So Close and Yet So Far: How Embodiment Shapes the Effects of Distance in Remote Collaboration

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Abstract

Technology can facilitate communication across large distances. Although today's technologies enable partners to convey rich verbal and non-verbal information, past research suggests that geographic distance can still hamper remote collaboration. In this study, we investigate whether a telepresence robot, by offering an embodiment of the user, allows communicators to experience their remote partners as being "really there," overcoming distance effects. We conducted a two-by-two (distance: on-campus vs. across-the-country; embodiment: video-mediated vs. robot-mediated) between-subjects experiment, assessing collaboration in self-presentation, persuasion, and negotiation tasks. Results showed that, while local participants viewed their remote partners as more present when communicating via telepresence robot, they also exhibited greater impression management in a self-disclosure task than did participants in video-mediated interactions. Consistent with embodiment helping to overcome geographic distance effects, we found that greater geographic distance had a negative impact on collaboration outcomes when a negotiation task was conducted via video-mediated communication, but not when conducted via robot-mediated communication. We did not observe effects of geographic distance, or interaction effects between embodiment and geographic distance in the self-presentation and persuasion tasks. These findings suggest that a partner's embodiment may change how individuals present themselves, and how geographic distance is experienced in remote collaboration, although these effects may vary across types of tasks being conducted remotely.

Keywords: Robot-mediated communication, robotic telepresence, video-mediated communication, collaboration, distance

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Interacting with others when co-located is something that we learn to do from a very young age. We learn that our communication partner's facial expressions, posture, gestures, and gaze cues add nuance and additional meaning to our communication (Argyle & Cook, 1976; Ekman, 1993; Kendon, 2004). In addition to these cues, we also reference a shared physical environment to scaffold our interactions, using our communication partner's proximity and orientation, spatial and temporal history, and shared context to build *common ground*—mutual knowledge, beliefs, and assumptions—that are critical for successful collaboration (Clark & Brennan, 1991; Gutwin & Greenberg, 2002).

When we are no longer present in our partner's space, we lose access to a number of important cues that help establish common ground. To address this challenge, various technologies have been developed to help convey verbal, aural, or visual information across distance. For instance, e-mail and text messaging convey verbal information, while telephone and videoconferencing go further by conveying non-verbal information such as vocal tone and facial expression. These systems all provide opportunities to exchange social cues across any number of miles. Yet, past work suggests that geographic distance still affects how we perceive and behave toward our communication partners, with greater geographic distance tending to inhibit important social processes of disclosure, persuasion, and cooperation (Bradner & Mark, 2002; Jolak et al., 2018; Moon, 1998; G. M. Olson & Olson, 2000).

Recently, robot-mediated communication systems, such as telepresence robots, have sought to further alleviate the effects of distance by providing a proxy for the *remote* user in the environment of the *local* user. While remote users could be down the street or halfway around the world, they are remote in the sense that they are not in the physical location of local users. However, in another important sense, remote users of telepresence robots are also quite close to local users, in that the robot acts on their behalf in the local environment, providing them with an “embodiment” (Deng et al., 2019; Haans & IJsselsteijn, 2012). Particularly when that embodiment allows for fluid interactions with the local environment, communicators may even feel an experience of “presence,” as though their interactions are unmediated, and they are truly in the partner’s local space (Haans & IJsselsteijn, 2012; Hartmann et al., 2015). While current telepresence robots allow a relatively limited repertoire of actions (e.g., moving, rotating), studies suggest that users, through these technologies, can have experiences of having a body, and of presence (Lei et al., 2019; Rae et al., 2013a). Furthermore, embodiment can allow simulation—in real-time—of a number of cues that facilitate building common ground and mutual understanding in face-to-face communication (Rae et al., 2014).

Robot-mediated communication has been envisioned as a catalyst for enhancing collaboration by lowering costs (Herring et al., 2016; Kachach et al., 2020), facilitating travel for those who are otherwise physically unable (Gallagher, 2016; Weiss et al., 2001), and granting access to services and expertise that may otherwise be unreachable (Latifi et al., 2007; Vespa et al., 2007), and has use cases in medicine, education, and workplace contexts, among others. However, questions remain regarding the specific ways that using a telepresence robot affects key interpersonal processes. In particular, it remains unclear whether the embodiment afforded by a telepresence robot offers sufficient cues to make geographic distance irrelevant. In other words, if you have an embodied presence via telepresence robot, does geographic distance still matter? In this laboratory study, we address this question by examining the extent to which geographic distance (on campus versus across the country) and embodiment (video-mediated vs. robot mediated) each shape collaborative processes in remote communication. We also examine whether embodiment may have different effects when partners are perceived as geographically near or far. We focus on three interpersonal processes central to collaboration: persuasion, self-disclosure, and cooperation. Findings from this study have potential to clarify the role of embodiment in computer-mediated communication, and to suggest ways that telepresence robots and other embodied technologies can be designed and deployed to optimize remote collaboration.

In the remainder of the paper, we outline past work that has informed our investigation, describe the hypotheses suggested by this work, explain our method for testing these hypotheses, outline our results, and discuss the implications of our findings for theory and design.

Related Work

In robot-mediated communication, although the remote user may be physically distant, his or her embodied representation operates in the local user's space. This paradox of simultaneous distance and closeness presents an opportunity to extend the computer-mediated communication literature by asking which is most central to shaping the local user's perceptions and behaviors: the geographic location of the remote partner or the location of the remote partner's proxy embodiment.

Distance in Computer-Mediated Communication

A number of studies have assessed how geographic distance can shape user interactions, both in the context of interacting with computers and with human partners. In early work on this topic, Moon (1998) asked participants to interact with a computer that they believed to be either across the country or on-campus with them, finding that participants who believed that the computer was farther away were less honest with the computer and less persuaded by it. Subsequently, a replication and extension of this work found similar patterns when partners were human (Bradner & Mark, 2002). In interactions through both instant messaging and video-conferencing, participants who believed their partner to be farther away: exaggerated more claims about themselves (i.e. engaged in more "self-deception"), were less persuaded by their partners, and cooperated less in solving a "prisoner's dilemma" problem for mutual benefit. Therefore, even with many verbal and non-verbal cues, perceiving a partner as far away compromised honesty, persuasion, and cooperation, processes central to building effective relationships and collaborations. In the years since this work, long-distance communication has become commonplace, and technologies have improved in how seamlessly they facilitate communication across distance; however, studies suggests that some distance effects have persisted, manifesting in challenges collaborating with remote colleagues in workplace contexts (Jolak et al., 2018; Morrison-Smith & Ruiz, 2020; G. M. Olson & Olson, 2000; J. S. Olson & Olson, 2006), and trends favoring geographically proximal partners in scientific collaborations (Hoekman et al., 2010), and when creating relationships in online virtual worlds (Huang et al., 2013).

These persistent effects of distance can be interpreted within computer-mediated communication theory, particularly the Social Identification Model of De-individuation Effects (SIDE) (Lea & Spears, 1991), which posits that computer users form impressions of their communication partners through inferences related to their partners' membership in social groups. Since individualizing information about new partners (e.g., appearance, biographical information) is often sparse in computer-mediated communication, individuals compensate by inflating the significance of other available information, including information about partners' membership in social groups. It is possible that geographic distance hampered collaboration in prior studies because it served as a signal of partners' *social* distance, with participants identifying partners that they believe to be on the same campus as being more similar to themselves or as part of an in-group. In contrast, partners believed to be in another city may have been classified as out-group members. Consistent with literature on social identity theory, perceiving similarity and shared group membership enhances processes such as self-disclosure, persuasion, and cooperation (Sears, 1983; Whittaker, 2003), while perceiving partners as out-group members negatively affects these important processes (Blauner, 1964).

