

Our House: Living in a Long Distance Relationship through a Telepresence Robot

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Many couples are in long distance relationships due to a variety of reasons ranging from work opportunities to family obligations. However, current computer-mediated communication tools are not designed to support the entire range of communication behaviors that long distance couples engage in during daily life. Our research explored how telepresence robots might fit into the array of tools that long distance couples use to communicate, given the factors of mobility and physicality that could support acts of interactivity and autonomy between partners. We found that telepresence robot communication facilitated interactions in five areas: participation in mundane everyday routines, feelings of sharing a home, connection with one's partner's family and friends, increased helpfulness, and the enjoyment of quiet companionship. However, telepresence robots also presented challenges related to privacy and asymmetry, as well as continued deficiencies in the level of interactivity. In response to these findings, we discuss design opportunities for telepresence robots.

CCS Concepts: • **Group and Organization Interfaces** → **Computer Supported Cooperative Work**

KEYWORDS

Telepresence robots; long distance relationships.

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1 INTRODUCTION

Given the importance of communication in maintaining relationships, and the prevalence of long distance couples [14,20,30], the continued exploration and improvement of communicative tools holds great value for improving the quality of life for those living far apart from their partners. Couples typically use computer-mediated communication (CMC) tools, such as email, text messaging, mobile phone calls, video chat, and social networking sites to stay connected [21]. While often considered necessary for maintaining relationships over distance [1], commonly used CMC tools do not support the full spectrum of communication needs that long distance partners have [21]. For example, mainstream CMC tools, such as text messaging and email, are not designed to support partners in “hanging out” during leisure hours at home [21] or in sharing activities [8]. They are typically unable to provide feelings like one is actually physically present in the remote location [21]. There is also little understanding of how emerging technologies map to the communication needs of long distance partners, and what design directions would be best-suited for supporting the at-home life of long distance couples.

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In this paper, we utilize an in-home field study to investigate how telepresence robot technology may be used as a method for connecting long distance partners. Telepresence robots are a multi-channel communication tool that includes a video conferencing display attached to a base with wheels. Remote users can see into the remote space and move the telepresence robot as desired. The embodied and mobile design of telepresence robots allows them to better replicate certain qualities of in-person interactions compared to traditional communication tools (e.g., email, text messaging, video chat) [22], making them a potentially beneficial tool for long distance couples. To date, telepresence robot research has primarily focused on workplace and other organizational entities (e.g., [18,22,23]), and yet the movement capabilities as well as the embodiment of telepresence robots make them a compelling tool for personal communication. Our work aims to answer the following research questions to address the research gap: How do long distance couples use telepresence robots in the home? How does communication between long distance partners change using telepresence robots, if at all? What design factors are important in telepresence robots to support long distance relationships in the home context? Our overarching goal was to identify both positive and negative experiences of using telepresence robots to support in-home activities in long distance relationships, and inform design opportunities.

To answer the research questions, we conducted one month long field trials in the homes of seven long distance couples who used a Beam+ telepresence robot. Together, our work contributes the first field study of telepresence robots in a domestic setting for connecting loved ones over distance, as most telepresence robot research focuses on organizational settings such as the workplace, schools, or health-care settings (e.g., [18,23,27]). Our work brings forward the unique needs of long distance couples for telepresence robots not seen in the prior literature, which includes using telepresence robots to connect to see the mundane everyday activities of one's partner and the need to just 'be present' without necessarily talking to support 'quiet companionship.' We also present both the benefits and challenges from asymmetry and the fact that the telepresence robots are only in one location and not both. Together, our results present a series of design opportunities for telepresence robots if they are to be designed to adequately support the needs of long distance partners in domestic contexts.

2 RELATED WORK

The role of computer-mediated communication (CMC) for maintaining relationships is becoming increasingly prominent. However, given the lengthy physical absence that long distance couples experience from one another, there are further forms of connectivity that are unavailable to them, such as touch, shared contexts, and the ability to participate in joint activities [8]. Current mediated communication tools do not support the same range of relationship maintenance behaviors that partners can engage in when together in person. Behaviours such as having open communication, managing conflicts, sharing tasks and chores, being positive, and expressing one's love physically are well-established in relationship literature as being important for the continued maintenance and development of relationships [32]. Yet CMC systems can constrain conversations to focus on topics that are easy to discuss over certain mediums (e.g., short conversations for text messaging) [21]. They also make it difficult and/or awkward to do activities together [21]. Thus, previous work has considered the implications of communicating through mediated channels versus in person [4]. It has been found that couples who are long distance full-time perform less maintenance behaviors than long distance partners who are only long-distance part-time [4]. Such findings are significant because engaging in relationship behaviors is positively correlated with desirable relationship outcomes such as relationship satisfaction [33] and development [6]. While long distance couples are using many of the same CMC tools as geographically close couples [31], research has shown that some long distance couples use video chat tools in a unique manner, that has been described as "always-on" video [21]. By leaving video chat systems on for extended

periods of time, often in the background of other activities, partners simulated hanging out with one another while at home. Together, this research provides strong motivations for continued explorations of CMC systems for long distance couples, especially with expanded abilities to better support a wider range of relationship maintenance behaviors.

