Showing, Telling, and Collaborating: Investigating the Relative Benefits of Videoconferencing and Different Augmented Reality Embodiments for Remote Meetings

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Abstract: In the face of "videoconferencing fatigue", augmented reality (AR) presents new means for embodiment in remote meetings, including the use of holograms (stereoscopic projections of attendees) and avatars (wholly virtual representations of users). To explore the prospective benefits of these emerging technologies, the current experiment assigned participants to one of three platform conditions (videoconferencing, hologram-based AR, or avatar-based AR) to complete two conversational tasks (unidirectional object presentation and interactive collaboration) during a remote meeting. Task outcomes (knowledge acquisition, partner persuasion) and participant evaluations of remote partners were then measured. Users reported that avatars—and not holograms—were significantly more useful than videoconferencing for object presentations. Further, though platform had no effect on perceived credibility of partners, social presence perceptions significantly differed across conditions. Specifically, the actions and expressions of a holographic partner were more saliently detected than those depicted through avatars and led to a stronger sense of co-location compared to videoconferencing.

1 INTRODUCTION

1.1 The Communication Demands of Videoconferencing

Reliance on videoconferencing for remote meetings has grown exponentially in recent years, with the pandemic accelerating the adoption of commercially available teleconferencing platforms (Iqbal, 2023; Hove and Watson, 2023). This widespread use has, in turn, led to the emergence of videoconferencing fatigue, a phenomenon characterized by negative psychological and behavioral effects associated with prolonged use of this technology (Beyea et al., 2025). Several potential causes for this fatigue have been proposed, drawing upon extensive research in interpersonal communication, social psychology, and computer-mediated communication (Bailenson, 2021; Bergmann et al., 2022; Li and Yee, 2022). One prominent factor may be cognitive overload, as users are required not only to follow conversational content but also to monitor and regulate their mediated nonverbal signals (Bailenson, 2021). Specifically, videoconferencing often demands frequent checking of one's positioning within the camera's field of view to remain properly framed; furthermore, because videoconferencing is largely sedentary and emphasizes the face and a forward-facing upper body, participants often feel compelled to exaggerate facial expressions and permitted gestures to demonstrate engagement. This includes prolonged nodding to indicate agreement or extended staring to signal attention, adding to the overall cognitive effort.

In addition to the challenge of sending these nonverbal signals, videoconferencing fatigue may arise from the effort required to detect and interpret such cues from others (Bailenson, 2021; Fauville et al., 2021; Nesher Shoshan and Wehrt, 2022). Compared to fully embodied face-to-face conversations, videoconferencing allows for relatively limited nonverbal communication, relying primarily on facial expressions and perceived eye gaze. However, as videoconferencing takes place on computers on which users are often multitasking with other software, a user's darting eyes or slight grin may be in response to screen

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content wholly unrelated to the conversation at hand, providing mistaken cues for one's conversation partners.

Additionally, videoconferencing imposes emotional demands by simulating interpersonal proximity typically reserved for interactions with close friends and family (Bailenson, 2021). In face-to-face meetings, discomfort from prolonged eye contact can often be alleviated by natural shifts in gaze. However, videoconferencing conventions involve maintaining the gaze of others directly on the user for extended periods, which can feel especially arousing and emotionally taxing. These front-facing, close-proximity interactions amplify affective demands, as users process both the persistent gaze and the seemingly intimate framing of their conversation partners. This emotional strain, alongside cognitive demands of regulating and detecting social cues as noted above, may explain the negative user experiences often reported in prolonged remote meetings.

1.2 Social Augmented Reality as an Alternative Technology for Remote Communication

Given such accounts, negative user experiences with videoconferencing may stem from its inability to fully replicate the dynamics of face-to-face communication, particularly in terms of salience of nonverbal cues, physical freedom for expressing these cues, and natural interpersonal distances. These limitations have driven interest in alternative forms of "digital travel" for remote meetings (Tjostheim and Waterworth, 2022), focusing on solutions that are more embodied, nonverbally rich, spatialized, or otherwise closer to in-person interactions.

One promising direction involves social augmented reality (AR) applications, which, unlike 2D videoconferencing or entirely virtual reality environments, create "hybrid" spaces (Harrison and Dourish, 1996). These combine virtual embodiments of participants with elements of their physical surroundings (van Dijk, 2022; Hauber et al., 2006). One approach is the development of AR holographic displays that render stereoscopic projections of remote partners. Alternatively, some social AR applications instead focus on avatar-based teleconferencing, where users interact through virtual embodiments overlaid on their immediate environment. These approaches may offer varying degrees of improvement over 2D videoconferencing by differentially addressing the factors thought to contribute to fatigue and other negative outcomes.

1.2.1 Hologram-Based Teleconferencing

Holographic imaging has been heralded as "the next big innovation in teleconferencing" (Tjostheim and Waterworth, 2022), with its potential applications in business (Pettit et al., 1988) and education (Hirschbuhl, 1980) discussed in academic literature since the 1980s. By the 1990s, researchers exploring videoconferencing in professional settings predicted that the drive for increasingly realistic and high-quality visual communication could eventually lead to holographic imaging as the next frontier in remote meeting technologies (Fini, 1993). Even into the 2010s, scholars suggested that holographic 3D displays remained a key avenue for advancing commercial-grade videoconferencing systems (Kuster et al., 2012).