Computer-mediated communication theories also suggest that, over time, computer users can overcome the sparsity of individualizing information in computer-mediated communication in order to build personal relationships. Specifically, Social Information

Processing Theory (SIPT) suggests that, despite the loss of cues in computer-mediated communication, people will draw on those cues that are available to exchange complex social information about themselves and their partners (Walther, 2008). Past work has shown that a number of cues can be adapted for purposes of conveying and interpreting social information in mediated communication, including chronemics—response latencies and silences (Kalman & Rafaeli, 2010)—or the voice and appearance of 3D avatars (Qiu & Benbasat, 2005). In robot-mediated communication, a range of additional cues become available pertaining to the partner's physicality, including orientation and movement in the local environment, which may enable partners to better understand one another and to establish common ground.

Embodiment in Robotic Telepresence

Use cases for robot-mediated communication include medical contexts, wherein remote clinicians can perform "telerounding" by moving from bedside to bedside, orienting to observe relevant information in the local environment (e.g., patients' vital signs, medical charts), and communicating with the patient and local care team (Latifi et al., 2007; Reynolds et al., 2012). Within workplace contexts, these technologies can allow remote team members to participate more fully, going beyond designated meeting times and spaces to allow for "water-cooler chats" and exploration of the office space (Gallagher, 2016; Rae et al., 2012). Similarly, for those unable to attend conferences and school in-person, these systems have promise to support self-directed navigation and spontaneous encounters (Lei et al., 2019; Neustaedter et al., 2016; Weiss et al., 2001).

Some past research in the area of telepresence has explored how physical embodiment via a robot affects remote collaborations. For example, in-situ studies revealed that using a telepresence system with a physical embodiment enhances the salience of the remote user's presence, leading to greater participation for the remote user and more opportunistic interactions (M. K. Lee & Takayama, 2011; Venolia et al., 2010). In controlled laboratory settings, prior work showed that using a physically embodied telepresence robot increased the remote user's presence (Rae et al., 2014; Sakamoto et al., 2007), fostered the development of trust between users (Rae et al., 2013a), and enhanced perceptions of leadership (Beattie et al., 2018). Other work has also shown that adjusting aspects of the system's physical configuration, such as height, visual framing, and movement, can affect feelings of involvement, rapport, and "groupness" with communication partners (Biehl et al., 2015; Choi et al., 2017; Rae et al., 2012, 2013b).

While prior work suggests that physical embodiment changes how local users collaborate with remote partners, the extent to which local users consider the embodiment to be a proxy for remote users across any geographic distance has yet to be explored. By seeking a more nuanced understanding of the role that embodiment plays, particularly in relation to the remote user's geographic location, we may contribute to better understanding use cases to which these systems are suited (e.g., connecting geographically close versus far partners) and may inform design decisions about telepresence systems. For instance, technologies could be adjusted to either highlight or de-emphasize partners' locations according to the effects of distance on self-disclosure, persuasion, and cooperation. Through this study, we also contribute to extending computer-mediated communication theory into the realm of robot-mediated communication by considering embodiment as a key media feature that may facilitate and/or hinder communicative processes.

Hypotheses

Based on a review of work on embodiment in the area of robot-mediated communication, and studies examining the effects of geographic distance in computer-mediated communication, we formulated three hypotheses, as described below.

Does technology matter?

Prior research highlights the benefits of telepresence for enhancing presence and providing opportunities for remote partners to participate and build relationships from afar, but questions remain about the extent to which these systems enhance key social processes of self-disclosure, influence, and collaboration, and how these technologies fare relative to well-established modes of distance communication such as videoconferencing. As discussed above, embodiment offers a range of additional cues that can facilitate building mutual understanding.

On the other hand, novice users of telepresence systems may not know how to utilize these cues in order to communicate effectively. Furthermore, it is important to note that not all interpersonal processes are affected in the same way by the social cues conveyed through embodiment (Bailenson et al., 2006). In particular, some work in computer-mediated communication suggests that candid self-disclosure can sometimes be facilitated by leaner media (i.e., media that convey fewer social cues), as individuals may feel less self-conscious when freed from monitoring their own or their partners' nonverbal behaviors (Joinson & Paine, 2007; Suler, 2004). Consistent with such accounts of "online disinhibition," some studies suggest that greater intimate disclosure occurs online than in face-to-face communication (Jiang et al., 2013; Schouten et al., 2009; Tidwell & Walther, 2002), although the extent of this effect appears to be shaped on specific features of the media environment (e.g., anonymity, publicness) (Bazarova & Choi, 2014; Clark-Gordon et al., 2019; Lapidot-Lefler & Barak, 2012). Consistent with this literature, it is possible that, in the context of disclosing to an embodied remote partner, that partner's greater social presence might elevate the local partner's self-consciousness, leading to more socially desirable responding, wherein individuals attempt to manage their self-presentation by emphasizing positive aspects of themselves and minimizing negative ones (Paulhus, 1988), as contrasted with more candid or unbiased disclosure. Therefore, the literature, on balance, suggests that robot-mediated communication should have benefits for many collaborative processes by providing additional cues through which to establish common ground. However, the literature is less clear about whether these cues would enhance self-disclosure specifically.

We therefore pose the following hypothesis and research question: **Hypothesis 1.** Local participants who interact with embodied partners in robot-mediated communication will be more persuaded and show more cooperation than those who interact with partners in video-mediated communication. **Research Question 1.** How will local partners' levels of socially desirable responding be affected when self-disclosing to a remote partner with different levels of embodiment?

Does distance matter?

Findings from previous research suggest that a partner's perceived geographic location affects collaboration (G. M. Olson & Olson, 2000), including interactions with human partners via text-based and video-mediated communication (Bradner & Mark, 2002). Specifically, perceiving partners as geographically close enhances collaboration, perhaps because local users feel that they share an in-group identity with their partners based on their shared location.

In this study, we expect to replicate these overall effects of geographic distance and thus posit the following hypothesis: **Hypothesis 2.** Participants will exhibit less socially desirable responding, be more persuaded, and show more cooperation toward remote users perceived to be geographically close (e.g., on the same college campus) as opposed to remote users perceived to be geographically distant (e.g., across the country).

Does embodiment attenuate distance effects?

We next propose that technology may shape the effects of distance. Specifically, due to the increased cues provided through the remote user's embodiment (Rae et al., 2014), local participants may respond to their partners in robot-mediated interaction the same way they respond to partners who are co-located in their immediate environment. Indeed, prior work has shown that even relatively simple technologies can stand in for remote partners, such as the "HomeProxy" system, which represents family members on a computer screen mounted on a portable box (Tang et al., 2013). By allowing the remote partner to navigate, orient, and communicate through a live video feed at human height, the telepresence robot is designed to further escalate the ability of robot to serve as a proxy for the remote partner. If participants therefore behave on the basis of the location of the partner's embodiment rather than the partner's purported geographic location, using the telepresence robot to communicate might neutralize the negative effects of geographic distance found in prior literature. We therefore posit the following hypothesis:

Hypothesis 3. System embodiment will moderate the effects of geographic distance. When using videoconferencing, local participants will favor geographically close remote partners through engaging in less socially desirable responding, being more persuaded, and showing more cooperation. By contrast, in robot-mediated communication, local participants will show similar levels of self deception, socially desirable responding, persuasion, and cooperation regardless of their remote partners' geographic distance.

