains [74] and shown to enhance users' sense of social presence, emotional involvement, and interpersonal connection during mediated communication [4, 67]. Beyond these benefits, avatars also offer users the flexibility to express or suppress certain physical and psychological traits [14] and to fulfill psychological needs such as warmth, closeness, and intimacy [29]. In contexts where F2F interactions become problematic, communicating via avatars can meaningfully enhance older adults' feelings of social connectedness, social presence, and foster deeper social participation [9, 42, 51, 76].

Although older adults are frequently stereotyped as feeling indifferent about new technologies [48], growing evidence suggests that many are open to avatar-mediated communication [49]. An important predisposition is for the facilitating technology to be designed with their needs, preferences, and abilities in mind [45]. When given access to age-inclusive, user-friendly interfaces, older adults are not only able to successfully engage with avatars but can also experience substantial emotional and social benefits [44].

A key determinant of their experience, however, lies in the avatars' appearance and behavior. These factors have been closely related to the uncanny valley effect [52]. Older adults generally prefer avatars that look and behave in a humanlike manner, with realistic appearances and naturalistic movement patterns [8, 50]. Close resemblance between the avatar and the person it represents can also shape older adults' willingness to engage with technology. Many feel more comfortable interacting with realistic [50] and photorealistic avatars [8], especially when communicating with familiar individuals, such as family members and friends [49, 72].

Nonverbal communication cues, such as posture, gesture, body movements, and other forms of body language, can enhance the perceived quality and authenticity of virtual humans and avatar-mediated communication [6, 25]. Gestures, in particular, have been shown to foster mutual understanding and increase engagement of older adults during virtual exchanges [9]. These cues help simulate the richness of F2F interaction, making virtual conversations feel more natural and emotionally resonant [61]. Older adults express a desire for expressive humanlike communication in social virtual reality, especially regarding how the avatar behaves and the extent to which this behavior matches human behavior expectations (behavioral anthropomorphism) [8].

The capacity to display facial expressions of avatars is another important consideration. Currently, accurately representing emotions in avatars remains a persistent technical challenge, particularly in systems that rely on Head-Mounted Displays (HMDs), where limitations in facial tracking and therefore rendering of face expressions hinder the avatars' ability to convey subtle emotional cues [78]. Given that older adults consistently report that emotionally expressive avatars are vital for fostering higher social presence and intimacy [49, 72], addressing these technical limitations remains a central goal for future development, as researchers and designers seek to create avatar systems that support meaningful and emotionally fulfilling communication for aging populations.

2.2 Robot-Mediated Communication (among Older Adults)

RMC is human-human communication where one conversational partner is audiovisually telepresent and has the ability to move in the remote physical space in real-time using a telepresence robot [39]. It has been found that RMC facilitates participation in everyday routines, evokes feelings of sharing a home, connection, helpfulness, and companionship [77]. Telepresence robots are being increasingly used to promote healthy aging and to foster the social well-being of older adults [18, 28]. For instance, Baisch et al. [7] found that a telepresence robot was perceived as a valuable device if participants considered that the robot's features match their particular psychosocial needs, e.g., social support and life satisfaction. They can contribute to the social integration of older adults (especially in maintaining social contacts) [53, 55]. Robot technology could also be an interface that easily connects older adults to their social networks (relatives, friends, healthcare workers, etc.) [5, 16]. We advance this field by evaluating the use of telepresence robots in both communication and collaborative tasks with older adults.

Older adults demonstrated a willingness to use technology when the goal offers assistance for their independent living [17]. For instance, older adults were optimistic that a telepresence robot would give them a high perception of social presence when talking to their loved ones via RMC [21]. Moyle et al. [53, 54] found that older adults with dementia experience social presence, a sense of authenticity, and social connection when using a telepresence robot to communicate with family caregivers and health professionals. However, when investigating communication and social interaction, anthropomorphic robots (which contrast to the limited anthropomorphic features of a telepresence robot) have often been used to investigate social and co-presence, with findings pointing to the influencing factor of nonverbal behavior on co-presence [1]. These studies show the potential of RMC to evoke positive communication experiences and evoke social presence, especially to connect with family and friends. Our work continues this by contrasting these results and the use of telepresence robots(limited anthropomorphism) to avatars and F2F communication.

The uncanny valley effect has been studied at length in the context of robot design. Some studies show that older adults' perception of robots may differ from the younger population. Mara et al. [46] found that human likeness is associated with positive responses when a robot's appearance displays low to medium anthropomorphism. However, it has been found that older adults tend to prefer humanlike robots regardless of their use [71]. Hence, finding a mid-point is crucial when designing and using telepresence robots to avoid falling into the "uncanny valley of telepresence", which is characterized by a decline in the sense of belonging when the telepresence experience resembles too much the one when in F2F (physical presence) [41].

Closely related to anthropomorphism, nonverbal behaviors are crucial in communication and facilitate human-robot interactions [37]. Older adults perceive robots positively when they display nonverbal behaviors (gestures, blinks, and body movements) and have mentioned that they aid in building trust [66]. Here, moving robots are also perceived as more humanlike compared to static robots [46], especially for older adults. When interacting with a telepresence robot, it has been found that subtle robot movements that emulate human body movements can increase feelings of closeness to the conversational partner during RMC [19]. These findings highlight the role of nonverbal behaviors in RMC, especially when aiming to support and connect older adults with their family members and friends.

In summary, related work shows that both AMC and RMC are valid as mediated-communication technologies for older adults. However, telepresence robots differ from AR avatars through their physical embodiment and fidelity of communication cues. While AR avatars have improved in animation and rendering, they remain virtual and intangible. Robots, in comparison, are physically present and unaffected by limitations such as rendering latency or field-of-view constraints. In addition, most robots feature relatively small screens that display only a partial, two-dimensional view of the remote partner. Avatars, on the contrary, can represent full-body photorealistic animated 3D humans. This trade-off becomes salient in collaborative tasks: Tasks that, for example, require spatial interaction (e.g., pointing, moving) might benefit from the expressivity and movement capabilities of avatars, while conversational tasks may benefit from the low-latency, high-resolution video of the telepresence robot. Thus, both modalities support different aspects of remote communication. In this work, we examine their respective affordances and reflect on whether avatars or robots are better suited for specific communication or collaborative scenarios.

3 User Study

We present a 2×3 within-subjects exploratory study (6 conditions) to investigate the perception of the type of representation (avatar and telepresence robot) of a conversational partner for older adults and contrast it to F2F interaction using two different types of communication tasks: guided conversation (conversation) and collaborative referential communication (collaboration). We collected subjective impressions on the communication experience through questionnaires and "free-text" feedback. We balanced the order of the conversation topics per type of representation following a Graeco-Latin distribution, and the type of task and type of representation using a balanced Latin Square.

In our study, the conversational partner was a trained confederate, who was one of the experimenters and had already acted as such in similar mediated communication experiments [6]. Participants interacted with the confederate in F2F, through a personalized AR avatar, and a telepresence robot.

3.1 Participants

The study sample included N = 10 healthy older adults between 66 and 78 years of age (M = 72.1, SD = 3.8, 5 self-identified as men, 5 as women). The recruitment was done among older adults who had taken part in previous technology-related studies. The participation was voluntary, and no monetary compensation was given. Participants filled out the affinity to technology interaction (ATI) scale (6-point Likert scale, "1-completely disagree," "6-completely agree") [30]. This scale assesses the tendency to actively engage in intensive technology interaction or avoid it. The ATI scores (M = 4.23, SD = 1.18) fall slightly above the 3.5 scale midpoint, indicating a moderately high tendency to engage in intensive technology interaction.

This study was pre-approved by the university's ethical committee and carried out following the guidelines of the national research organization and the Declaration of Helsinki.

3.2 Task

In our experiment, we used a guided conversation task, where each participant was sitting in front of the confederate, and a collaborative spatial communication task, where each participant was standing while the confederate was walking in the room. Each task lasted 4 minutes. Figure 1 illustrates the setup.