Design work on connecting couples over distance has often focused on expressive communication systems involving interconnected tangible objects [8,34]. For example, WearLove is a device worn on the wrist and used to send heart symbols to the wearer's partner's device [11]. Cubble lets partners express their emotional connection through colors, vibration, and warmth sent to one another's devices [16]. MissU transmits shared music and background sounds between partners so they can share an audio space [19]. Flex-N-Feel transmits touch over distance through vibrotactile gloves, and has been found to support both feelings and acts of intimacy between partners [29]. MyEyes streams first person views between partners and includes viewing modes, such as overlapping or split views to 'see through a partner's eyes' [25]. The Sensing Beds simulates the warmth of each partner's body on the other partner's bed [5]. CoupleVIBE automatically sends location updates to one's partner through coded vibrational signals to increase partners' sense of connectedness [2]. A study found that it was able to help keep couples in 'sync' [2]. Naturally, there are a whole host of other systems of a similar genre where awareness information or interactions can be shared between partners using a specific object or device. In contrast, our work explores what it might be like to have long distance partners use a telepresence robot to connect across homes with a much larger range of possible interactions than these systems.

In 1996, Paulos and Canny introduced the concept of socially oriented telerobotics and described a Personal Roving Presence (PRoP) [26]. Presently, it is more widely called a telepresence robot. Telepresence robots are video chat systems with added mobility and physicality. Research on telepresence robot usage for social purposes is consistent across various settings. Both remote pilots and local interactants view telepresence robots as useful communication tools for people who cannot physically be somewhere they need to be [18,22]. For example, companies have explored the use of telepresence robots to better integrate remote workers into the workplace experience and have found them to be useful for supporting a sense of presence in the remote location, largely because of the remote user's ability to be mobile [18]. Local interactants also became more aware of the remote user's presence as the remote user moved around autonomously through the space [18]. Furthermore, the remote pilots benefitted from greater impromptu availability, which led to inclusion in spontaneous conversations, such as hallway discussions, and unplanned meetings [18]. Use in schools granted similar benefits as seen in the workplace, such as access to hallway conversations and joining peers for lunch [3]. Telepresence robot usage at academic conferences has found them beneficial for small-scale social interactions [22].

Issues with telepresence robot use include the effort of driving, the lack of self-awareness (ie. what do I look like? how loud am I to the people around me?), lack of self-presentation (ie. the ability to dress the robot or represent other facets of one's appearance) [18,22,23], and privacy challenges due to use across mixed contexts [22,23]. Due to the absence of appendages, telepresence robots are limited in expressiveness when it comes to body language [22,23]. Furthermore, the lack of a head-turning function leads to a limited field of view leaving remote users with less peripheral awareness [10]. Given these challenges, researchers have suggested various improvements to telepresence robots including wide or panoramic views [10,12,13], robots with adjustable heights [28], adjustable audio levels based on ambient noise [12], and features to mask video details to better preserve privacy [22]. While many findings are generalizable across settings, there has been little research into telepresence robot usage in the home as a communication tool between loved ones [37]. An initial study of telepresence robots in long distance partners' homes shows preliminary results from two couples and illustrates the value of the robot's mobility [37]. We provide a larger scale study in the current paper with a

more nuanced exploration of couples' behaviors with telepresence robots and their effect on relationship maintenance behaviors.

Overall, our work extends the literature on telepresence robot usage for social purposes in considering the use of this technology in the home setting. The relaxed nature of at-home interactions is counter to the high-efficiency communication that CMC tools are typically designed for in workplace and educational contexts, and yet the home is also an important space for our daily interactions. Thus, there is a need for better understanding of how to design for communication in this private space. The embodied and mobile traits of the telepresence robot represent a potentially beneficial tool for supporting natural in-person interactions, making it potentially suitable for scenarios that are currently poorly supported by CMC tools, such as sharing activities and hanging out. On the other hand, telepresence robots may also reveal new challenges. This is the focus of our research where we explore how telepresence robots might be used by long distance partners to support everyday activities and interactions in the home.

3 USER STUDY

The goal of our research was to understand how long distance couples would use telepresence robots in the home; how communication between long distance partners might change when using telepresence robots, if at all; and, what design factors are important in telepresence robots to support long distance relationships. The study was approved by our university research ethics board.

3.1 Participants

We recruited seven couples through snowball sampling across our social networks. We created email and social media posts and shared them within our social networks via email lists at our university, Facebook, and Twitter. Of the couples who participated, two couples had direct ties to the researchers. The remaining couples were not known to the researchers prior to the study. When responding to our study call, some participants were hesitant to the idea of using a telepresence robot to mediate their relationship. In some cases, one of the two partners had to convince the other to try out the technology. Overall, what this means is that some participants were excited about trying out a new technology, while others were hesitant and skeptical. Thus, in our convenience sample, we have a diversity of perspectives coming into the study, which we believe helped us draw out both positives and negatives about the technology.