Method

To test our hypotheses, we conducted a 2 (system embodiment: low or video-mediated vs. high or robot-mediated) × 2 (perceived distance: on-campus vs. across the country) × 3 (three types of cooperative tasks) controlled laboratory study, where system embodiment and perceived distance were between subjects factors, and tasks were within subjects. The three tasks had different outcomes, and we analyzed between-subjects data for each task separately. As we were interested in how local users perceived and interacted with remote users, participants acted as the local user and a confederate acted as the remote user. The interaction was conducted either via a Beam Pro telepresence robot[1] or via the Skype videoconferencing software.[2] To manipulate distance, participants were informed that the remote confederate was participating in the study from either a building on campus or from across the country in California. In actuality, the

[1] Suitable Technologies Beam Pro: https://www.suitabletech.com/

[2] Microsoft Skype: http://skype.com/

confederate—either a 36 year-old woman or a 22 year-old man—logged into the telepresence robot or videoconferencing system from a nearby office and interacted using semi-scripted responses throughout the study.

Systems

We used an unmodified Beam Pro in the telepresence robot condition and an Apple iMac running Skype in the videoconferencing condition. The Beam Pro weighs 90 pounds and stands 62-inches tall with a 17-inch LCD screen, two wide-angle cameras with pan and zoom capabilities across a 105-degree field of view, and a top speed of two miles per hour. The remote user operates the Beam through an app that allows for orienting and moving forward, backward, left, and right. The iMac had a 27-inch LED-backlit display and was running Skype v7.1 in full-screen mode.

Tasks and Measures

Following examples in prior work (Bradner & Mark, 2002; Moon, 1998), participants and confederates engaged in collaborative tasks demonstrating self-presentation, persuasion, and cooperation. Tasks were ordered roughly in terms of their complexity, starting with the self-disclosure task to allow dyads to get-to-know one another, followed by the persuasion task, and finally the negotiation task.

Balanced Inventory of Desirable Responding

To assess socially desirable responding, we used the Balanced Inventory of Desirable Responding (BIDR), a measure tested and validated for assessing ego-enhancement when disclosing about the self (Paulhus, 1988). The inventory assesses two components of socially desirable responding: (1) self-deceptive enhancement, in which individuals exaggerate flattering claims about themselves (e.g., "I always know why I like things"), and (2) impression management, in which individuals over-report positive behaviors and under-report negative ones (e.g., "When I was young I sometimes stole things"). Each of the sub-measures consists of 20 statements. Participants rated their agreement on a seven-point scale (1 = “Not true;” 7 = “Very true”).

To make the administration of the BIDR cooperative, we created eight stations, each represented by a sheet of paper listing a random selection of five questions from the inventory. In the videoconferencing condition, these stations were placed in a packet in a random order and provided to the participant. In the telepresence robot condition, these stations were placed on walls around the room. Participants were instructed to go to each station, in order. At each station, the participant read the numbers to the confederate, and the confederate asked the corresponding questions and recorded the participant’s responses. In the telepresence condition, the confederate used the movement controls of the robot to accompany the participant around the room.

Desert Survival Task

To measure the extent to which participants were persuaded by the confederate’s arguments, we used the Desert Survival Task, which was developed and validated by Lafferty et al. (1974) and modified by Rae et al. (2012). In this task, the participant was given a scenario of a bus crash in the desert and a list of nine items (e.g., flashlight, first-aid kit). The participant was given up to five minutes to rank the list of items in order of their importance for survival. This initial ranking was completed without discussion with the confederate. Following the individual ranking, the participant and confederate engaged in discussion for up to ten minutes, first comparing their initial rankings and then deciding on a shared final ranking for the items.

During the discussion, the confederate proposed rankings that were algorithmically generated to be consistently different from the participant’s rankings. For example, the item that the participant ranked first was the fourth on the confederate’s list, and the item that the participant ranked second was the sixth on the confederate’s list. Using semi-scripted responses, the confederate discussed each item in turn, offering one argument for why the item should be moved up or down, according to whether the algorithm placed that item higher or lower than the participant had. Following each argument, the confederate allowed the participant to make the decision on the final ranking for each item.

Participants in the videoconferencing condition were given pictures of each of the nine items to be placed on a sheet with nine ranked spots, as shown on the left side of Figure 1. Participants in the telepresence-robot condition were given pictures of each of the nine items to be placed on a wall with nine ranked spots, as shown on the right side of Figure 1.

Final rankings were recorded by the experimenter, and persuasion was measured as the distance between the confederate's proposed ranking and the final ranking, summed across the nine items, such that smaller distance indicates that the confederate was more successful in persuading the participant to adopt his or her rankings.

Negotiation Task

For the final task, we selected a job negotiation simulation to increase the external validity of the study, as telepresence systems are envisioned for use in this scenario. Taken from a study on multi-round negotiation conducted by Curhan et al. (2010), the task involved the participant acting as a hiring manager and the confederate acting as a job applicant. The participant and the confederate each received a sheet of eight issues for negotiation with differing scoring matrices for each.

Each issue was divided into five items of potential agreement (e.g., Salary: $90,000, $88,000, $86,000, $84,000, or $82,000). The local participant and confederate each received complementary scoring sheets, such that, of the eight issues, two were fixed sum, so that a gain to one party came at an equal loss to the other; two were compatible, so that interests were aligned; and four were integrative, so that point values were disparately proportioned. Thus, both parties were on equal footing when beginning the negotiation. Figure 2 shows an example of one participant's scoring sheet. Based on this example, if Signing Bonus were a fixed sum issue, the confederate's scoring sheet would show declining points from 1600 to 0. If Job Assignment were a compatible issue, the confederate's scoring sheet would show the same declining point values from 0 to -2400. If Vacation Days were an integrative issue, the confederate's scoring sheet would show point values on a different scale (e.g., declining from 800 to 0). Eight pairs of scoring sheets were created, with each version rotating the allocation of points for each issue. Each dyad was randomly assigned to one of the eight pairs of scoring sheets at the beginning of the task.

Participants received a short instructional sheet explaining the hiring situation and were told to stay in role during the task. The instructions stated that the goal of the task is to reach an agreement with the other participant on all eight issues that is best for you (i.e., maximizing points), and that the two parties must agree on all 8 issues for the agreement to be valid. The instruction to the participant also stated that he or she should consider it to be worth hiring the confederate if his or her score was above zero, but that higher scores were better. The confederate recorded each item the pair agreed to during the task, facilitating computation of total points for each party based on the points assigned in their complementary scoring sheets.

To maintain consistency across participants, the confederate followed a semi-scripted negotiation strategy with the following rules: (1) at the beginning of the interaction, name the two issues with the highest point values as most important and name the two issues with the lowest point values as areas where the confederate could be flexible; (2) when asked to make a first offer, propose the most advantageous value for that issue; (3) when negotiating an item worth a negative number of points, propose also accepting an item in another issue worth a corresponding positive point value; (4) when the participant gives an initial offer on any issue, propose the item with the second-highest value in that issue; and (5) agree with the second proposal by the participant on any issue. Participants were given up to ten minutes to complete the negotiation.

Subjective Questionnaires

Participants filled out a questionnaire at the conclusion of the study. The questionnaire included 19 items measuring perceptions of the interaction along four dimensions. For three dimensions, items were rated on a Likert scale from 1 = "Strongly disagree" to 7 = "Strongly agree": engagement with the partner (four items, e.g., "I often felt as if I was working alone"; $\alpha = .83$), remote users' engagement with the local environment (five items, e.g., "The other participant knew where things in my environment were in relation to them"; $\alpha = .61$), and ease of working via the technology (seven items, e.g., "I never had trouble hearing or seeing the other participant"; $\alpha = .80$). The fourth dimension, dominance, included three items, reported on a bi-polar Likert scale where anchors are reversed versions of the same statement (e.g., 1 = "The other participant followed my lead during our interactions" to 7 = "I followed the other participant's lead during our interactions"; $\alpha = .72$). See Appendix A for the full list of items.