For the guided conversation task, we provided different topics and suggested possible questions in a written manner. The topics included recycling (e.g., "What do you think about recycling?"), work-life balance (e.g., "What do you think about the balance between work and free time?"), and healthy eating habits (e.g., "Do you think that people eat healthier today compared to 100 years ago?"). These topics have been used in other similar mediated communication studies [31]. Participants could freely choose whether to use the provided questions, and the confederate frequently asked follow-up questions to maintain the conversational flow and avoid silences that can arise when interacting with strangers (in this case, the confederate).

Spatial collaborative communication requires partners to collaborate to locate objects in their common space by exchanging information and using referential communication to establish a common understanding when referring in conversations [20]. Tangrams (polygons that form shapes) [65] have been commonly used to explore referring dynamics. In this type of communication task, each conversational partner has a role as a "director" or "matcher." Directors, in our case, the participants, give verbal descriptions, while matchers, in our case, the confederate, listened to the description and pointed at the image they considered the director was referring to. As we added movement to this task, we displayed 17 tangrams around a room and the confederate walked around the room looking for the image that would match the description, while the participant would stand, see Figure 1. We instructed participants to give further descriptions if the confederate did not guess the tangram right the first time. The confederate was instructed to walk around the room after describing each tangram.

3.3 Procedure

The experiment lasted between 90 and 120 minutes (many older adults needed a longer time to reply to questionnaires and took their time writing feedback about each system). An experimenter remained in the room with the participant to operate the devices throughout the study. First, participants were welcomed and given a short introduction about the experiment, equipment to be used (HMD, eye tracker, telepresence robot). Second, they signed a consent form, provided demographic information, and filled out a questionnaire regarding their affinity to technology. Third, a calibration process was performed on each device before. This step was repeated for each condition. Fourth, participants received the task in a written form, were given time to read the questions, and sat in a chair. They were informed that the conversational partner would arrive either using a telepresence robot, an avatar, or in person (depending on the condition). For the conversation task, once the confederate reached an initial position, participants were informed that they could move closer or further from the confederate. After each condition, participants filled out a questionnaire about their experience and provided open feedback about AMC and RMC in written form, all on a computer.

3.4 Measures

We collected subjective impressions of the communication experience using self-reported measures that have already been translated and validated in the German language or used in other studies in the German language. We also marked the physical distance between participants and the confederate during the conversation task for the three types of confederate representations, to better understand if participants feel inclined or not to move towards a specific representation of the confederate. Furthermore, participants wore an eye-tracker during F2F and RMC. The analysis of the gaze data is not included in this paper.

We considered the dimension of co-presence ("being in the company of others") (6 questions, 7-point Likert scale from "1-Strongly Disagree" to "7-Strongly Agree") from [12] and measured social presence ("being with another") with an adapted Social Presence scale from [58] (5 questions, 5-point Likert scale), self-translated to German for this study. For closeness, we used the Inclusion of Others in the Self questionnaire, similar to [19], one question using a pictorial representation of the self and the other on a 1-7 scale ("1-no overlap", "2-little overlap", "3-some overlap", "4-equal overlap", "5-strong overlap", "6-very strong overlap", "7-most overlap"). We used these two questionnaires to determine if both co-presence and social presence are affected differently by the type of representation of the conversational partner.

After the AMC and RMC condition, participants additionally rated the uncanny valley effect using the semantic differential from Ho & McDorman [40] in German [69]. After the AMC condition, we asked participants to rate the avatar's appearance ("The appearance of the person you interacted with face-to-face is similar to the appearance of the avatar you saw.") on a 7-point Likert scale ("1-Strongly Disagree" to "7-Strongly Agree"). Additionally, we asked participants to give open feedback about each type of representation in written form and explain the reasoning behind their preference ranking.

The questionnaire data were analyzed using Aligned Rank Transform (ART) [26] when the normality assumption was not met. When normality was met, we used a two-way ANOVA. We assessed normality by visual inspection using QQ-plots and Shapiro-Wilk tests. If significant differences were detected (alpha level of 5%), we calculated post-hoc pairwise comparisons using ART-C and Bonferroni correction.

Written feedback was analyzed using Thematic Content Analysis (TCA) following Anderson's approach [2]. Two researchers analyzed the data separately, provided codes, and converted them into themes. Then, these themes were contrasted and rated by another researcher who combined and wrote the final themes. We established the criterion for relevancy that at least five different participants (half of our sample) should have mentioned the same aspect.

3.5 Apparatus

3.5.1 Robotic Platform. We used a customized telepresence robot (MetraLabs TORY[1]) by adding additional sensors and actuators as described in [Anonymized for review].It enables conversations between a remote and a local party, by providing a self-hosted video conferencing system based on WebRTC and has been used in other studies [Anonymized for review]. The video stream from the robot side is captured by a Microsoft Azure Kinect[2]. To ensure high-quality audio and clear communication, we used a Rode Wireless GO II microphone. Highlighting things in the environment is enabled by projecting a black image with a green dot from the LG HF60LS Largo 2.0[3] projector, which can be panned and tilted by the FLIR PTU E46[4]. This allows for keeping a target highlighted while moving the robot's camera. The video stream of the remote user is captured by a Logitech Brio Stream[5] webcam, attached to a desktop PC.

Moving the robot could be done by using the right and left arrow keys to turn, and the down and up arrow keys to drive backward and forward. To use the projector and highlight (pointing) specific positions, a 3D model of the environment is required. To enable that, we use a PanopticNDT [63] map and leverage the known camera parameters and the 3D map. This allows the translation of the mouse clicks into coordinates in the robot's environment. These are then used as either a driving goal or to highlight targets.

3.5.2 AR System. Our AR system allows bi-directional communication using Photon Fusion and Photon Voice [6]. An overview of the AR System can be found on [Anonymized for Review]. We have developed our system with Unity 2022.3.8f1 using the High-Definition Render Pipeline (HDRP). The conversation partner wore a Varjo XR-3 Head Mounted Display (HMD) and a Logitech H390 headset, while the participant used a Varjo XR-4 utilizing the built-in microphone and loudspeakers. We chose to use SteamVR tracking instead of the HMD's built-in inside-out tracking because it proved more stable in our tests and supported VIVE trackers.

Both persons were visualized as avatars, using head and hand tracking from the HMD and, optionally, VIVE trackers for animation. To allow for full-body tracking with additional finger tracking, the conversation partner used a setup that included the HMD and two VIVE trackers, one for each wrist. The participants only had their heads tracked continuously using the HMD's position and hand tracking when the hands were in the sensor's field of view.

We used Final IK [7] to implement full-body Inverse Kinematics (IK) for the avatars' animation using the aforementioned data. As the hand tracking could be inaccurate, we have moved the targets to a default idle pose in case no tracking is available. The eyes and eyelids were animated using the eye-tracking data collected from the HMD. Lastly, the visemes and corresponding blend shapes were used to animate the lower face. The viseme weights were determined using Oculus LipSync[8].

We recreated the real-world light setup by placing several lights in the scene. To ensure the best image quality, we kept the HMD's white balance, exposure, and ISO in automatic mode.

3.5.3 Avatar Design. We used Character Creator 4 [9] to manually create the avatar. The process began with a detailed analysis of the confederate's physical attributes, including facial structure, body type, and distinctive features (e.g., tattoos), with a strong focus on the actors' proportions. To improve the similarity in proportions, the images of the real person in T-pose were overlaid with images of the avatar in T-pose in an image processing software. The characteristics were replicated within the Character Creator 4 software to create a realistic digital counterpart with high fidelity. The avatar

[1]https://www.metralabs.com/de/tory-rfid-inventurroboter/, Last accessed: 5. May 2025
[2]https://azure.microsoft.com/en-us/products/kinect-dk/, Last accessed: 5. May 2025
[3]https://www.lg.com/de/beamer/portable-und-lifestyle-projektoren/hf60ls/, Last accessed: 5. May 2025
[4]https://www.flir.eu/support/products/ptu-e46/, Last accessed: 5. May 2025
[5]https://www.logitech.com/en-us/products/webcams/4kprowebcam.960-001390.html, Last accessed: 5. May 2025
[6]https://www.photonengine.com/, Last accessed: 16. April 2025
[7]http://root-motion.com/ Last accessed: 16 April 2025
[8]https://developer.oculus.com/documentation/unity/audio-ovrlipsync-unity/, Last accessed: 16. April 2025
[9]https://www.reallusion.com/character-creator/, Last accessed: 14 April 2025

used in this study can be categorized as a realistic look-alike avatar, i.e., humanlike visual and behavioural appearance that may still look synthetic [33] which does not yet reach photorealistic levels (visual and behavioural characteristics that resemble the natural video of an actual person [23]).