After years of such projects, holographic communication, featuring stereoscopic renderings of remote meeting attendees, is finally entering the market. This progress has been enabled by recent technological advances, most notably the expansion of reliable 5G networks, which provide the high-speed, low-latency infrastructure necessary for real-time holographic communication (Su et al., 2020; He et al., 2023). Beyond technology, societal demand has also fueled interest in this medium. While avatars are often used as virtual alternatives to face-to-face communication, holographic technologies are increasingly framed as full substitutes or "digital twins" of reality. The COVID-19 pandemic, which made face-to-face interaction impossible in many cases, has been cited as a catalyst for their development (Hsiao et al., 2022).

Holographic conferencing, by rendering participants as they naturally move and appear, offers richer social cues than lower-fidelity formats such as text or 2D video, potentially reducing perception gaps common in computer-mediated communication (Yang, 2021). Consumer-facing systems are now under development, including Google's Project Starline (Google, 2024) and Cisco's Webex Hologram (Webex, 2024b). These AR-based platforms maintain users' connection to their immediate surroundings, avoiding the perceptual disconnection associated with fully immersive virtual reality. Instead, they aim to replicate a sense of physical co-location with remote participants.

Empirical studies on AR teleconferencing with volumetric 3D projections of attendees, as opposed to 2D video recordings, remain sparse. Existing research primarily focuses on prototype validation and system presentations (Plüss et al., 2016; Pejsa et al., 2016), rather than detailed evaluations of user experience or conversational dynamics. However, in line with these systems' emphasis on perceived co-

location with remote others, it has been suggested that they may elicit relatively high levels of perceived social presence between users (Yoon et al., 2019).

1.2.2 Avatar-Based Teleconferencing

Another emerging AR-based alternative to videoconferencing is the use of 3D avatars layered over one's physical surroundings. While commercial platforms like Microsoft Mesh (Microsoft, 2024a) and Meta Horizon Worlds (Meta, 2024) have recently popularized avatar-centric AR and VR applications, academic research on avatar-based teleconferencing dates back decades. Early studies often compared 2D avatars to minimalist self-representations, such as static images or screen markers, finding that while avatars may distract from instrumental tasks, they can enhance informal exchanges and socialization, with these richer representations able to enhance informal information exchange through playful behaviors (Shami et al., 2010). Rendering physical motions—via video or 2D avatars—has been shown to improve communication compared to static representations or voice-only chats (Tanaka et al., 2013), though 2D avatars may result in lower perceived co-location (Tanaka et al., 2014) and trust levels compared to video-based interactions (Pan and Steed, 2016).

In contrast, recent research into 3D avatars in immersive virtual environments suggests they may offer stronger feelings of copresence compared to conventional videoconferencing tools like Microsoft Teams (Ferrer and Fujiwara, 2022; Microsoft, 2024b). Beyond teleconferencing scenarios in particular, studies on embodiment levels in avatars indicate that even limited motion-controlled representations, such as head and hands, can heighten copresence and behavioral interdependence, suggesting full-body avatars are unnecessary for effective social interactions in AR or VR (Heidicker et al., 2017). Furthermore, visual realism of avatars influences social perceptions: realistic 3D avatars can enhance perceived credibility of a remote conversation partner compared to cartoonish avatars (Jo et al., 2016a), though both types elicit similar levels of social presence (Yoon et al., 2019). Users generally prefer realistic avatars for self-representation (Inkpen and Sedlins, 2011). Additionally, the fully virtual nature of avatars in immersive environments allows for dynamic modulation of embodiment in social contexts, such as adjusting interpersonal distance (Choudhary et al., 2021), which is not possible with video recordings.

Further, avatars also address common issues related to focusing on self-presentation in videoconferencing, such as "mirror anxiety" and dissatisfaction with one's appearance (Fauville et al., 2021; Ratan et al., 2022). Importantly, as research shows that environmental fidelity can enhance outcomes like presence and task performance (Luo et al., 2023), social AR applications that retain perceptual self-location within users' actual physical surroundings while enabling avatar-based interactions may combine the benefits of heightened embodiment with the familiarity of a real-world environment, reducing the need to adapt to entirely virtual spaces as is the case with social VR platforms.

1.3 The Possible Relative Benefits of New AR Holograms and Avatars over Conventional Videoconferencing

Despite the ongoing development of AR-based remote meeting platforms, and the aforementioned research into both avatars and holograms, little empirical research has directly compared these new AR hologram and avatar-based platforms to mainstream videoconferencing. Based on the literature, it remains unclear how the visual displays of AR platforms may differ in avoiding or replicating the issues thought to underlie interpersonal communication challenges associated with videoconferencing (Bailenson, 2021; Li and Yee, 2022) or simple 2D avatar systems (Tanaka et al., 2014; Pan and Steed, 2016).

Whether hologram-based or avatar-based, spatialized conferencing technologies that incorporate real-world reference frames may enhance the detection of nonverbal cues, such as eye gaze, compared to 2D videoconferencing (Hauber et al., 2006). This could help mitigate the cognitive demands related to cue-processing thought to contribute to videoconferencing fatigue. However, the extent to which hologram-based and avatar-based systems address specific factors—such as nonverbal cue delivery, user physical orientation requirements, approximated interpersonal distance, attention focus, or self-perception of facial appearance—varies. For instance, avatar-based teleconferencing may reduce fatigue by fostering heightened feelings of copresence, enabling spatial positioning at appropriate interpersonal distances, and emphasizing key nonverbals like hand gestures, resulting in more socially engaging interactions. By contrast, holographic teleconferencing, which relies on specialized cameras for depth capture, often limits user mobility and body language similar to 2D video conferencing. However, it may provide higher visual realism and a stronger sense of spatial co-location with other attendees.