Additionally, following prior literature (Bradner & Mark, 2002), we asked participants to draw a picture representing the location of the remote partner relative to them. Participants also provided their demographic characteristics and reported what they liked and did not like about the interaction in an open-ended format.

Analyses

As recommended in prior research (Stöber et al., 2002), responses corresponding to the two sub-measures of the BIDR were summed, yielding continuous measures for self-deceptive enhancement and impression management. We used an analysis of variance (ANOVA) with these self-disclosure dimensions as dependent variables and system embodiment and geographic distance as independent variables.

Persuasion in the Desert Survival Task was analyzed using an ANOVA, with the summed absolute values of the differences between the confederate's proposed ranking and final ranking as the dependent variable and system embodiment and geographic distance as independent variables.

We also used an ANOVA to analyze effects on cooperation during the Negotiation Task. The dependent variable was the absolute value of the difference between the participant's and confederate's total points, with a smaller difference indicating greater cooperation, and a larger difference indicating less cooperation. The independent variables were system embodiment and geographic distance.

For the subjective measures, sub-scales from the questionnaire were tested for reliability, averaged, and then used as dependent variables in an ANOVA with system embodiment and geographic distance as independent variables.

The free form drawings from the questionnaire were coded by two independent raters, blind to condition, as "room" if they depicted the confederate as being in the room with the participant (i.e., representing the confederate in the location of the technology used to mediate the interaction), "close" if they depicted the confederate as being on the same campus, and "far" if they depicted the confederate as being across the country. Eleven participants (16.92%) were excluded from the dataset of drawings because they did not follow instructions to depict both themselves and the confederate. Inter-rater reliability for these drawings indicated a high level of agreement (Cohen's $\kappa = .82$, $p < .001$).

A Pearson's Chi-squared test was used for manipulation checks and to determine the effects of system embodiment on the confederate's location as depicted in the coded drawings.

Procedure

Upon arrival at our laboratory, participants were greeted and asked to read and sign a consent form. Next, the experimenter provided a high-level overview of the tasks. The experimenter then told the participant that there would be a short delay until the other study participant—either on-campus or across the country (depending on the condition)—indicated readiness. During this time, the confederate logged in to either the videoconferencing program or the telepresence robot system.

Following confirmation of the confederate's login, the experimenter led the participant into the experiment room and introduced the confederate as another participant in the study. The experimenter then stated that she would be providing all of the instruction for the tasks and told the confederate that the experimenter on campus or across the country should have provided a manila envelope marked "one" containing the questions for the first task. The confederate confirmed that he or she had received the questions for the first task. The experimenter instructed the participant to go to each station in order, reading the question numbers to the confederate, and the confederate to read the corresponding questions and record the participant's responses. The experimenter then left the room.

When all eight stations had been completed, the experimenter returned to the room and asked both the participant and confederate to read the instructions for the Desert Survival Task, stating that the confederate's experimenter on campus or across the country should have provided them with a second manila envelope. After the participant indicated readiness for the initial ranking, the experimenter set a timer for five minutes, told the participant and confederate not to discuss their rankings, and then left the room. If the timer went off or the participant indicated that the rankings were complete, the experimenter came back into the room and turned off the timer.

During the next instruction period, the experimenter told the participant and the confederate that they would be discussing their initial rankings and coming up with a final ranking for the items in the task. The experimenter provided the participant with nine pictures of the items and showed him or her the board or the wall with spaces for recording the final rankings. The experimenter told the participant and the confederate that they would have up to ten minutes to rank the items in order of importance, from one to nine, and that once an item was placed in a ranking spot it could not be moved. The experimenter then set the timer for ten minutes and left the room.

Following completion of the final rankings, the experimenter came back into the room and asked the confederate to open the third manila envelope provided by their experimenter on campus or across the country. The experimenter provided the participant with a copy of the instructions for the Negotiation Task and asked both to read them. When the participant had finished reading and indicated that there were no questions, the experimenter gave the participant a sheet of eight issues with accompanying point values. The experimenter asked the confederate to flip to the next page in their packet for their point values, set the timer another ten minutes, and left the room. Following the negotiation, the experimenter returned, invited the participant and the confederate to say goodbye to each other, and asked the participant to complete the questionnaire.

The time to complete the instructions and three tasks ranged from approximately 40 to 60 minutes.

Participants

A total of 65 participants participated in the study, of whom 27 were men and 38 were women. They were recruited in person from a college campus and from online job postings. Their ages ranged between 18 and 31, $M = 21.39$, $SD = 2.28$, with participants reporting low familiarity with robots (1 = "Not at all familiar;" 7 = "Very familiar"), $M = 2.815$, $SD = 1.57$, and high levels of comfort with videoconferencing (1 = "Not at all comfortable;" 7 = "Very comfortable"), $M = 5.49$, $SD = 1.35$. Participants were compensated at a rate of $10 per hour.

Results

We first conducted manipulation checks, showing that participants were able to distinguish between the videoconferencing and telepresence robot conditions, $\chi^2(1, n = 65) = 46.59$, $p < .001$. Based on the drawings from the second questionnaire, manipulations of perceived distance were also successful. Of the 24 participants in the across-the-country condition who followed the drawing instructions, 14 depicted their partner as being in the room with them, and 10 depicted their partner as “far” (e.g., across the country); thus, no participants in the across-the-country condition represented their partner as “close” (e.g., on campus). Similarly, of the 30 participants in the on-campus condition who followed the drawing instructions, 16 depicted their partner as being in the room with them, and 14 depicted their partner as as “near” (e.g., on campus); thus, no participants in the on-campus condition represented their partner as “far” (e.g., across the country). The paragraphs below describe the findings of the tests of our hypotheses and analyses of subjective measures. We only report effects that are significant at α level .05 and discuss marginal effects at α level .10 in order to inform future research. The main results of our analyses are illustrated in Figure 3.

Hypothesis 1

Our first hypothesis suggested that using an embodied system would increase persuasion and cooperation relative to videoconferencing. We did not find support for our first hypothesis. As far as persuasion, we did not find a significant effect of technology used on the difference between the confederate’s ranking and final ranking in the Desert Survival task, $F(1, 61) = 0.041$, $p = .841$, ${\eta_p}^2 = .001$ ($M = 7.41$ and $SD = 4.47$ in the videoconferencing condition; $M = 7.65$ and $SD = 4.25$ in the telepresence robot condition). As far as cooperation, we did not find a significant effect of technology used on the point difference between the participant and confederate in the negotiation task, $F(1, 61) = 0.067$, $p = .797$, ${\eta_p}^2 = .001$ ($M = 2737.50$ and $SD = 2016.82$ in the videoconferencing condition; $M = 2924.24$ and $SD = 2107.28$ in the telepresence robot condition).

Research Question 1

Our first research question asked how using an embodied system would affect socially desirable responding in the self-disclosure task. We did not find a significant effect of the technology used on self-deceptive enhancement, $F(1, 61) = 0.003$, $p = .959$,

${\eta_p}^2 = .000$ ($M = 86.69$ and $SD = 13.41$ in the videoconferencing condition; $M = 87.06$ and $SD = 11.62$ in the telepresence robot condition); however, we did find that participants whose partners were embodied via the telepresence robot demonstrated greater impression management, $M = 89.42$, $SD = 13.42$, than those whose partners interacted via videoconferencing, $M = 81.38$, $SD = 14.39$, $F(1, 61) = 5.26$, $p = .025$, ${\eta_p}^2 = .079$.