Iterative refinements were made to ensure that the avatar's appearance remained consistent under various lighting and interactive conditions, as well as changes over time. The avatar wore a black t-shirt and jeans to match the confederate's clothing during the experiment. To justify the similarity with the avatar, the confederate repeatedly gave feedback on the avatar design.

4 Results

We carried out thematic content analysis of participants' written feedback after each condition. Additionally, we carried out inferential analysis on the collected questionnaire data. For that, we performed a sensitivity power analysis (post-hoc) using G*Power (α = .05, power = .8), which indicates that with our sample size, we could reliably detect effect sizes of at least Cohen's f = 0.34 (medium to large). Smaller effects have to be interpreted with caution.

4.1 Thematic Content Analysis

The participants' verbatim (originally in German) are coded in the following manner: "RC" for telepresence Robot and Conversation, "RT" for telepresence Robot and Collaboration/Tangrams, "AC" for Avatar and Conversation task, and "AT" for Avatar and Collaboration/Tangrams. Our analysis resulted in three main themes:

- Transmission of nonverbal behavior,
- Perceived realism and naturalness, and
- Social Presence and Closeness.

4.1.1 Transmission of Nonverbal Behaviors. This theme contains aspects related to nonverbal behaviors when interacting with the confederate through an avatar (10 mentions: 6 during conversations, 4 during collaboration) or a telepresence robot (6 mentions: 3 during conversation and 3 during collaboration).

For AMC, six participants mentioned nonverbal behaviors during conversation and four during collaboration. Seven participants mentioned movements (e.g., AC4 commented "the avatar should make even more natural movements"). AC8 emphasized "Unnatural eye movements". Regarding posture, AC6 said, "Some postures, especially the arms were a little bit irritating;" and PC10 commented on gestures: "Conversation was good and the gestures were understandable".

Regarding RMC, six participants mentioned characteristics related to the transmission of nonverbal behaviors during conversations (3 mentions) and collaboration (3 mentions). The participants mentioned aspects such as: movements (2 mentions; RT8: "The movements of the robot could be more fluid;"), eye contact (1 mention; RT7: "In spite of the limited movement, the eye contact was important and pleasant"), gestures (1 mention; RC9: "The gestures and the speech are somewhat distorted"), and facial expressions (2 mentions; RC3: "I could clearly see the face and the gestures").

4.1.2 Perceived Realism and Naturalness. This theme gathers participants' perceptions related to how natural or realistic the interaction with the confederate using an avatar (8 mentions: 6 during conversations and 2 during collaboration) or a robot (7 mentions: 4 during conversations and 3 during collaboration).

In AMC, most participants emphasized the naturalness and expressiveness during communication, while one participant mentioned that it was artificial. For instance, AT4 said, "It is more expressive than just talking on the phone or on videoconferencing,". PC1 added, "it is very realistic, the person sat almost identically in front of me."

With respect to RMC, participants mentioned that the robot is perceived as an object, different from a F2F experience, and not personal. Participants mentioned: RC7, "the robot is still a technical aid," and RT9, "It is different from in-person contact."

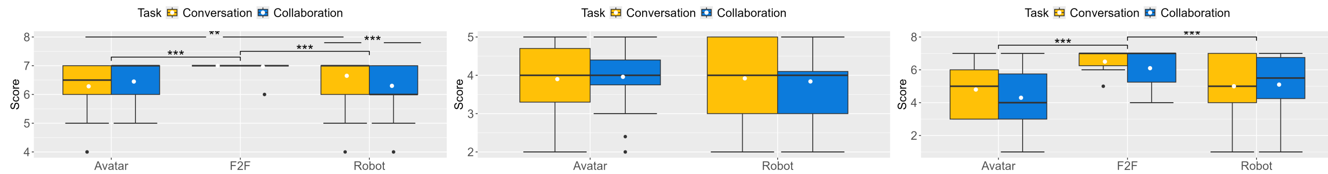
4.1.3 Social Presence and Closeness. This theme contains subthemes related to social presence or closeness to the confederate. Here, five participants (3 during the conversation, 2 during collaboration) mentioned that aspect when interacting with an avatar, e.g., AT3 commented, "I could feel his immediate proximity," and AC6 added, "at times I forgot it was an avatar." Two participants (1 during collaboration, 1 during conversations) mentioned a similar aspect when using a telepresence robot, e.g., RT3 mentioned "I felt a certain closeness to the robot, it is humanlike," however, RC8 said, "it was impersonal."

4.2 Statistical Analysis

4.2.1 Co-presence. Figure 2a illustrates results on co-presence. Our results show significant differences for the type of representation (F(2,345) = 72.04, p <.001, η_p^2 = .29), type of task (F(1,345) = 17.06, p <.001, η_p^2 = .05) and a two-way interaction effect (F(2,345) = 12.06, p <.001, η_p^2 = .07).

Regarding type of representation, post-hoc pairwise comparisons show that F2F (M = 6.98, SD = 0.13, 95% CI [6.96, 7.00]) led to higher scores in co-presence compared to the robot (M = 6.48, SD = 0.70, 95% CI [6.34, 6.60]), (p <.001) or avatar (M = 6.37, SD = .83, 95% CI [6.21, 6.51]), (p <.001). In terms of the type of task, our results show that higher co-presence was experienced when conversing (M = 6.64, SD = .70, 95% CI [6.54, 6.71]) compared to the collaboration task (M = 6.57, SD = .67, 95% CI [6.47, 6.67]), (p <.001). The interaction effects of task and type of representation derive mostly from the main effects, i.e., during conversations and collaboration, F2F leads to higher co-presence than interacting with an avatar or a robot. However, conversing with the confederate using a telepresence robot (M = 6.65, SD = .61, 95% CI [6.49, 6.80]) leads to higher co-presence when compared to an avatar (M = 6.28, SD = .92, 95% CI [6.04, 6.52]), (p = .002). Additionally, our results point to an effect of task for RMC, where conversing led to higher perceived co-presence compared to collaboration (M = 6.3, SD = .74, 95% CI [6.10, 6.49]), (p <.001).

4.2.2 Social Presence . We also compared the reported social presence during mediated communication (cf. Figure 2b). Our results did not yield significant effects of task (F(1,9) = .01, p = .92, η_p^2 <.001), type of representation (F(1,9) = .04, p = .85, η_p^2 <.001) or interaction effects (F(1,9) = .43, p = .53, η_p^2 <.001). We did not collect measures of social presence for the F2F condition, as the questionnaire used was developed specifically for mediated communication.



(a) Co-presence **(b) Social presence** **(c) Closeness**

Figure 2: Influence of confederate's type of representation and type of task, where F2F led to the highest scores compared to the other two representations. The white dot on the boxplot indicates the mean.

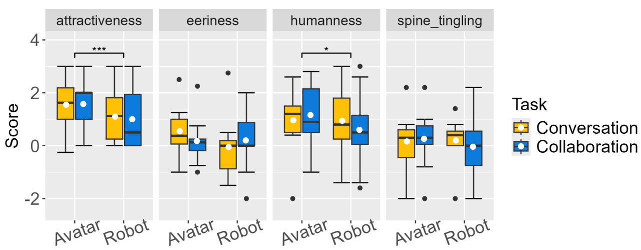


Figure 3: Uncanny Valley's dimensions with significant differences for the type of representation. The white dot on the boxplot indicates the mean.

4.2.3 Closeness. We found a significant difference for type of representation (F(2,45) = 11.41, p <.001, η_p^2 = .34, see Figure 2c), where communicating in F2F (M = 6.30, SD = 1.08, 95% CI [5.79, 6.80]) led to higher reported closeness compared to an avatar (M = 4.55, SD = 1.82, 95% CI [3.69, 5.40]), (p <.001) or a robot (M = 5.05, SD = 1.96, 95% CI [4.13, 5.96]), (p = .009). We did not find other significant differences for the type of tasks (F(1,45) = .10, p = .75, η_p^2 = .002) or a two-way interaction effect (F(2,45) = .26, p = .77, η_p^2 = .01).