In summary, both avatar-based and hologram-

based teleconferencing may offer advantages over conventional videoconferencing, but their relative benefits depend on which aspects of face-to-face interactions they replicate most effectively.

In turn, this exploratory study directly compares cutting-edge hologram- and avatar-based remote meeting platforms to assess their relative advantages over traditional videoconferencing for mediated conversation tasks (Gaver, 1992). It represents one of the first formal examinations of task outcomes and user evaluations of remote partners in a holographic teleconferencing context. Additionally, it investigates how these differences vary depending on the type of conversational task, such as a unidirectional, visually oriented presentation versus a bidirectional, discussion-oriented collaboration. While prior studies have applied 3D AR concepts to social interactions (Hirskyj-Douglas et al., 2020; Ludwig et al., 2021), this research is among the first to empirically compare multiple commercially available spatialized conferencing platforms with contemporary videoconferencing. It provides novel insights into the context-specific strengths of hologram- and avatar-based teleconferencing, offering practical and immediate implications for their design. In doing so, the study makes both theoretical and empirical contributions to human-computer interaction (HCI) research (Wobbrock and Kientz, 2016).

2 METHODOLOGY

2.1 Procedure

This between-participants experiment evaluated the potential advantages of AR avatars and holograms over videoconferencing by assigning participants to one of three conditions: videoconferencing, avatar-based AR, or hologram-based AR. All participants completed two conversational tasks within their assigned platform—a unidirectional object presentation and an interactive collaboration—with a remote research confederate as their partner (see section 2.3). These tasks were conducted in a randomized order. After completing the tasks, participants exited the conferencing platform and provided self-report evaluations of both their conversation partner and the communication platform used (see section 2.4).

2.1.1 Object Demonstration Task

This task involved the confederate partner presenting and describing a display object to the participant, allowing us to assess how the platform condition influenced the experience of unidirectional instructional content and knowledge acquisition. The object used was a monocular bench microscope, chosen for several reasons. First, it is a plausible tool for real-world remote work scenarios, such as health or research training. Second, the participants' baseline knowledge of microscopes was sufficiently low to observe potential knowledge gains. Third, the object allowed for an easily obtainable virtual twin for use in the avatar condition. Figure 1 shows the physical microscope used in the videoconferencing and hologram conditions (left) and the virtual model used in the avatar condition (right).

During the task, the confederate followed a scripted presentation, raising and turning the object to provide visual access to its components while naming and describing their functions. Afterward, participants completed two quizzes to measure knowledge acquisition (see section 2.4.1).

2.1.2 Interactive Collaboration Task

To examine interactive collaboration during conversation sessions, participants worked with the remote confederate partner to complete a modified version of the Desert Survival Problem (Lafferty and Elmers, 1974). This exercise, commonly used in studies on mediated communication (e.g., (Huang et al., 2002; Rae et al., 2012)), provides an objective measure of agreement between discussants. In the standard version, team members face a hypothetical plane crash scenario and must rank the importance of salvaged items for surviving in a desert environment. Examples include a magnetic compass, a flashlight, salt tablets, and a copy of Edible Animals of the Desert.

In this study, participants first provided an initial ranking of 12 items. They then entered their assigned remote meeting platform to discuss their rankings with the confederate partner, who had purportedly completed their own ranking. During the meeting, the pair compared and debated the rationale behind their rankings. Afterward, participants exited the platform and submitted a second ranking of the 12 items. Comparing pre- and post-conversation rankings allowed us to evaluate the persuasiveness of the confederate partner.

As with the object demonstration task, the confederate's comments were scripted to ensure standardized tone and content. To prevent initial agreement between participant and confederate rankings from influencing subsequent evaluations or rankings, we adapted a script from Rae et al. (2012). This algorithm ensured the confederate's rankings consistently differed from the participant's. The confederate explained that they were referencing their own notes,

Figure 1: Physical and virtual microscopes used in the object demonstration task.

providing a plausible rationale for responses sounding scripted. Additionally, the turn-taking structure of the script—where the confederate mentioned their ranking for an item and then inquired about the participant's—ensured controlled dialogue.

2.2 Apparatus

As previously mentioned, three platform conditions—avatars, holograms, and videoconferencing—were implemented to compare their relative effects on remote meeting task outcomes and perceptions of conversation partners. Figure 2 illustrates how conversation partners were presented in each condition.

2.2.1 Avatar Condition

This study utilized the Microsoft Mesh platform (Microsoft, 2024a) for avatar-based remote meetings. Participants in this condition wore a HoloLens2 augmented reality headset, which required automatic eye calibration before launching the Mesh app. Within the app, participants viewed a virtual stimulus layered over the floor of the bare laboratory room. The confederate partner's avatar was positioned across a generic meeting table interface within the AR space.

During the sessions, participants could not see their own avatar and instead focused solely on the confederate's avatar—whose head movements, body orientation, and arm gestures reflected those of the confederate and whose mouth opened and closed when the confederate spoke. In the object demonstration task, participants were not allowed to touch or manipulate the virtual microscope model, ensuring standardized conversation trajectories and consistent access to the object across all three platform conditions.