Hypothesis 2

Our second hypothesis predicted a main effect wherein participants would demonstrate greater social distance when perceiving their partners to be across the country rather than on campus by showing greater socially desirable responding, being less persuaded, and showing less cooperation. In contrast with prior work, we found no support for this hypothesis across any of our outcome measures. As far as socially desirable responding, we did not find a significant effect of geographic distance on self-deceptive enhancement, $F(1, 61) = 1.079$, $p = .303$, ${\eta_p}^2 = .017$ ($M = 88.44$ and $SD = 13.41$ in the close condition; $M = 85.16$ and $SD = 11.24$ in the far condition), or impression management, $F(1, 61) = 0.014$, $p = .907$, ${\eta_p}^2 = .000$ ($M = 85.44$ and $SD = 16.44$ in the close condition; $M = 85.48$ and $SD = 11.99$ in the far condition). As far as persuasion, we did not find a significant effect of geographic distance on the difference between the confederate's proposed ranking and final ranking, $F(1, 61) = 0.017$, $p = .895$, ${\eta_p}^2 = .000$ ($M = 7.47$ and $SD = 4.66$ in the close condition; $M = 7.60$ and $SD = 4.01$ in the far condition). As far as cooperation, we did not find a significant effect of geographic distance on the point difference between the participant and confederate, $F(1, 61) = 0.015$, $p = .901$, ${\eta_p}^2 = .000$ ($M = 2814.71$ and $SD = 1699.93$ in the close condition; $M = 2851.61$ and $SD = 2404.01$ in the far condition).

Hypothesis 3

Our third hypothesis predicted that the embodiment of the remote partner in robot-mediated communication would alleviate the negative effects of geographic distance relative to its effects in video-mediated communication. Thus, we posited an interaction effect, wherein participants interacting via the telepresence robot would demonstrate similar levels of socially desirable responding, persuasion, and cooperation regardless of their partners' geographic distance, while participants using videoconferencing would exhibit higher socially desirable responding, would be less persuaded, and would demonstrate less cooperation toward a remote user perceived to be across the country as opposed to one perceived to be on campus with them.

We found partial support for this hypothesis. We did not observe interaction effects between system and geographic distance on self-deceptive enhancement, $F(1,61) = 0.194$, $p = .661$, ${\eta_p}^2 = .003$, impression management, $F(1,61) = 0.004$, $p = .952$, ${\eta_p}^2 = .000$, or the difference between the confederate's proposed ranking and final ranking in the persuasion task, $F(1,61) = 0.369$, $p = .546$, ${\eta_p}^2 = .006$. However, we did find a significant interaction effect between system and geographic distance on the gap between confederate and participant scores in the negotiation task, $F(1,61) = 7.87$, $p = .007$, ${\eta_p}^2 = .114$, as shown in Figure 3. Planned comparisons assessed, for each technology, the simple effects of distance on the gap in negotiation outcomes. As expected, in video-mediated negotiation, perceiving the partner as geographically close led to a smaller distance between scores, $M = 2018.75$, $SD = 1137.38$, than did perceiving the partner as geographically far, $M = 3456.25$, $SD = 2451.66$, $F(1,61) = 4.25$, $p = .044$, ${\eta_p}^2 = .065$. In robot-mediated negotiation, however, there was a marginal effect in the opposite direction, such that more equal outcomes tended to result when perceiving the partner as geographically far, $M = 2206.67$, $SD = 2254.03$, than when perceiving the partner as geographically close, $M = 3522.22$, $SD = 1828.07$, $F(1,61) = 3.64$, $p = .061$, ${\eta_p}^2 = .056$.

Subjective measures

There was a main effect of the system used on participants' perceptions of how engaged the remote user was with the local environment; participants who interacted with the confederate via the telepresence robot rated their remote partner as more engaged with the local environment, $M = 5.48$, $SD = 0.88$, than did participants who interacted using videoconferencing, $M = 4.87$, $SD = 0.87$, $F(1, 61) = 8.58$, $p = .005$, ${\eta_p}^2 = .123$. We also found an unexpected marginal effect of the partner's perceived geographic location on engagement in the local environment, with those who believed their partner to be across the country rating that partner as more engaged in the local environment, $M = 5.37$, $SD = 0.65$, than participants who believed their partner to be on campus with them, $M = 5.01$, $SD = 1.09$, $F(1, 61) = 3.55$, $p = .064$, ${\eta_p}^2 = .055$. There was no significant interaction between technology and geographic distance on engagement in the local environment $F(1, 61) = 1.525$, $p = .222$, ${\eta_p}^2 = .024$.

We found no main effects of system embodiment or geographic distance on the other subjective measures. For engagement with the partner, there was no significant effect of technology, $F(1, 61) = 0.030$, $p = .864$, ${\eta_p}^2 = .000$, geographic distance, $F(1, 61) = 1.243$, $p = .269$, ${\eta_p}^2 = .020$, or their interaction, $F(1, 61) = 1.104$, $p = .298$, ${\eta_p}^2 = .018$. For ease of working with the technology, there was a marginally significant effect of technology, $F(1, 61) = 3.815$, $p = .055$, ${\eta_p}^2 = .059$, such that greater ease of use was reported by those communicating by videoconference ($M = 6.23$, $SD = 0.62$) than by those communicating by telepresence robot ($M = 5.86$, $SD = 0.86$), but there was no significant effect of geographic distance, $F(1, 61) = 0.245$, $p = .622$, ${\eta_p}^2 = .004$, and no significant interaction between technology and geographic distance, $F(1, 61) = 0.407$, $p = .526$, ${\eta_p}^2 = .007$. For dominance, there was no significant effect of technology, $F(1, 60) = 0.013$, $p = .911$, ${\eta_p}^2 = .000$, geographic distance, $F(1, 60) = 0.342$, $p = .561$, ${\eta_p}^2 = .006$, or their interaction, $F(1, 60) = 0.091$, $p = .764$, ${\eta_p}^2 = .002$.

In their free-form drawings, 65.52% of those in the robot condition represented their partner as being in the room with them versus 44.00% in the videoconference condition, but this difference was not significant, $\chi^2(1, n = 54) = 2.52$, $p = .11$.

Discussion

In a series of three tasks, we found that the technologies participants used to communicate with their remote partners affected how they collaborated. First, as in prior studies, our findings suggest that embodiment increased local users' sense of their partners' engagement in the environment. We also found a main effect of embodiment on socially desirable responding, with local users who interacted with their partners via the telepresence robot showing greater impression management than did those whose interacted with their partners via videoconferencing, although no main effects of embodiment were observed for persuasion or negotiation tasks. Contrary to prior literature, we did not find main effects of geographic distance on any outcome. Finally, our results from the negotiation task suggest that effects of geographic distance on cooperation were moderated by the technology used. In videoconferencing, negotiation outcomes were more equal when partners were perceived to be geographically close and less equal when partners were perceived to be geographically far, which aligns with prior research. Participants in robot-mediated interactions, however, did not demonstrate such a pattern. These findings extend and add nuance to the literature relating to the effects of embodiment and geographic distance in remote collaboration.

While prior literature has often depicted embodiment as enabling common ground and building intimacy between local and remote partners, the present study suggests that the confederate's embodiment actually escalated the local partner's impression management. Relative to those answering questions posed by partners in video-mediated communication, local users answering questions posed by embodied partners tended to emphasize positive aspects of themselves and to deemphasize negative ones. This finding may relate to participants in robot-mediated interactions having greater awareness of their embodied partners' presence, perhaps making partners' potential judgment salient and escalating inhibition. For instance, one participant relayed discomfort related to her partner's embodied movement during the self-presentation task, writing the following:

> *"Sometimes I would catch myself waiting to see whether or not [the confederate] was following behind me during the questionnaire activity."*

Conversely, in videoconferencing, the diminished presence of the partner may have reduced inhibition, such that individuals expended less effort to manage their impressions. If supported by further work, this finding suggests that embodiment via a telepresence robot could have consequences for building relationships, since candid self-disclosure is a well-established mechanism by which communication partners come to like one another more (Collins & Miller, 1994).