4.2.4 Uncanny Valley. We compared the perception of the uncanny valley for the representation of the confederate using a robot and an avatar. The results of the four dimensions of the uncanny valley can be seen in fig. 3 and are described in detail in the following.

Attractiveness. We found a significant main effect of type of representation (F(1,147) = 40.77, p <.001, η_p^2 = .22). We did not find significant effects of type of task (F(1,147) = .45, p = .50, η_p^2 = .003) or two-way interaction (F(1,147) = .37, p = .54, η_p^2 = .002).

Our results indicate that the participants perceived the confederate represented using an avatar (M = 5.56, SD = .95, 95% CI [5.35, 5.77]) to be more attractive compared to the robot (M = 5.06, SD = 1.09, 95% CI [4.80, 5.29]).

Humanness. Our results show a significant main effect of the type of representation (F(1,147) = 4.49, p = .04, η_p^2 = .02). We did not find significant effects of the type of task (F(1,147) = .66, p = .41, η_p^2 = .003) or a two-way interaction (F(1,147) = 3.56, p = .06, η_p^2 = .02).

Participants perceived the avatar to be more human (M = 5.06, SD = 1.42, 95% CI [4.77, 5.34]) than the robot (M = 4.77, SD = 1.60, 95% CI [4.45, 5.08]), (p = .02).

Eeriness and Spine-tingling. In regards to eeriness, we did not find any significant difference for type of task (F(1,147) = .19, p = .65, η_p^2 = .001), type of representation (F(1,147) = 2.27, p = .13, η_p^2 = .01) or two-way interaction effect (F(1,147) = 2.08, p = .15, η_p^2 = .01).

With regard to spine-tingling, we did not find any significant differences either for type of task (F(1,147) = .28, p = .6, η_p^2 = .001), type of representation (F(1,147) = 2.66, p = .10, η_p^2 = .01) or two-way interaction (F(1,147) = 2.70 p = .10, η_p^2 = .01).

4.2.5 Preferences, Physical Distance, and Ranking. After interacting with the robot and the avatar, we asked participants to rank their preferred type of confederate representation. Seven participants reported AMC as their preferred confederate representation, while three reported RMC as their preferred representation. Participants mentioned: P7, "The avatar's movements are still very wonky, but you see it more as a human being. The robot may have had a human face, but it remains a technical device." P6 added, "Personal closeness can hardly be replaced. The avatar at least offers certain similarities, but the robot is always recognizable as a technical system."

We also asked about the similarity between the confederate's avatar and the real person during each task. For both tasks, the average rate was "somewhat similar" to the real person, i.e., for the conversation task, the avatar was sitting in front of participants (M = 5.4, SD = 1.07), and for collaboration, the avatar was walking and pointing (M = 5.1, SD = 1.29).

Regarding the distance between participants and the confederate during conversations. Our results using a Kruskal-Wallis test show that there are no significant differences between the types of representation ($\chi^2(2)$ = 2.68, p = .26). The initial distance was set at 190 cm.

5 Discussion

Reducing social isolation and providing easy support are central to increasing older adults' quality of life. The study's results draw a positive picture of both communication media in general, and when compared to face-to-face communication. Feedback on co-presence, social presence, and closeness was positive, with nuanced aspects (and criticism) of the robot and the avatar in the qualitative feedback. As this study involved a small sample (N = 10), the results are best understood as exploratory, offering first insights into older adults' perceptions of avatars and robots in mediated communication. The patterns observed here motivate further empirical work with larger samples to confirm and extend these findings. Nonetheless, our study offers a direct comparison of mediated communication with technologies (an AR avatar and a telepresence robot), which are novel or unfamiliar to most older adults.

5.1 Avatars or Robots?

Our results show that communication using a telepresence robot and an avatar can lead to high levels of co-presence ("being in the company of others"), social presence ("being with another"), and closeness. These findings are encouraging and build upon studies that found rather high levels of social presence for older adults in AMC [51] and in RMC for older adults with dementia [53, 54]. Our findings strengthen this empirical basis.

Our TCA (Section 4.1.3) revealed nuances. Participants mentioned experiencing aspects related to being together, such as "feeling proximity" or "like F2F" only when interacting with the avatar. That is despite the high-resolution video and the robot's physicality (a real entity moving in the physical space and pointing at real objects). We attribute this to the high behavioral fidelity, i.e., more head, arm, and hand movements, of the avatar, which provided a closer experience to F2F compared to the telepresence robot, which was still perceived as being a "technical device" carrying the confederate rather than representing him. Still, having a conversation using a telepresence robot led to higher reported co-presence compared to having a conversation using an avatar (but only in the guided conversation task, not in the collaboration task). We consider that this could be a result of familiarity bias or the mere exposure effect [34], i.e., having a conversation with someone through a screen is an experience that participants may have experienced, witnessed or heard of in the media, which may have influenced the higher ratings for co-presence.

Together, this indicates that while both robot and avatar are capable of delivering a satisfactory communication experience and similar levels of closeness, the humanlike appearance and movement of the avatar are factors that older adults value during mediated communication. However, a legacy bias might influence co-presence, favoring the robot.

Beyond that, we also measured the physical distance that participants kept from the confederate during the conversation, as it may have hinted at their perceived co-presence. Participants tended to move closer to the robot compared to the avatar, but our results did not point to significant differences, and this may be a result of other factors, such as the screen's small size. These distances are within the social distance space and are common between non-familiar individuals when interacting in F2F [36] and align with previous findings of mediated communication [57, 75]. We consider this positive, as none of our participants tried to move away from their conversational partner during mediated communication.

Regarding F2F communication, as expected and aligning with other findings [6, 10, 35], our results show that communication in F2F is preferred and leads to the highest co-presence, social presence, and closeness when compared to mediated communication (AMC, RMC).

When comparing AMC, RMC and F2F, it has been found that younger adults report averting attention from nonverbal behaviors that do not achieve F2F levels [6]. Our findings suggest that nonverbal behaviors are also considered crucial for older adults, especially gestures and body movements. Other studies that did not make a direct comparison like ours have also found that gestures, body movements, and facial expressions can help build confidence when communicating with a robot [66] or with virtual agents [61]. Further, in terms of co-presence, we found that older adults can experience higher co-presence conversing in RMC compared to AMC, which may not be the case for younger adults [6]. This encourages further investigation into the factors influencing co-presence in RMC and AMC with older adults, and the reasons behind these differences across demographics.

5.2 Consistency across Tasks

We considered that the structural differences between the two tasks would influence how each communication medium was perceived. The conversation focused on facial expressions, which is where the robot excels through video, and collaboration was goal-oriented and relied more on movement and gestures, aligning with the strengths of the avatar. However, our results were surprising. We found that only in RMC, participants reported a lower co-presence when collaborating compared to having a conversation. There was no significant difference in the avatar condition between conversation and collaboration, despite the limited facial expression (we only had eye tracking and lip synchronization). Considering that the task did not lead to other significant differences in closeness or social presence, this points towards the avatar's potential across tasks.

We assume that two aspects primarily contributed to these results. First, the avatar was able to provide humanlike expressive deictic gestures during the collaboration task. Previous work has shown that kinematic fidelity (the level of accuracy of movement replication of the real person within the space) contributes to high co-presence [32]. Our robot, while being able to point, was not able to perform such expressive gestures, and, by that, did not benefit from this with respect to co-presence. Another factor is that the robot usually turned away from the user when pointing and driving (as the confederate was relying on the front-facing camera to navigate). Thus, most of the time during the collaboration task, the video feed was not visible to the participant, enhancing the perception of it being a technical device.