2.2.2 Hologram Condition

In the hologram condition, participants used a HoloLens2 headset to access a proof-of-concept app developed by Webex Hologram (Webex, 2024b). After completing the headset's automatic eye calibration, participants opened the app and joined the confederate partner. Tracking distances were precalibrated by the research team to ensure that the hologram of the confederate—seated at a similar table in their own location—appeared directly across from the participant during the hologram call. The confederate's movements were captured in real-time using custom tracking equipment and rendered to the participant at 30fps in 720p throughout the conversation sessions.

2.2.3 Video Condition

The videoconferencing condition utilized the Cisco Webex platform (Webex, 2024a). Participants accessed Webex using default settings on a laboratory laptop, joining a call where the confederate partner was already present.

Figure 2: The three platforms compared. The images above are cropped screen captures from the perspective of the participant in the (a) hologram-based AR meeting, (b) avatar-based AR meeting, and (c) videoconferencing meeting. Note – the same female graduate assistant served as the confederate conversation partner for all participant study sessions.

2.3 Participants

Participants were recruited through two methods: a convenience sample from the college's student research pool and external recruitment via canvassing flyers. Student participants received course credit, while non-students were compensated with $50 Amazon gift cards. A total of 30 participants completed the study, including 4 pilot sessions used to train research staff and refine the procedure. An additional 5 sessions were excluded from the final analysis due to technical issues (e.g., calibration or spatial mapping errors) that may have interfered with task completion. This resulted in a final sample of 21 participants.

Participant ages ranged from 18 to 32 years (M = 21.46, SD = 3.55). Of the sample, 85% identified as female and 15% as male. Regarding education, 38% had some college experience, 29% held a bachelor's degree, 29% had earned a master's, and 4% held an advanced graduate degree. The sample reported significant experience with media technologies, particularly audio, voice, and video calls, as well as messaging applications. However, experience with console and PC games varied, and most participants had little familiarity with commercial VR or AR platforms.

2.4 Measures

To examine the relative advantages of different remote meeting platforms, behavioral and perceptual outcomes were measured after the completion of the two conversation tasks.

2.4.1 Task Outcomes

The two conversation tasks—the instructional object demonstration and the interactive collaboration task—allowed us to investigate how the meeting platform influenced different types of task outcomes.

Knowledge acquisition was assessed following the microscope demonstration using two short quizzes (8 items each). The first quiz measured visual memory by asking participants to correctly label the microscope's parts using a provided word bank. The second quiz assessed semantic memory, requiring participants to match each microscope part to its function as described by the confederate during the demonstration.

Persuasiveness was evaluated through the collaborative Desert Survival task. By algorithmically setting the confederate's rankings to differ consistently from each participant's baseline rankings, we could measure persuasiveness based on how closely participants' final rankings aligned with the confederate's stated preferences. Persuasion scores were calculated by summing the differences between the participant's final rankings and the confederate's rankings for each survival item. Larger differences indicated that the participant was less influenced by the confederate's scripted arguments (Lafferty and Elmers, 1974).

2.4.2 Technology Perceptions

We also collected participants' subjective evaluations of the technology they each used. This included a series of 7-point Likert-like questions gauging perceived usefulness of the technology for each of the tasks completed (object demonstration [M = 4.78, SD = 1.06, Cronbach's α = .92], interactive collaboration

[M = 5.03, SD = 1.27, Cronbach's α = .96]) and a single 7-point Likert-like question each for gauging (3) perceived ease of use (M = 2.14, SD = 0.96) and (4) ease of learning to use (M = 1.76, SD = 1.00). In addition to completing these scaled measures, participants were also asked to complete open-ended questions in which they commented on (5) how/if the technology they used might be incorporated into their daily work and (6) what other types of tasks or activities might benefit from the use of that technology.

2.4.3 Partner Perceptions

Finally, participants also reported their subjective evaluations of their conversation partner. As the same graduate research assistant served as the confederate partner relying on a scripted dialogue across all study sessions, any differences in evaluations may more readily be attributed to the remote meeting platform used. Evaluations of partners included rating their perceived credibility. This construct was measured through the established instrument from McCroskey and Teven (1999), consisting of a series of semantic differential items. These items together capture three distinct dimensions of credibility, including competence (related to perceived intelligence, training, and degree to which the individual appears informed; [M = 5.82, SD = 0.59, Cronbach's α = .71]), caring/goodwill (or the extent to which the individual seems sensitive, understanding, or, conversely, self-centered [M = 3.68, SD = 1.15, Cronbach's α = .83]), and trustworthiness (that is, the level to which one seems genuine, honest, and ethical [M = 4.94, SD = 0.88, Cronbach's α = .76]).

We also measured participants' experiences of social presence during the remote meeting sessions. This concept has gained traction in both popular media and promotional materials as firms market VR, AR, and other remote technologies (e.g., (Meta, 2021)). Previous research on 3D remote meeting platforms has considered reported levels of social presence as indicators of system quality (Greenwald et al., 2017; Jo et al., 2016b; Kim et al., 2018), with recent work calling for multidimensional frameworks of presence to better address emerging communication technologies (Cruz et al., 2021). In empirical studies, "social presence" encompasses various interpersonal evaluations during mediated communication (Cummings and Wertz, 2018, 2023; Kreijns et al., 2021), and recent research on social AR has measured multiple dimensions of the construct (Yoon et al., 2019). Accordingly, we measured several dimensions of social presence commonly addressed in the literature and relevant to perceptions of a remote conversation partner: *salience*, *perceived actorhood*, *co-location*, and *association* (Cummings and Wertz, 2023).