The observed effects of geographic distance partially confirm but also contrast those found in earlier studies. While prior studies have observed that geographic distance can impede video-mediated collaboration, our study only found support for these effects on negotiation outcomes. Consistent with findings by Bradner and Mark (2002), we observed that videoconferencing participants achieved more equal negotiation outcomes when interacting with partners that they believed to be geographically close. Since more equal outcomes may reflect greater empathy toward the partner (Nguyen & Canny, 2009), prior findings were interpreted as suggesting that geographic distance implies *social* distance, with cooperation being heightened due to participants' perceiving their on-campus partners as sharing an in-group membership.

Importantly, whereas Bradner and Mark (2002) found geographic distance effects that were independent of the mediating technology (videoconferencing or instant messaging), our results suggest that the same pattern does not extend to robot-mediated communication. We had proposed that embodiment would diminish the influence of geographic distance by providing a sense that the partner was "really there" in the local user's space. Consistent with our third hypothesis, we found differential effects of geographic distance on negotiation outcomes according to whether interactions were video-mediated or robot-mediated.

We did not anticipate, however, that embodiment would potentially *reverse* effects of geographic distance. In robot-mediated interaction, our data show a trend toward more equal negotiation outcomes when partners were perceived as geographically far from the participant. This finding warrants further investigation but suggests that embodiment led local participants to extend greater cooperation toward those perceived to be far away. Related to this possibility, open-ended responses suggest that some participants tied their enthusiasm for robot-mediated interaction to the distance of their partner, with one participant writing as follows:

> *"I thought [that] it was really cool that someone so far away from me can interact with me so effortlessly with this technology."*

Thus, the partner's embodiment may have had appeal when considering distance. This could reflect the novelty involved in being simultaneously close in the sense of the embodiment and far in the sense of geography, or perhaps that the partner's greater geographic distance alters perceptions of their status.

Has Technology Closed Distance Over Time?

Taken together, the effects of geographic distance we describe are less consistent and less robust than those observed in prior research. Indeed, we did not replicate effects of geographic distance on persuasion or self-presentation. Perhaps diminishing effects of geographic distance relate to the nearly 20 years elapsed since the earlier research (Bradner & Mark, 2002). We now live in a more connected world in many ways, with participants having personal experience connecting to far away partners through videoconferencing and other technologies, and some participating in geographically dispersed professional teams, online communities, or romantic relationships. In this context, geographic distance may no longer be as meaningful a determinant of social distance. An erosion of distance effects might correspond to the "contact hypothesis" proposed by Allport (1958), which suggests that relationships with out-group members undermine the application of group-based stereotypes. That is, tendencies to treat partners as out-group members based on geographic distance may have eroded through personal contact with far-away partners. On the other hand, our results suggest persistence of geographic distance effects when it comes to video-mediated negotiation. Perhaps in-group and out-group identities are especially salient when considering financial rewards, or when self interests (to maximize points) compete with cooperative outcomes.

The Match Between Need and Use

Experience and novelty may also relate to the surprising trend we observed in robot-mediated communication wherein marginally greater cooperation was extended to partners who were perceived as geographically far. As a form of technology becomes commonplace, people develop more nuanced mental models of how it works, the skills required to engage with it, and when its use is socially appropriate. Whereas videoconferencing has been integrated into everyday routines for connecting to both proximal and distant partners, telepresence robots have not. Perhaps individuals' mental models for robot-mediated communication tend to focus on more obvious applications of these systems in connecting people across large distances, neglecting other possibilities. When told that the remote partner was across the country, the use of the telepresence robot may therefore have matched participants' expectations. However, when told that the remote user was on campus, participants' expectations may not have been met. With a range of technologies, prior research shows that a mismatch between a technology's perceived application and its observed use can result in consequences such as hostility toward the technology, anger at the system's users, or outright rejection of the value of the system (Ames, 2013; Humphreys, 2005; Jung & Philipose, 2014; Takayama & Go, 2012). Removing telepresence from the context of long-distance communication could have made participants uneasy, allowing remote partners to enter their immediate environment in a way that felt inappropriate given alternative opportunities to meet face-to-face when they were on the same campus.

Theoretical Implications

Our findings suggest a number of implications for computer-mediated communication theory, two of which we discuss here. First, our findings in the self-disclosure task suggest that a partner's embodiment may produce more socially desirable responding. This contrasts with views of computer-mediated communication, broadly, as facilitating "online disinhibition," wherein online communicators present themselves in a candid manner (Joinson & Paine, 2007; Suler, 2004). Subsequent work has since clarified that specific features of technologies can support or undermine disinhibition. For instance, individuals may be less inhibited when technologies let them disclose anonymously, without eye contact, or to specific versus undefined audiences (Bazarova & Choi, 2014; Joinson & Paine, 2007). Our findings extend this work by suggesting embodiment as a media feature with potential to inhibit self-disclosure, and thus a potential boundary condition for online disinhibition. Similarly, some work on embodiment and disclosure considers how users communicate with embodied computer agents (e.g., virtual humans, relational agents) (Schuetzler et al., 2018; Sproull et al., 1996), finding that an agent's embodiment (e.g., via an animated face) can escalate socially desirable responding, which has been interpreted as reflecting greater "humanness" of the computer agent, as well as greater social presence (Schuetzler et al., 2018). In the case of telepresence, likewise, the nonverbal cues conveyed by the embodied partner (e.g., movement, proximity, orientation) appear to escalate that partner's social presence, which may contribute to the observed effects on self-disclosure.

Another theoretical implication of our findings is that they challenge the notion that geographic distance activates a perception of social distance in remote collaboration. Specifically, Bradner and Mark (2002) suggested that their results show a psychological bias favoring those who are geographically close, noting that perceived proximity enhanced collaboration regardless of the technology used. These findings were also consistent with construal level theory, which proposes that—with regard to both spatial and psychological distance—people move from a relatively “closer” construal level, where they recognize nuance and detail, to a “farther away” construal level, where they perceive people and things more abstractly, including seeing them in less individualized ways (Trope & Liberman, 2010). In contrast, our results in the present study fail to show main effects of geographic distance. We have suggested that the reduction of effects of geographic distance could perhaps relate to a more connected world view, or a “flattened world,” as mediated communication has become mainstream for connecting individuals to distant partners.

Design Implications

We next consider the implications of our findings for design, both the design of telepresence systems’ appearance and the cues they convey, and the design of strategies for when and how to deploy these technologies to optimize collaboration.

Our findings first suggest that interacting via the telepresence robot system had an inhibitory effect on local partners’ candid self-disclosure, with these partners presenting themselves more in more socially desirable ways than did those interacting through videoconferencing. It is possible that the same embodiment that allows individuals to feel enhanced presence of their partners also brings these partners *too* close for comfort in the context of disclosure. If future research supports such effects, it is worth considering how telepresence robots should be deployed in contexts where intimate disclosure is required, at least with new communication partners with whom one has not yet established trust. We might therefore consider the capacity of robotic telepresence systems to de-escalate self-consciousness, perhaps by modulating the level of embodiment they support. For instance, while movement, orientation toward the partner at eye level, and high-resolution video are helpful in many scenarios, the level of presence these features generate might be excessive when the situation calls for local partners to share personal vulnerabilities. In such contexts, perhaps different “modes” could facilitate a reduction in cues, such that the remote partner’s level of presence is more conducive to candid self-disclosure.

Of course, it is important to note that socially desirable responding is not always undesirable. For example, when seeking a job, a raise, or a promotion, presenting oneself positively may be quite beneficial. Whether a designer seeks to amplify or diminish socially desirable responding may depend on the particular domain of interaction.