Our findings on rather high reported co- and social presence, as well as closeness with the avatar in a variety of tasks, suggest that AMC can possibly allow for companionship for older adults. Companionship is not about achieving external goals (such as in our tasks) but rather about enjoying the company of another person and intrinsic rewards, such as shared leisure activities, recreation, or discussing mutual interests. Unlike interactions aimed at problem-solving, these activities are pursued for their own enjoyment [62] So far, achieving companionship for older adults through technology has been explored mostly with robots (for an overview, see [70]). We consider that our findings encourage further a new line of investigation into companionship using avatars or agents for older adults.

5.3 Nonverbal Behaviors in AMC and RMC

The TCA revealed that nonverbal behaviors are crucial during mediated communication for older adults, such as body movements, gestures, eye contact, and facial expressions, Section 4.1.1.

Older adults expressed positive reactions to being able to see facial expressions and some eye contact through the screen of the robot. This aligns with other findings where facial expressions and other nonverbal behaviors are deemed important for older adults in RMC [21] and findings of higher ratings of anthropomorphism if the face of a real person is displayed on a robot [79]. In AMC, only eye movements were mentioned as unnatural, in spite of using eye tracking to display the real eye movements of the confederate. Here, it has been found that avatar perception is affected if eye tracking fidelity does not match human behavior expectations [38]. Further investigation on the required tracking and display fidelity is necessary to guide research and practitioners towards the most effective and efficient solution.

Gestures were mentioned as being recognizable during AMC while distorted in RMC. In our experiment, the hand and finger movements of the confederate were tracked and displayed via the controller, which may have contributed to the preference for AMC [24] and aligns with older adults' valuing behavioral anthropomorphism during communication [8]. To provide the robot with similar capabilities, we added a projector to the robot to simulate deictic gestures. However, moving towards a specific location and then pointing at a specific point with the robot took longer (despite the room-mapping algorithm outlined in Section 3.5.1) and is arguably not very humanlike as pointing in F2F or using an avatar. Overall, this seems not to have been an effective strategy for deictic gestures, leaving room for improvement on how such telepresence robots can efficiently point.

Appropriate body movements were the most mentioned shortcomings in both AMC and RMC. It has been found that robot motion evokes a feeling of human presence [79] and moving robots are rated more humanlike compared to static robots [46]. In our study, participants saw the robot moving towards them to initiate communication and around the room during collaboration, but it was still perceived as requiring improvements in terms of fluid movements. Regarding AMC, body movements in avatars have been mentioned as a requirement to enhance social presence for older adults [49]. However, if the body movement fidelity does not match F2F, this may affect rapport and trust in the conversational partner [64]. This suggests the need to improve arm and hand movements (gestures) for AMC.

All in all, these results emphasize the relevance of nonverbal behaviors in mediated communication for older adults as a path toward media richness that can effectively foster being together at a distance.

5.4 The Uncanny Valley

Our results suggest that for older adults, communicating with an avatar can lead to a higher reported humanness and attractiveness in comparison to communicating with a telepresence robot, with neutral impressions on eeriness and spine-tingling. The subtheme about perceived realism and naturalness (Section 4.1.2) corroborates findings on humanness and attractiveness, as participants deemed the robot to be a "technical device" while emphasizing AMC as enabling expressiveness and being almost like F2F interaction. We consider that the affordances of the type of robot used, i.e., a telepresence robot with limited degrees of freedom and a non-humanoid shape, influenced these results, especially for older adults. Tu et al. [71] found that older adults prefer human-like robots compared to non-humanlike ones in spite of their use case. However, it has been found that the portrayal of robots as humanlike entities in sci-fi literature and movies influences the perception and expectation of robots [47, 49], where robots displaying low to medium anthropomorphic features evoke positive responses [46].

Together, the lower uncanny valley effect of AMC compared to RMC and the perceived realism mentioned in the TCA are influencing factors of older adults' preference for AMC over RMC. The positive assessment of realism and naturalness (Section 4.1.2) aligns with previous findings of older adults preferring realistic avatars [50]. Added to that, Baker et al. [8] emphasized that older adults deem important not only realism but realistic behavioral anthropomorphism (an avatar's ability to move and speak in a humanlike manner). A further contributing factor that favors AMC can be the appearance similarity between the real confederate and the look-alike avatar, which also aligns with findings about older adults' preference for photorealistic avatars (avatars that replicate a real person) [60].

6 Limitations

Our study is exploratory, and we present our findings with caution. Our limited sample size does not allow us to rely only on inferential statistics or derive generalizable results. That is why we capitalize on our qualitative findings and present the statistical analysis to support our claims. However, we consider that studies involving older adults or people with disabilities (participants that may not be easy to recruit) should not be discarded merely based on sample size. They represent a segment of the population that is often overlooked due to recruitment difficulties, which can lead to widening the digital gap and marginalization. Further, studies with small "N" can still be valuable and serve to encourage further investigation, especially with complex setups like the one presented in this paper. Additionally, experiments that include older adults are crucial to better understand older adults' perceptions and can guide the design of future mediated collaboration environments for this demographic group.

We call for a note of caution in our findings as they present perspectives of a group of older adults who live independently, possess formal education, and live in Germany. Older adults are a demographic group with high variability that stems from different health conditions, lifestyles [27], and different levels of openness for new technology adoption [5]. However, we consider that our results provide a picture of a segment of older adults who are interested in using rather novel communication technologies.

Our findings may apply to similar telepresence robots and encourage further investigation considering humanoid robots with videoconferencing capabilities for older adults . Additionally, the inconsistent tracking performance from the devices used, e.g., Varjo XR 4 and Vive trackers highlight the relevance of stable and reliable tracking when interacting with virtual humans.

Our collaboration task is relatively artificial. Further investigations of other tasks (e.g., the confederate acts as the director and the older adult takes on the role of the matcher) will provide further insights into the communication experience. Also, our experimental task was rather short (4 minutes), which does not allow to determine long-term effects of robot or avatar-mediated communication.

An opportunity for future research is to quantify the effect of interpersonal relationships (family/friends or acquaintances) in AMC and RMC. This could help to understand when to enhance mediated communication. In this experiment, we used a confederate to control for the cofounding factor that having different conversational partners may add. However, the confederate was a stranger to all participants, which may have also influenced the perceived communication experience.

7 Conclusion

We present an exploratory study that compares AMC and RMC for older adults for communication and collaboration, and contrasts these findings with face-to-face interaction. Our findings suggest that both AMC and RMC can effectively foster co-presence, social presence, and closeness among older adults, but still do not reach the level of face-to-face communication. Our results highlight aspects that can lead to a preference for avatars among older adults, such as their humanlike appearance and expressiveness. In contrast, telepresence robots, while useful, were perceived more as "technical devices" due to limitations in conveying nonverbal behavior such as gestures and movement. Further improvements in expressiveness are essential to enhance the communication experience, particularly in terms of non-verbal cues such as body movements and gestures. While avatars were slightly preferred in our study, local requirements play a significant role in real-world applications. Factors such as the available space, digital twinning and scene reconstruction are critical considerations. By effectively leveraging both AMC and RMC strengths and integrating our findings into development and research, we can create new opportunities for connection and empowerment for older adults.

Acknowledgments

This research was conducted for the CO-HUMANICS (Co-Presence of Humans and Interactive Companions for Seniors) project funded by the Carl-Zeiss-Stiftung within the "Durchbrüche 2020" program.

References

[1] Luis Almeida, Paulo Menezes, and Jorge Dias. 2022. Telepresence social robotics towards co-presence: A review. *Applied Sciences* 12, 11 (2022).

[2] Rosemarie Anderson. 2007. Thematic content analysis (TCA). *Descriptive presentation of qualitative data* 3 (2007), 1–4.