Salience refers to the extent to which another social entity is detectable or perceptible. It was measured using the social presence passive interpersonal scale from Lombard and Ditton (Lombard et al., 2009) (M = 4.59, SD = 1.41, Cronbach's α = .78).

Perceived actorhood is the degree to which another party is recognized as a real person with their own thoughts and feelings. This was assessed with Bailenson et al.'s instrument (Bailenson et al., 2001) (M = 4.68, SD = 1.11, Cronbach's α = .71).

Co-location reflects the perception that a remote other is physically proximate and tangible, aligning with corporate messaging about technologies that evoke *"a feeling of being right there with another person"* (Meta, 2021). It was measured using Nakanishi et al.'s instrument (Nakanishi et al., 2008) (M = 4.15, SD = 1.12, Cronbach's α = .83).

Association represents a sense of camaraderie, liking, or affiliation with a mediated other. This was captured using Nowak's self-reported copresence scale (Nowak, 2001) (M = 3.83, SD = 1.07, Cronbach's α = .83).

Each of these perceptions was measured through established self-report instruments using multiple 7-point Likert-type items.

3 RESULTS

3.1 Task Performance

A separate one-way analysis of variance (ANOVA) was conducted to test for platform-based differences in each of the task performance measures. Tests were run at the 5% significance level. Performance on the object demonstration task was measured via two separate metrics: the total number of correct answers on the object labeling quiz and on the object function quiz. In both cases, participants in the avatar condition produced higher scores on average (M = 8.00, SD = 1.29; M = 6.29, SD = 1.89) than those in either the hologram (M = 6.57, SD = 1.99; M = 5.57, SD = 1.13) or videoconferencing conditions (M = 5.86, SD = 2.27; M = 5.14, SD = 2.19). However, these differences were not statistically significant (F = 2.32, p = .13; F = 0.72, p = .50). Persuasion scores did not differ across platform conditions (F = 0.05, p = .95). See Figure 3.

3.2 Technology Perceptions

A second series of one-way ANOVAs were conducted to test for group differences in the perceived useful-

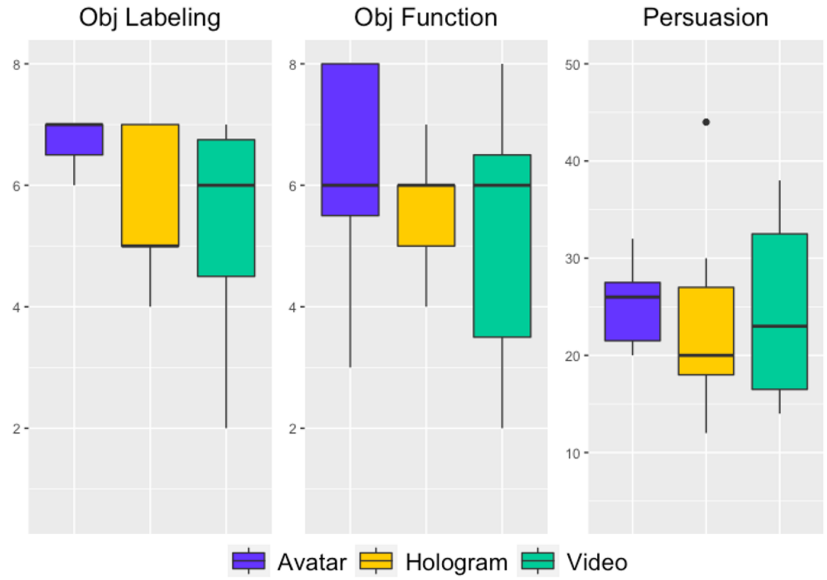

Figure 3: Task performance by platform.

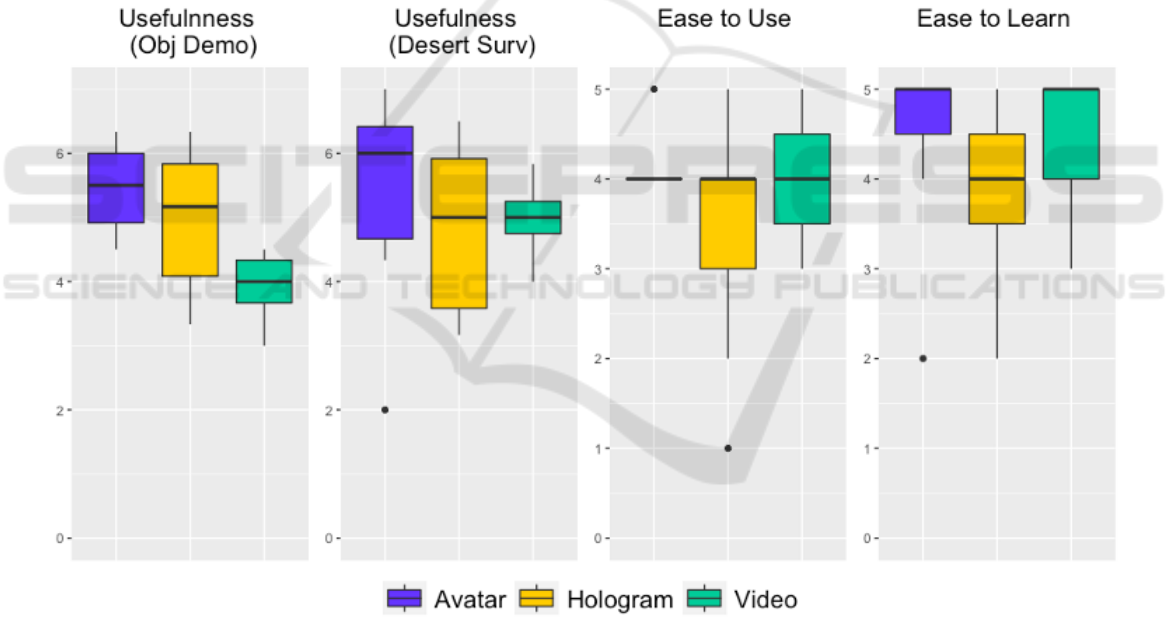

Figure 4: Technology perceptions by platform.