Our results also suggest that users of telepresence systems may have mental models that influence their perceptions of when it is socially acceptable to use these technologies. We suggested that marginally less cooperation may have been extended to geographically close partners in robot-mediated interactions because of the mismatch between perceived need and actual use of the telepresence system. Likewise, while using a cellphone to contact a family member from across the country may be deemed appropriate, using a cellphone to call a family member in the other room may violate social norms, leading to a negative reaction or even a rejection of the technology (e.g., a "no-cellphones-in-the-house" rule). Designers of communication technologies should consider the expectations that might be evoked when developing new platforms and how these expectations match actual use cases. For instance, to prevent perceptions of the use of telepresence robots as being gratuitous, designers may strive to display information that provides greater context regarding the remote user (e.g., if they are far away, have a disability or health concern, or have a tight schedule such that they can't leave their office).

Limitations and Future Work

As does any single laboratory study, our study has a number of limitations. First, similar to prior work in this area (Bradner & Mark, 2002), we employed a confederate to create a more consistent manipulation across conditions. However, future work should examine how geographic distance affects both local and remote users and whether this effect is symmetric. Notably, our study featured only the participant answering personal questions, and this participant was not embodied via a technology, whereas their partner was. This contrasts with some recent work on disclosure and embodiment in interpersonal communication that has featured disclosers who are themselves embodied (e.g., as avatars) (Hooi & Cho, 2014; Y.-H. Lee et al., 2018). Future work might assess whether similar levels of socially desirable responding are present when the discloser is embodied, the partner is embodied, or both are embodied. Furthermore, since disclosure is typically reciprocal (Collins & Miller, 1994; Cozby, 1972; Jiang et al., 2013), future work may also examine effects or embodiment on socially desirable responding where disclosure requirements are mutual.

Additionally, we used two confederates in order to recruit sufficient participants to carry out the analyses, but it is possible that personal qualities of these confederates may have affected collaboration. We attempted to minimize this potential by using semi-scripted responses. We also conducted sensitivity analyses with confederate as a covariate, but because these results were substantively the same, we presented ANOVA results for purposes of simplicity.

Our study is also limited in the sense that we use one particular commercial telepresence robot. Our results provide a first glimpse into the effects that the system has on collaborative processes and perceptions of distance, but more work is needed to replicate these findings. While the rapid pace of technological development may create hurdles in such research, in that systems become out-of-date more rapidly, it also provides opportunities to investigate an expanding range of system factors that may strengthen or weaken these effects. For example, future studies may investigate whether the screen size, sound volume, and level and fluidity of movement affect user behaviors.

Future research may also further probe the relationship between system embodiment and socially desirable responding. While we suggest that embodiment may represent a boundary condition for online disinhibition (Suler, 2004), it is unclear from our research whether embodiment only partially erodes online disinhibition or reduces it to a level that is consistent with face-to-face interaction. A partner's embodiment via telepresence robot could even increase inhibition to *exceed* levels in face-to-face interaction.

Given that a use case for telepresence robots involves embodied clinicians providing remote care (Latifi et al., 2007), it will be important to understand whether patients in these interactions feel comfortable candidly disclosing details about their health histories and behaviors. Future work should also seek to clarify whether expert users of a telepresence robot could better harness the embodied cues to express empathy and attention in ways that counteract the local partner's inhibition.

Furthermore, a range of technologies beyond telepresence robots provide an embodiment of the user, and some may come closer to giving an experience of unmediated interaction with the world. We used a high-end telepresence robot, designed for professional use, but its actions still provide only a rough approximation of the ways people move and interact with their local environments and face-to-face communication partners (e.g., walking, shaking hands, sitting, engaging with objects in the room) (Choi et al., 2017). Future research could therefore assess how increasing the level of embodiment alters communication processes, such as when robots allow for more nuanced movements and gestures. In addition, some work has begun to examine the effects of embodiment when users interact through virtual avatars, or through augmented and virtual reality systems that capture natural body movements (e.g., through the use of sensors), but more work is needed to clarify the precise relationship between these different forms of embodiment, the subjective experience of presence, and interpersonal processes (Li, 2015; Mutlu, 2020). For example, future work may ask what types of embodiment produce the strongest experience of presence, and whether activating a sense of presence represents a necessary condition for building common ground through an embodied system.

One of the more interesting findings from our study was the apparent reduction in geographic-distance effects relative to prior studies with a similar design. While we partially replicated effects of geographic distance in a negotiation task, we did not find effects on self-presentation and persuasion. These findings raise the question of whether tendencies to attribute greater social distance to geographically far partners have eroded over time as remote collaboration became ubiquitous. Notably, since these data were collected, remote collaboration has become even more commonplace as a consequence of social distancing and working from home during the COVID-19 pandemic (Waizenegger et al., 2020), and this may have further shifted how individuals conceive of the geographic distance of their collaborators. Future research could address this by comparing the effects of perceived geographic distance between those who do and do not have experience with remote collaboration. In addition, future work might seek to better disentangle physical proximity and in-group/out-group distinctions by manipulating these separately, such that a remote partner may be geographically near or far, and may also belong or not belong to the same organization. For example, in order to increase geographic distance but not social distance, the remote partner may be presented as interacting from a different campus of the same University.

Additionally, our results highlight the need to clarify the mechanisms by which embodiment shapes the effects of distance. We proposed that partners in robot-mediated negotiation may be less cooperative to geographically close partners due to this technology feeling gratuitous for this context. Future work may solicit participants' expectations about appropriate use cases for telepresence and may measure affective experiences (e.g., frustration) that could emerge from perceived mismatches (Rae et al., 2015), as well as ways to address these mismatches. For example, telepresence technologies might feel less gratuitous if participants were given convincing rationales for their use with geographically close partners, such as remote users being physically unable to travel.

Finally, it should be noted that behavioral outcomes (socially desirable responding, persuasion, and negotiation results) involve high levels of variability across individuals and dyads. Our results provide partial support for our hypotheses, but additional work in this area may further clarify the role of embodiment and geographic distance in collaboration, including using different study designs that are better able to detect small effects. In studies with multiple tasks, there is a possibility of order effects (e.g., participants becoming more comfortable with telepresence robots over time). Counterbalancing of tasks could be helpful in future studies, particularly if comparisons are made across tasks.

We chose the tasks in this experiment to build on prior research and to represent core social processes involved in collaboration; clinical and workplace uses of telepresence robots involve self-presentation, application of telepresence robots in sales and presentations involve persuasion, and workplace uses of telepresence robots involve cooperation toward common goals. That said, further research should examine these processes, and the role of distance, in the context of in situ uses of remote communication technologies. For example, participants in our experiment were routinely informed of the supposed location of their remote partner, but it is unclear whether remote partners' locations are more or less salient when interacting outside the laboratory, such as in medical, workplace, and classroom contexts.

Conclusion

In this study, we examined how collaboration was affected by the interplay between a partner's perceived geographic distance and their embodiment via a communication system. We examined outcomes in three tasks involving self-presentation, persuasion, and negotiation. In contrast to prior work, we found main effects of system embodiment but not geographic distance. When using a physically embodied system (a telepresence robot) relative to a system without physical embodiment (a videoconferencing system), participants perceived remote partners as being more engaged in the local environment, but they also demonstrated more impression management during a self-presentation task. We also found an interaction effect such that perceiving greater geographic distance produced different effects depending on the technology used to mediate the interaction. When the remote user was perceived as being on the same campus as the local user, we observed more equal negotiation outcomes, but only in the case of videoconferencing. Our results illustrate the role of physical embodiment in shaping self-presentation and moderating the effects of geographic distance. We hope that future work can clarify how cues afforded by embodied telepresence technologies contribute to these effects.