[3] Stephanie Arévalo Arboleda, Söhnke Fischedick, Chenayo Diao, Kay Richter, Horst-Michael Gross, and Alexander Raake. 2024. An exploratory study on the impact of varying levels of robot control on presence in robot-mediated communication. In *2024 33rd IEEE International Conference on Robot and Human Interactive Communication (ROMAN)*. 83–88. doi:10.1109/RO-MAN60168.2024.10731330

[4] Stephanie Arévalo Arboleda, Christian Kunert, Jakob Hartbrich, Christian Schneiderwind, Chenyao Diao, Christoph Gerhardt, Tatiana Surdu, Florian Weidner, Wolfgang Broll, Stephan Werner, and Alexander Raake. 2024. Beyond Looks: A Study on Agent Movement and Audiovisual Spatial Coherence in Augmented Reality. In *2024 IEEE Conference Virtual Reality and 3D User Interfaces (VR)*. 502–512. doi:10.1109/VR58804.2024.00071

[5] Stephanie Arevalo Arboleda, Melisa Conde, Nicola Doering, and Alexander Raake. 2024. Introducing Personas and Scenarios to Highlight Older Adults' Perspectives on Robot-Mediated Communication. In *Companion of the 2024 ACM/IEEE International Conference on Human-Robot Interaction* (Boulder, CO, USA) *(HRI '24)*. ACM, New York, NY, USA, 5 pages. doi:10.1145/3610978.3640659

[6] Stephanie Arevalo Arboleda, Jakob Hartbrich, Florian Weidner, Söhnke Benedikt Fischedick, Christoph Gerhardt, Kay Richter, Christian Kunert, Bea Vorhof, Horst-Michael Gross, Wolfgang Broll, and Alexander Raake. 2025. Robot, Avatar, or Human: The Impact of Partner Representation and Task on the Communication Experience. *Proc. ACM Hum.-Comput. Interact.* 9, 7, Article CSCW472 (Oct. 2025), 27 pages. doi:10.1145/3757653

[7] Stefanie Baisch, Thorsten Kolling, Arthur Schall, Saskia Rühl, Stefanie Selic, Ziyon Kim, Holger Rossberg, Barbara Klein, Johannes Pantel, Frank Oswald, et al. 2017. Acceptance of social robots by elder people: does psychosocial functioning matter? *International Journal of Social Robotics* 9 (2017), 293–307.

[8] Steven Baker, Ryan M. Kelly, Jenny Waycott, Romina Carrasco, Thuong Hoang, Frances Batchelor, Elizabeth Ozanne, Briony Dow, Jeni Warburton, and Frank Vetere. 2019. Interrogating Social Virtual Reality as a Communication Medium for Older Adults. *Proceedings of the ACM on Human-Computer Interaction* 3, CSCW (2019), 1–24. doi:10.1145/3359251

[9] Steven Baker, Jenny Waycott, Romina Carrasco, Ryan M. Kelly, Anthony John Jones, Jack Lilley, Briony Dow, Frances Batchelor, Thuong Hoang, and Frank Vetere. 2021. Avatar-Mediated Communication in Social VR: An In-depth Exploration of Older Adult Interaction in an Emerging Communication Platform. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems (CHI '21)*. ACM, 1–13. doi:10.1145/3411764.3445752

[10] Jacob T. Biehl, Daniel Avrahami, and Anthony Dunnigan. 2015. Not Really There: Understanding Embodied Communication Affordances in Team Perception and Participation. In *Proceedings of the 18th ACM Conference on Computer Supported Cooperative Work & Social Computing* (Vancouver, BC, Canada) *(CSCW '15)*. ACM, New York, NY, USA, 1567–1575. doi:10.1145/2675133.2675220

[11] Frank Biocca, Chad Harms, and Judee K Burgoon. 2003. Toward a more robust theory and measure of social presence: Review and suggested criteria. *Presence: Teleoperators & virtual environments* 12, 5 (2003), 456–480.

[12] Frank Biocca, Chad Harms, and Jenn Gregg. 2001. The networked minds measure of social presence: Pilot test of the factor structure and concurrent validity. In *4th annual international workshop on presence, Philadelphia, PA*. 1–9.

[13] Vanessa Burholt, Gill Windle, Merryn Gott, and Deborah Jane Morgan. 2020. Technology-mediated communication in familial relationships: Moderated-mediation models of isolation and loneliness. *The Gerontologist* 60, 7 (2020), 1202–1212.

[14] Jean-François Bélisle and H. Onur Bodur. 2010. Avatars as information: Perception of consumers based on their avatars in virtual worlds. *Psychology & Marketing* 27, 8 (2010), 741–765. doi:10.1002/mar.20354

[15] Clara Caldeira, Matthew Bietz, Marisol Vidauri, and Yunan Chen. 2017. Senior Care for Aging in Place: Balancing Assistance and Independence. In *Proceedings of the 2017 ACM Conference on Computer Supported Cooperative Work and Social Computing* (Portland, Oregon, USA) *(CSCW '17)*. ACM, New York, NY, USA, 1605–1617. doi:10.1145/2998181.2998206

[16] Niccolò Casiddu, Amedeo Cesta, Gabriella Cortellessa, Andrea Orlandini, Claudia Porfirione, Alessandro Divano, Emanuele Micheli, and Matteo Zallio. 2015. Robot interface design: The giraff telepresence robot for social interaction. In *Ambient Assisted Living: Italian Forum 2014*. Springer, 499–509.

[17] Amedeo Cesta, Gabriella Cortellessa, Andrea Orlandini, and Lorenza Tiberio. 2016. Long-term evaluation of a telepresence robot for the elderly: methodology and ecological case study. *International Journal of Social Robotics* 8 (2016), 421–441.

[18] Shu-Chuan Chen, Cindy Jones, and Wendy Moyle. 2018. Social robots for depression in older adults: a systematic review. *Journal of Nursing Scholarship* 50, 6 (2018), 612–622.

[19] Mina Choi, Rachel Kornfield, Leila Takayama, and Bilge Mutlu. 2017. Movement Matters: Effects of Motion and Mimicry on Perception of Similarity and Closeness in Robot-Mediated Communication. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems* (Denver, Colorado, USA) *(CHI '17)*. ACM, New York, NY, USA, 325–335. doi:10.1145/3025453.3025734

[20] Herbert H Clark and Deanna Wilkes-Gibbs. 1986. Referring as a collaborative process. *Cognition* 22, 1 (1986), 1–39.

[21] Melisa Conde, Veronika Mikhailova, and Nicola Döring. 2024. "I have the Feeling that the Person is Here": Older Adults' Attitudes, Usage Intentions, and Requirements for a Telepresence Robot. *International Journal of Social Robotics* 16, 7 (2024), 1619–1639.

[22] Kristina M Conroy, Srikripa Krishnan, Stacy Mittelstaedt, and Sonny S Patel. 2020. Technological advancements to address elderly loneliness: practical considerations and community resilience implications for COVID-19 pandemic. *Working with Older People* 24, 4 (2020), 257–264.

[23] Ross Cutler, Babak Naderi, Vishak Gopal, and Dharmendar Palle. 2025. A Multidimensional Measurement of Photorealistic Avatars Quality of Experience. *Proceedings of the ACM on Human-Computer Interaction* 9, 7 (2025), 1–29. doi:10.1145/3757542

[24] Henrique Galvan Debarba, Sylvain Chagué, and Caecilia Charbonnier. 2022. On the Plausibility of Virtual Body Animation Features in Virtual Reality. *IEEE Transactions on Visualization and Computer Graphics* 28, 4 (2022), 1880–1893. doi:10.1109/TVCG.2020.3025175