ness and ease of the various conferencing platforms. Participants' perceived usefulness of the platform was separately evaluated after each of the two conversational tasks. For the object demonstration task, the avatar platform (M = 5.45, SD = 0.71) was perceived as significantly more useful than the videoconferencing platform (M = 3.93, SD = 0.57; F = 5.47, p = .01), with no significant differences between either condition and the hologram condition (M = 4.95, SD = 1.22). In contrast, the perceived usefulness of the platforms did not vary in the context of the Desert Survival interactive collaboration task (F = 0.26, p = .77). Additionally, participants reported no significant differences across platforms with respect to perceived ease of use (F = 1.09, p = .36) or ease to learn (F = 0.75, p = .49). See Figure 4.

3.3 Partner Perceptions

A third series of one-way ANOVAs were conducted to test for differences in users' partner perceptions based on platform condition. Participants' perceived credi-

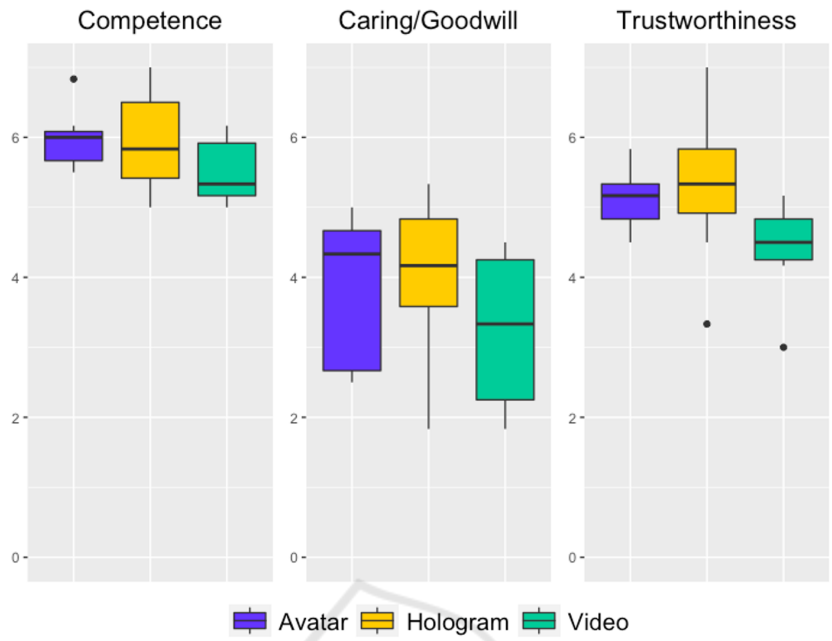

Figure 5: Perceived credibility of the confederate partner by platform.

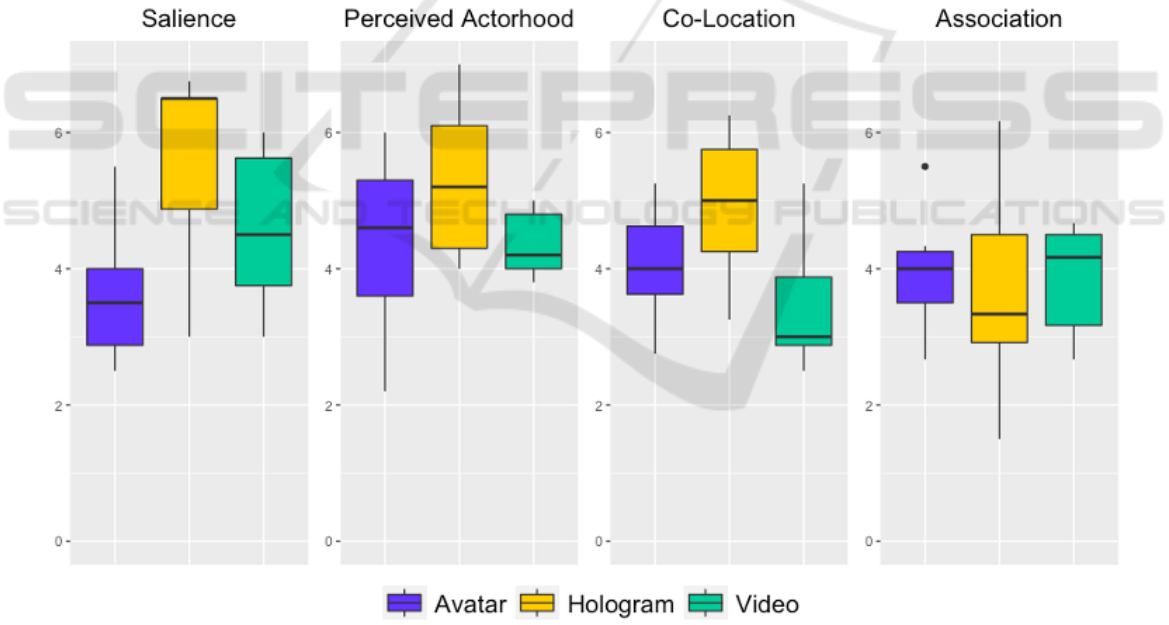

Figure 6: Social presence of the confederate partner by platform.