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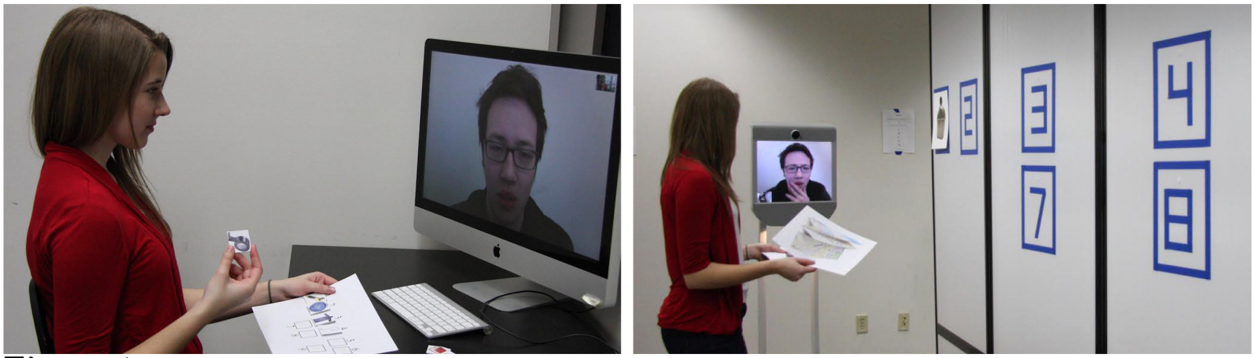

Figure 1

The Desert Survival Task as administered with the two systems. On the left, the nine pictures and sheet provided in the videoconferencing condition. On the right, the nine pictures and wall placements provided for the telepresence-robot condition.

Signing Bonus	Points	Moving Expenses	Points
10%	0	100%	0
8%	400	90%	200
6%	800	80%	400
4%	1200	70%	600
2%	1600	60%	800
Job Assignment	**Points**	**Insurance Provider**	**Points**
Division A	0	Allen Ins.	0
Division B	-600	ABC Ins.	800
Division C	-1200	Good Health	1600
Division D	-1800	Best Ins. Co.	2400
Division E	-2400	Insure Alba	3200
Vacation Days	**Points**	**Salary**	**Points**
30 days	0	$90,000	-6000
25 days	1000	$88,000	-4000
20 days	2000	$86,000	-3000
15 days	3000	$84,000	-1500
10 days	4000	$82,000	0
Starting Date	**Points**	**Company Car**	**Points**
June 1	0	LUX EX2	1200
June 15	600	MOD 250	900
July 1	1200	RAND XTR	600
July 15	1800	DE PAS 450	300
Aug 1	2400	PALO LSR	0

Figure 2

An example scoring sheet used in the negotiation task adapted from Curhan et al. (2010).

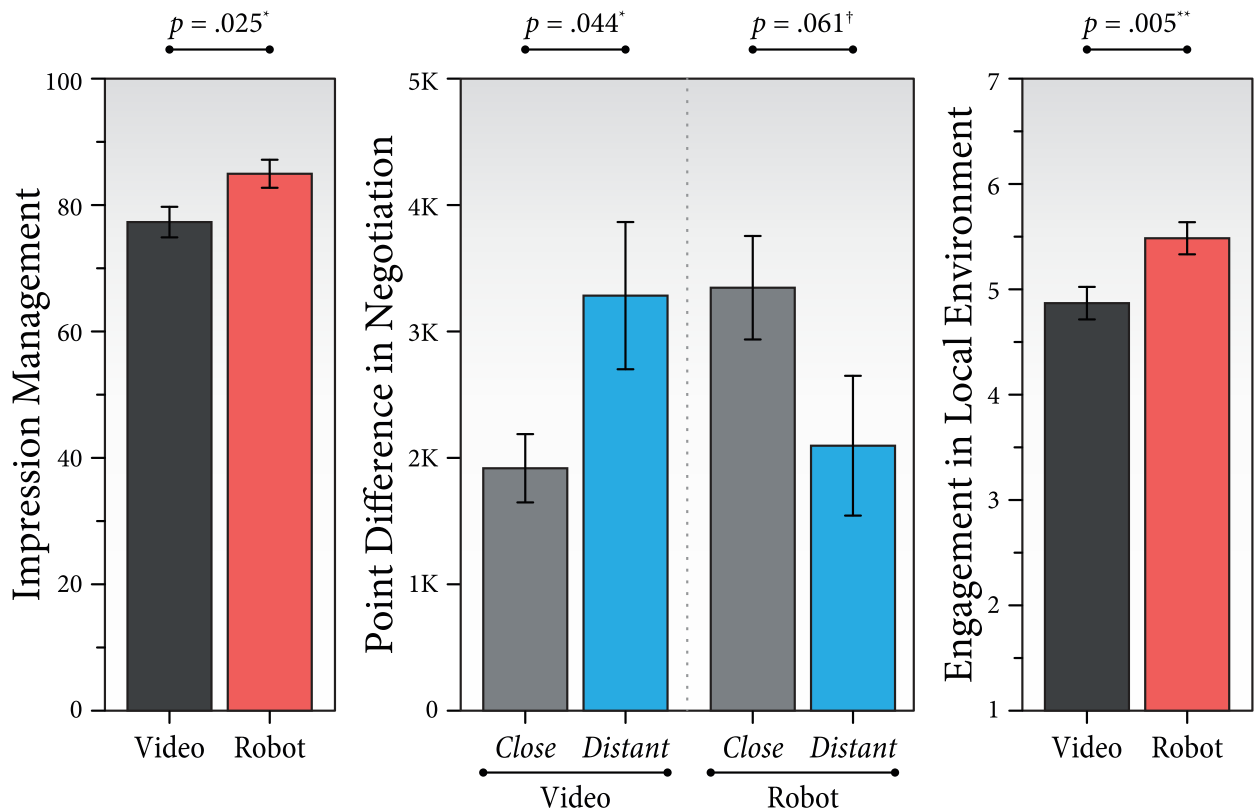

Figure 3

Significant results from the impression-management task, the negotiation task, and the subjective measurements of partner engagement. (†), (*) and (**) denote $p < .10$*,* $p < .05$ *and* $p < .01$*, respectively.*

Dimension	Item
Partner's engagement in local environment	The other participant spent more time paying attention to things in their environment than in my environment. (R)
Partner's engagement in local environment	The other participant had no trouble understanding where they were in my environment.
Partner's engagement in local environment	The other participant knew where things in my environment were in relation to them.
Partner's engagement in local environment	The other participant knew where I was at all times.
Partner's engagement in local environment	There were times when I felt like the other participant was with me in the room.
Engagement with the partner	It was easy to forget that the other participant was there.
Engagement with the partner	It was easy for the other participant to forget that I was there.
Engagement with the partner	I often felt as if I was working alone.
Engagement with the partner	I think the other participant often felt like they were working alone.
Ease of working with the technology	Lag made it difficult to communicate. (R)
Ease of working with the technology	I never had trouble hearing or seeing the other participant.
Ease of working with the technology	I followed the other participant's lead during our interactions.
Ease of working with the technology	I was always able to understand what objects or locations the other participant was talking about.
Ease of working with the technology	The other participant was always able to understand what objects or locations I was talking about.
Ease of working with the technology	I was able to easily get the other participant's attention.
Ease of working with the technology	The other participant was able to easily get my attention.
Dominance	I had more input into the outcome of our tasks than the other participant.; The other participant had more input into the outcome of our tasks than I did.
Dominance	The other participant followed my lead during our interactions.; I followed the other participant's lead during our interactions.
Dominance	I had more control over our interaction that the other participant.; The other participant had more control over our interaction than I did.

Figure 4

Appendix A: Measures of subjective perceptions of the remote interaction