[25] Nicola Döring, Melisa Conde, Karlheinz Brandenburg, Wolfgang Broll, Horst-Michael Gross, Stephan Werner, and Alexander Raake. 2022. Can communication technologies reduce loneliness and social isolation in older people? A scoping

review of reviews. *International journal of environmental research and public health* (2022).
- [26] Lisa A Elkin, Matthew Kay, James J Higgins, and Jacob O Wobbrock. 2021. An aligned rank transform procedure for multifactor contrast tests. In *The 34th annual ACM symposium on user interface software and technology*. 754–768.
- [27] Olujoke A Fakoya, Noleen K McCorry, and Michael Donnelly. 2020. Loneliness and social isolation interventions for older adults: a scoping review of reviews. *BMC public health* 20 (2020), 1–14.
- [28] Söhnke Benedikt Fischedick, Kay Richter, Tim Wengefeld, Daniel Seichter, Andrea Scheidig, Nicola Döring, Wolfgang Broll, Stephan Werner, and Horst-Michael Raake, Alexander Gross. 2023. Bridging Distance with a Collaborative Telepresence Robot for Older Adults – Report on Progress in the CO-HUMANICS Project. In *ISR Europe 2023; 56th International Symposium on Robotics*.
- [29] Katrina Fong, Joshua A. Quinlan, and Raymond A. Mar. 2023. Select your character: Individual needs and avatar choice. *Psychology of Popular Media* 12, 1 (2023), 30–39. doi:10.1037/ppm0000384
- [30] Thomas Franke, Christiane Attig, and Daniel Wessel. 2019. A personal resource for technology interaction: development and validation of the affinity for technology interaction (ATI) scale. *International Journal of Human–Computer Interaction* 35, 6 (2019), 456–467.
- [31] Kexue Fu, Yixin Chen, Jiaxun Cao, Xin Tong, and RAY LC. 2023. "I Am a Mirror Dweller": Probing the Unique Strategies Users Take to Communicate in the Context of Mirrors in Social Virtual Reality. In *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems* (Hamburg, Germany) *(CHI '23)*. ACM, New York, NY, USA, Article 385, 19 pages. doi:10.1145/3544548.3581464
- [32] Guillaume Gamelin, Amine Chellali, Samia Cheikh, Aylen Ricca, Cedric Dumas, and Samir Otmane. 2020. Point-cloud avatars to improve spatial communication in immersive collaborative virtual environments. *Personal Ubiquitous Comput.* 25, 3 (2020), 467–484. doi:10.1007/s00779-020-01431-1
- [33] Li Gong and Clifford Nass. 2007. When a talking-face computer agent is half-human and half-humanoid: Human identity and consistency preference. *Human communication research* 33, 2 (2007), 163–193.
- [34] Anne Greul, Tim G Schweisfurth, and Christina Raasch. 2023. Does familiarity with an idea bias its evaluation? *Plos one* 18, 7 (2023), e0286968.
- [35] Jonathan Gruber, Eszter Hargittai, and Minh Hao Nguyen. 2022. The value of face-to-face communication in the digital world: What people miss about in-person interactions when those are limited. *Studies in Communication Sciences* (2022), 1–19.
- [36] Edward T Hall, Ray L Birdwhistell, Bernhard Bock, Paul Bohannan, A Richard Diebold Jr, Marshall Durbin, Munro S Edmonson, JL Fischer, Dell Hymes, Solon T Kimball, et al. 1968. Proxemics [and comments and replies]. *Current anthropology* 9, 2/3 (1968), 83–108.
- [37] JingGuang Han, Nick Campbell, Kristiina Jokinen, and Graham Wilcock. 2012. Investigating the use of Non-verbal Cues in Human-Robot Interaction with a Nao robot. In *2012 IEEE 3rd International Conference on Cognitive Infocommunications (CogInfoCom)*. 679–683. doi:10.1109/CogInfoCom.2012.6421937
- [38] Jakob Hartbrich, Florian Weidner, Christian Kunert, Alexander Raake, Wolfgang Broll, and Stephanie Arévalo Arboleda. 2023. Eye and Face Tracking in VR: Avatar Embodiment and Enfacement with Realistic and Cartoon Avatars. In *Proceedings of the 22nd International Conference on Mobile and Ubiquitous Multimedia* (Vienna, Austria) *(MUM '23)*. ACM, New York, NY, USA. doi:10.1145/3626705.3627793
- [39] Susan C Herring. 2016. Robot-mediated communication. *Emerging trends in the social and behavioral sciences: An interdisciplinary, searchable, and linkable resource* (2016), 1–16.
- [40] Chin-Chang Ho and Karl F MacDorman. 2017. Measuring the uncanny valley effect: Refinements to indices for perceived humanness, attractiveness, and eeriness. *International Journal of Social Robotics* (2017).
- [41] Brennan Jones, Yaying Zhang, Priscilla N. Y. Wong, and Sean Rintel. 2021. Belonging There: VROOM-ing into the Uncanny Valley of XR Telepresence. *Proc. ACM Hum.-Comput. Interact.* 5, CSCW1, Article 59 (2021), 31 pages. doi:10.1145/3449133
- [42] Saleh Kalantari, Tong Bill Xu, Armin Mostafavi, Benjamin Kim, Andrew Dilanchian, Angella Lee, Walter R Boot, and Sara J Czaja. 2023. Using Immersive Virtual Reality to Enhance Social Interaction Among Older Adults: A Cross-Site Investigation. *Innovation in Aging* 7, 4 (2023). doi:10.1093/geroni/igad031
- [43] David S. Kirk, Abigail Sellen, and Xiang Cao. 2010. Home video communication: mediating 'closeness'. In *Proceedings of the 2010 ACM Conference on Computer Supported Cooperative Work* (Savannah, Georgia, USA) *(CSCW '10)*. ACM, New York, NY, USA, 135–144. doi:10.1145/1718918.1718945
- [44] K. W. Lau. 2024. Social Virtual Reality as a Solution for Aging Services and Gerontology: Understanding the Older Adults' Acceptance of Virtual Reality Applications. *Advances in Gerontology* 14, 4 (2024). doi:10.1134/s207905702460068x
- [45] Li Na Lee, Mi Jeong Kim, and Won Ju Hwang. 2019. Potential of Augmented Reality and Virtual Reality Technologies to Promote Wellbeing in Older Adults. *Applied Sciences* 9, 17 (2019), 3556. doi:10.3390/app9173556
- [46] Martina Mara, Markus Appel, and Timo Gnambs. 2022. Human-like robots and the uncanny valley. *Zeitschrift für Psychologie* (2022).
- [47] Martina Mara, Simon Schreibelmayr, and Franz Berger. 2020. Hearing a Nose? User Expectations of Robot Appearance Induced by Different Robot Voices. In *Companion of the 2020 ACM/IEEE International Conference on Human-Robot Interaction* (Cambridge, United Kingdom) *(HRI '20)*. ACM, New York, NY, USA, 355–356. doi:10.1145/3371382.3378285
- [48] João Mariano, Sibila Marques, Miguel R. Ramos, Filomena Gerardo, Cátia Lage da Cunha, Andrey Girenko, Jan Alexandersson, Bernard Stree, Michele Lamanna, Maurizio Lorenzatto, Louise Pierrel Mikkelsen, Uffe Bundgård-Jørgensen, Sílvia Rêgo, and Hein de Vries. 2021. Too old for technology? Stereotype threat and technology use by older adults. *Behaviour & Information Technology* (2021). doi:10.1080/0144929x.2021.1882577
- [49] Veronika Mikhailova, Melisa Conde, and Nicola Döring. 2024. "Like a Virtual Family Reunion": Older Adults Defining Requirements for an Augmented Reality Communication System. *Information* 15, 1 (2024), 52. doi:10.3390/info15010052
- [50] Veronika Mikhailova, Christoph Gerhardt, Christian Kunert, Tobias Schwandt, Florian Weidner, Wolfgang Broll, and Nicola Döring. 2024. Age and Realism of Avatars in Simulated Augmented Reality: Experimental Evaluation of Anticipated User Experience. In *2024 IEEE Conference Virtual Reality and 3D User Interfaces (VR)*. IEEE. doi:10.1109/vr58804.2024.00032
- [51] Veronika Mikhailova, Christian Kunert, Jakob Hartbrich, Tobias Schwandt, Christoph Gerhardt, Alexander Raake, Wolfgang Broll, and Nicola Döring. 2024. Work-in-Progress: Older Adults' Experiences With an Augmented Reality Communication System. In *Proceedings of the 2024 ACM International Conference on Interactive Media Experiences* (Stockholm, Sweden) *(IMX '24)*. ACM, 6 pages. doi:10.1145/3639701.3663641
- [52] Masahiro Mori, Karl F. MacDorman, and Norri Kageki. 2012. The Uncanny Valley [From the Field]. *IEEE Robotics & Automation Magazine* 19, 2 (2012). doi:10.1109/MRA.2012.2192811
- [53] Wendy Moyle, Cindy Jones, Marie Cooke, Siobhan O'Dwyer, Billy Sung, and Suzie Drummond. 2014. Connecting the person with dementia and family: a feasibility study of a telepresence robot. *BMC geriatrics* 14 (2014).
- [54] Wendy Moyle, Cindy Jones, Toni Dwan, Tamara Ownsworth, and Billy Sung. 2019. Using telepresence for social connection: views of older people with dementia, families, and health professionals from a mixed methods pilot study. *Aging & Mental Health* 23, 12 (2019), 1643–1650.
- [55] Wendy Moyle, Cindy Jones, Jenny Murfield, and Fangli Liu. 2020. 'For me at 90, it's going to be difficult': feasibility of using iPad video-conferencing with older adults in long-term aged care. *Aging & mental health* 24, 2 (2020).
- [56] Elizabeth D. Mynatt, Irfan Essa, and Wendy Rogers. 2000. Increasing the opportunities for aging in place. In *Proceedings on the 2000 Conference on Universal Usability* (Arlington, Virginia, USA) *(CUU '00)*. ACM, New York, NY, USA, 7 pages. doi:10.1145/355460.355475
- [57] Min Ni, Stephanie Arevalo Arboleda, and Alexander Raake. 2025. Exploring Proxemics in Volumetric Video vs. Face-to-Face through Charades. In *Proceedings of the Extended Abstracts of the CHI Conference on Human Factors in Computing Systems*. 1–7.
- [58] Kristine L. Nowak and Frank Biocca. 2003. The Effect of the Agency and Anthropomorphism on Users' Sense of Telepresence, Copresence, and Social Presence in Virtual Environments. *Presence: Teleoperators and Virtual Environments* 12, 5 (Oct. 2003), 481–494. doi:10.1162/105474603322761289
- [59] Ye Pan and Anthony Steed. 2016. A comparison of avatar-, video-, and robot-mediated interaction on users' trust in expertise. *Frontiers in Robotics and AI* 3 (2016), 12.
- [60] Arushi Puri, Steven Baker, Thuong N Hoang, and Romina Carrasco Zuffi. 2017. To be (me) or not to be? photorealistic avatars and older adults. In *Proceedings of the 29th Australian Conference on Computer-Human Interaction* (Brisbane, Queensland, Australia) *(OzCHI '17)*. ACM, New York, NY, USA, 503–507. doi:10.1145/3152771.3156166
- [61] S. Zahra Razavi, Lenhart K. Schubert, Kimberly van Orden, Mohammad Rafayet Ali, Benjamin Kane, and Ehsan Hoque. 2022. Discourse Behavior of Older Adults Interacting with a Dialogue Agent Competent in Multiple Topics. *ACM Transactions on Interactive Intelligent Systems* 12, 2 (2022), 1–21. doi:10.1145/3484510
- [62] Karen S Rook. 1987. Social support versus companionship: effects on life stress, loneliness, and evaluations by others. *Journal of personality and social psychology* 52, 6 (1987), 1132.
- [63] Daniel Seichter, Benedict Stephan, Söhnke Benedikt Fischedick, Steffen Mueller, Leonard Rabes, and Horst-Michael Gross. 2023. PanopticNDT: Efficient and Robust Panoptic Mapping. In *IROS*.
- [64] Panote Siriaraya and Chee Siang Ang. 2019. The social interaction experiences of older people in a 3D virtual environment. *Perspectives on Human-Computer Interaction Research with Older People* (2019), 101–117.
- [65] Jerry Slocum. 2003. Tangram: the world's first puzzle craze. *Published by Sterling* (2003).
- [66] Nicole Strutz, Luis Perotti, Anika Heimann-Steinert, and Robert Klebbe. 2024. Older adults' communication with an interactive humanoid robot: Expectations and experiences of older adults in verbal and nonverbal communication with a socially interactive humanoid robot: a mixed methods design in germany. *Zeitschrift für Gerontologie und Geriatrie* 57, 5 (2024), 371–375.
- [67] Laramie D. Taylor. 2011. Avatars and Emotional Engagement in Asynchronous Online Communication. *Cyberpsychology, Behavior, and Social Networking* 14, 4