bility of the confederate partner did not vary with respect to any of the three credibility dimensions: competence ($F = 1.34$, $p = .29$), caring/goodwill ($F = 0.84$, $p = .45$), and trustworthiness ($F = 2.36$, $p = .12$); see Figure 5. However, feelings of social presence with the confederate partner varied as a function of the platform used for conversations (Figure 6). Specifically, participants who engaged with the remote confederate partner via the hologram platform reported the partner to be significantly more salient ($M = 5.57$, $SD = 1.40$) than did those using avatars ($M = 3.60$, $SD = 1.03$; $F = 4.60$, $p = .02$), though no significant differences were found between either group and those individuals using videoconferencing ($M = 4.60$, $SD = 1.17$). Conversely, participants in the hologram condition reported a significantly higher sense of co-

location with the confederate (M = 4.93, SD = 1.16) than did those communicating via videoconferencing (M = 3.46, SD = 0.95; F = 3.85, p = .04), though neither of these conditions significantly differed from the avatar condition (M = 4.07, SD = 0.84) in this regard. No significant differences were observed between platform conditions with respect to perceived actorhood (F = 1.70, p = .21) of or feelings of association with the confederate (F = 0.10, p = .91).

4 DISCUSSION

In light of accounts of videoconferencing fatigue and recent advancements in teleconferencing technology, this study explored the relative advantages of avatar- and hologram-based platforms for remote meetings. In addition to comparing these tools to conventional videoconferencing, the study examined the distinct benefits each platform may offer depending on the type of conversational task. Complementing scale measures of technology and partner perceptions, participants' open-ended responses permitted insight into the extent to which the two different AR-based platforms replicate or address factors that recent literature suggests contribute to the interpersonal challenges associated with negative videoconferencing experiences, such as the conveyance and processing of nonverbal signals.

Users reported avatars, but not holograms, were significantly more useful for object presentations during remote meetings. However, actual knowledge acquisition scores showed no significant differences across platforms. While platform type had no effect on the perceived credibility of conversation partners, it uniquely influenced different aspects of social presence. Specifically, holographic partners were reported as significantly more salient to users than avatars, and holograms — unlike avatars — elicited heightened feelings of physical co-location compared to videoconferencing.

These results highlight the specific benefits emerging consumer-facing mixed reality technologies offer over traditional videoconferencing. They also provide important insights into the circumstances under which remote meetings may benefit from one type of digital representation over another.

4.1 The Perceived Usefulness of Avatars for Object-Focused Exchanges

The differences in subjective evaluations observed in this study suggest that avatars are particularly suited for tasks involving object-oriented discussions where visualization is a key component of the information exchange. While this perception was not fully supported by the learning outcomes of the object demonstration task (participants in the avatar condition scored higher on object labeling and function quizzes, but the differences were not significant), this may be due to a ceiling effect related to the sample size and the object used. Specifically, the use of a familiar object like a microscope may have limited the ability to detect differences; a wholly novel object might better reveal the comparative advantages of avatars.

Nonetheless, the perceived benefit of avatars was supported by open-ended participant feedback. Comments highlighted the system's utility for tasks such as *"explaining details about a device"*, providing *"display and explanation"*, or showcasing *"a model of an intricate design."* While some participants noted similar uses for holographic displays, the hologram's utility was often qualified by the level of object complexity. Participants in the hologram condition reported that the platform was useful only if the object *"does not have that many details"*, citing issues with visual quality. Common complaints included that the hologram's resolution was *"not that clear"* and that the display did not allow them to *"see details clearly during the presentation."*

These visual quality issues may explain the more mixed perceived usefulness of holograms, especially for object demonstration tasks. However, the fact that perceived usefulness for 3D immersive platforms was only significant for object demonstrations—and not the Desert Survival Task meetings—suggests that such platforms are beneficial primarily when communication genuinely requires a sense of three-dimensional space. This raises the implicit question for users of platforms rendering conversations in 3D space: *"Why is a sense of space needed?"* Object demonstrations, provided the visual details are clear, seem to offer a compelling answer. Yet, for now, avatars appear to be best suited for object-focused exchanges, at least until holographic communication can offer similar advantages once visual quality improves.

4.2 AR Holograms Are Effective for Replicating Face-to-Face Interpersonal Exchanges

As discussed, holograms may be most effective for demonstrations involving relatively simple visual objects with minimal detail until their visual quality improves. However, the primary strength of holograms compared to avatars or videoconferencing lies in their

ability to replicate the experience of face-to-face communication. Holograms elicited significantly higher levels of different aspects of social presence compared to the other platforms.

For example, participants in the hologram condition reported greater feelings of co-location with their confederate partner than those in the videoconferencing condition. This aligns with open-ended feedback describing the holographic display as *"an upgraded Zoom meeting"* that renders real-time feeds in three dimensions. Additionally, compared to the avatar condition, participants found their holographic partners more salient, detecting social cues such as facial expressions, tone, and nonverbal behaviors more clearly. Participants suggested that the hologram platform might be particularly beneficial when a partner *"heavily relies on body language."*, whereas avatars—even those used here, capable of basic facial tracking and rendering—were perceived as lacking *"the human aspect of having a face-to-face conversation"*.

Holograms appear to offer a closer approximation of offline communication by enabling users to perceive their partners as physically present and accessible while more easily interpreting conventional social cues. This suggests that efforts to digitally replicate the full-body experience of face-to-face interactions may be more effectively supported through holograms than through avatars or videoconferencing.

4.3 Realistic Mediated Nonverbals – Especially Facial Expressions – Matter

The differences in social presence across platforms appear to stem largely from the availability of nonverbal social cues. When represented via an avatar, the range of social cues a conversation partner can convey is significantly reduced compared to face-to-face communication. Participants in the avatar condition noted difficulties in *"capturing the motions and facial expressions"* of others, with some expressing a preference for seeing *"an actual person's face"* and describing the experience as *"a little awkward and uncomfortable at times."* Similarly, participants in the videoconferencing condition reported that while *"it was easy to talk virtually and exchange ideas,"* they struggled to *"build an emotional connection."* Even in the hologram condition — which scored highest for social presence — participants highlighted concerns over *"no eye contact"* and identified *"the problem of eye contact"* as an issue that needed to be *"solved."*

Thus, across all conditions, participants emphasized the importance of clearly perceiving and conveying social cues. This aligns with extensive research, beginning with Argyle and Dean in the 1960s, demonstrating the role of visual cues like eye contact, gaze, and head movements in fostering perceptions of intimacy, trust, and connection (Argyle and Dean, 1965; Williams, 1977). More recent studies have similarly shown that realistic avatar eye gaze can influence communication dynamics (Steed and Schroeder, 2015), underscoring the importance of nonverbals in validating new remote communication platforms (Colburn et al., 2000; dos Anjos et al., 2019). Although holograms provide better access to these cues compared to avatars or videoconferencing, they are evidently still far from replicating the ideal face-to-face experience.

An ideal remote communication platform would avoid obscuring facial expressions with avatars nor headsets, render expressions in high resolution, and display full body language with a wide field of view. Such a platform could not only enhance social presence but also significantly improve partner credibility perceptions and persuasive task outcomes. Moreover, it could reduce the cognitive effort required to send and interpret nonverbal cues, addressing a major contributor to videoconferencing fatigue (Bailenson, 2021; Li and Yee, 2022).

However, for object-oriented conversations, these concerns may be less pronounced. Research suggests that when tasks involve virtual objects, users spend significantly less time focused on a partner's face (Hanna and Brennan, 2007). In such cases, lower-quality holographic displays or avatar-based systems with limited facial tracking may suffice, as the focus shifts away from interpersonal dynamics toward the shared task.

5 LIMITATIONS AND FUTURE DIRECTIONS

As with many laboratory studies, this research faced certain operational constraints. For example, both the participant sample and the communication platforms were relatively limited. While the participants were generally representative of prospective users in terms of demographics and prior experience with media technologies, they were primarily recruited via convenience sampling. Additionally, only a single example of each platform type—commercial-grade videoconferencing, avatar AR, and hologram AR—was included, which may limit the generalizability of the findings (Cummings and Reeves, 2022). User perceptions may also have been influenced by hardware-specific factors beyond the display itself. For in-

stance, a recent systematic review highlights that the type of 3D display device (e.g., projector-based vs. head-mounted) can affect interaction outcomes (Fadzli et al., 2021). In turn, future research should adopt a variable-centered approach (Nass and Mason, 1990) to identify specific platform elements—such as resolution, visual depth, behavioral realism, or embodiment level—that drive observed differences. This aligns with calls to investigate technological factors influencing social presence (Cummings and Wertz, 2018). Additionally, differences in perceived usefulness for object demonstrations could be further explored by assessing knowledge acquisition using wholly novel artifacts or multiple objects with varying visual complexity.

Furthermore, though this study focused on AR avatars rather than VR avatars to avoid confounding digital representation with environmental settings and to align with prior research on spatialized conferencing, future studies could compare AR holograms with fully virtual avatars and environments, such as those in Horizon Worlds and other commercial VR platforms.

Thus, while this study provides an initial exploration, future research should investigate whether the distinct perceived benefits of avatars and holograms replicate across different participant samples, products, and user configurations.

6 CONCLUSIONS

Videoconferencing usage is at an all-time high, but it often leads to fatigue and other limitations compared to face-to-face communication. This study examined how visual displays in emerging immersive remote meeting platforms—avatar-based AR and hologram-based AR—may reproduce or mitigate these issues. The findings highlight distinct advantages for each platform: avatars excel in object-centered exchanges but may cause confusion or distraction in non-object-focused conversations, while holograms more closely simulate face-to-face interactions by enhancing social presence with one's partner.

In turn, when selecting enterprise software for remote meetings, institutions and employees should choose platforms based on the meeting's focus—avatars for tasks centered on presented materials and holograms for interactions emphasizing interpersonal connection. However, both platforms currently offer limited capabilities for perceiving and conveying nonverbal information, a concern that may be alleviated as holographic technologies advance in resolution and field of view.

As these technologies evolve, academic and industry research should further explore how the interaction between technology and task shapes the relative advantages of avatars and holograms, providing clearer guidance for their optimal use in remote communication settings.

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