(2011), 207–212. doi:10.1089/cyber.2010.0083

[68] Alan R Teo, Sheila Markwardt, and Ladson Hinton. 2019. Using Skype to beat the blues: Longitudinal data from a national representative sample. *The American Journal of Geriatric Psychiatry* 27, 3 (2019), 254–262.

[69] Markus Thaler, Stephan Schlögl, and Aleksander Groth. 2020. Agent vs. Avatar: Comparing Embodied Conversational Agents Concerning Characteristics of the Uncanny Valley. In *2020 IEEE International Conference on Human-Machine Systems (ICHMS)*. 1–6. doi:10.1109/ICHMS49158.2020.9209539

[70] Gomathi Thangavel, Mevludin Memedi, Karin Hedström, et al. 2022. Customized information and communication technology for reducing social isolation and loneliness among older adults: scoping review. *JMIR mental health* 9, 3 (2022), e34221.

[71] Yun-Chen Tu, Sung-En Chien, and Su-Ling Yeh. 2020. Age-related differences in the uncanny valley effect. *Gerontology* 66, 4 (2020), 382–392.

[72] Akshith Ullal, Mahrukh Tauseef, Alexandra Watkins, Lisa Juckett, Cathy A. Maxwell, Judith Tate, Lorraine Mion, and Nilanjan Sarkar. 2024. An Iterative Participatory Design Approach to Develop Collaborative Augmented Reality Activities for Older Adults in Long-Term Care Facilities. In *Proceedings of the CHI Conference on Human Factors in Computing Systems (CHI '24)*. ACM. doi:10.1145/3613904.3642595

[73] Michele van Volkom, Janice C Stapley, and Vanessa Amaturo. 2014. Revisiting the digital divide: Generational differences in technology use in everyday life. *North American Journal of Psychology* 16, 3 (2014).

[74] Florian Weidner, Gerd Boettcher, Stephanie Arevalo Arboleda, Chenyao Diao, Luljeta Sinani, Christian Kunert, Christoph Gerhardt, Wolfgang Broll, and Alexander Raake. 2023. A Systematic Review on the Visualization of Avatars and Agents in AR & VR displayed using Head-Mounted Displays. *IEEE Transactions on Visualization and Computer Graphics* 29, 5 (2023), 2596–2606. doi:10.1109/TVCG.2023.3247072

[75] Travis J Wiltshire, Emilio JC Lobato, Anna V Wedell, Wes Huang, Benjamin Axelrod, and Stephen M Fiore. 2013. Effects of robot gaze and proxemic behavior on perceived social presence during a hallway navigation scenario. In *Proceedings of the human factors and ergonomics society annual meeting*, Vol. 57. SAGE Publications Sage CA: Los Angeles, CA, 1273–1277.

[76] Tong Bill Xu, Armin Mostafavi, Benjamin C. Kim, Angella Anyi Lee, Walter Boot, Sara Czaja, and Saleh Kalantari. 2023. Designing Virtual Environments for Social Engagement in Older Adults: A Qualitative Multi-site Study. In *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems (CHI '23)*. ACM, 1–15. doi:10.1145/3544548.3581262

[77] Lillian Yang and Carman Neustaedter. 2018. Our House: Living Long Distance with a Telepresence Robot. *Proc. ACM Hum.-Comput. Interact.* 2, CSCW, Article 190 (2018), 18 pages. doi:10.1145/3274459

[78] Xin Yi, Ziyu Han, Xinge Liu, Yutong Ren, Xin Tong, Yan Kong, and Hewu Li. 2023. Catch my Eyebrow, Catch my Mind: Examining the Effect of Upper Facial Expressions on Emotional Recognition for VR Avatars. In *2023 IEEE Conference on Virtual Reality and 3D User Interfaces Abstracts and Workshops (VRW)*. IEEE, 761–762. doi:10.1109/vrw58643.2023.00223

[79] Nungduk Yun and Seiji Yamada. 2025. Investigation of Factors That Influence Human Presence and Robot Anthropomorphism in Telepresence Robot. *IEEE Access* 13 (2025). doi:10.1109/ACCESS.2024.3516782

A Digital Appendix

This paper's digital appendix contains the questionnaires used in german and a video of the experiment, which are available at: https://doi.org/10.5281/zenodo.19232745