	Couple #1	Couple #2	Couple #3	Couple #4	Couple #5	Couple #6	Couple #7
Name Aliases	Ron & Kelly	Stan & Tara	Gary & Laetitia	Beth & Carl	Arnie & Mirna	Ellie & Alan	Sarah & Ken
Length of Relationship (years)	4	1.5	5	5	2.5	2	0.4
Relationship Type	Married	Dating	Dating	Dating	Dating	Dating	Dating
Time Difference (hours)	15	3	0	3	13	3	0
People in the Household	2	2	1	5	4	4	1
Local Gender	m	m	m	f	m	f	f
Local Age	23	25	32	20	27	24	35
Local Occupation	Master's student	Master's student	researcher	student	student	Master's student	teacher
Remote Gender	f	f	f	m	f	m	m
Remote Age	23	23	31	23	22	30	40
Remote Occupation	software engineer	Master's student	Master's student	store clerk	student	senior analyst	pharmacist
Remote Location	Southeast Asia	East Coast USA	Western Canada	East Coast USA	South Asia	Eastern Canada	Western Canada
Main CMC used before study	WeChat	FaceTime iMessage	text, phone, email	Skype	Facebook Messenger	WhatsApp	WhatsApp
Activities shared during CMC before study	playing video games	local cooking during call	none - the focus is on the call	watching shows/playing games at the same time	playing built-in games and sharing links in Messenger	local partner cooking or showing remote partner the birds	none - the focus is on the call
Most important long distance challenge	timezone differences	scheduling calls	missing non-verbal communication	timezone differences	time zone differences	not being able to do activities together	scheduling calls

Table 1. Summary of participants (names anonymized).

Table 1 describes details about each couple who participated in the study. ‘Local’ refers to the partner who lived in our university’s city and had the telepresence robot at their home. ‘Remote’ refers to the partner living afar who connected into the telepresence robot. The study included one married couple and six dating couples with a range of relationship lengths from five months to five years. The average age of participants was 27 (range: 20-40; SD: 5.78). There was an equal number of male and female participants. The distances between partners ranged from ~115km to ~11,200km. These couples represented common long distance scenarios of being separated for work or educational purposes [20,32]. As well, participants ranged from self-described tech-resistant to tech-savvy. Two couples lived within the same time zone, while the rest of the couples lived in time zones with three to fifteen hour time differences. Two local partners lived alone, while the rest lived with roommates or family members. The local partner from Couples #1, 2, 6 lived with similarly aged roommates, the local partner from Couple #4 lived with her family members, and the local partner from Couple #5 lived with a family from whom he was renting his room (two parents and a child). All couples were in heterosexual relationships and did not have children.

3.2 Method

For each couple, we brought a Beam+ telepresence robot (hereafter called a Beam) (see Fig. 1) to the local partner’s home. Each couple used a telepresence robot over a period of four weeks, during which we conducted three semi-structured interviews. The first interview was at the start of the first week (Time 1), the second interview was at the start of the second week (Time 2), and the third interview was at the end of the last week (Time 3).

Prior to the first visit to the local homes, we had the partners set up accounts for access to the Beam. During our first visit, we taught the partners how the Beam was controlled. We introduced the partners to the Beam controls by having the remote partner Beam in. We explained the camera views, had the remote partner navigate around the apartment, and showed them how to park the Beam. This orientation process took approximately 10-15 minutes.

During the study, remote partners controlled the Beam via an app, using a device of their choice (ie. computer or mobile phone). Once the remote partner logged into the app, the local partner was notified by a melodic sound and they could see and hear the remote partner through the robot.

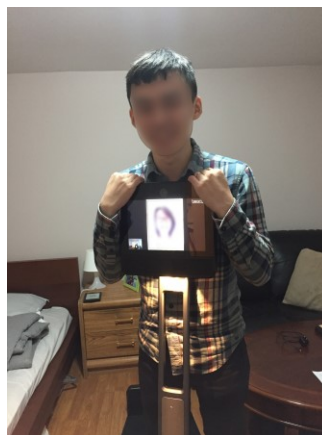


Fig. 1. Couple using telepresence robot (shown with permission).

During the first interview, we asked about the couples' relationships, and gained an in-depth understanding of how the couples communicated prior to using the telepresence robot. This introductory interview took an average of ~35 minutes and included questions about the couple's relationship and existing communication patterns, prior to experiencing life with the telepresence robot. For example, we asked, "What tools do you use to talk to each other?" and "What are the biggest challenges to communicating while you're apart?"

We used the second interview to check-in on the participants in case of any issues, and to get an understanding of their initial reactions to using the telepresence robot. This check-in interview took an average of ~15 minutes. It began with the open question "How is your experience using the Beam so far?" Any issues with the telepresence robot were brought up at this point. We were careful to probe for both positive and negative experiences that the couples might be having as we were interested in the benefits of the technology, as well as areas where it may not be working well.

During the final interview, we asked participants about how, when, where, and why they used the telepresence robot, as well as how the usage affected their communication. This final interview went into more depth and took an average of 50 minutes. We also learned about situations where participants chose to use other CMC tools, and the reasons behind these choices. The final interview gave a detailed picture of how the telepresence robot fit into the couples' daily communication patterns and where, when, and why it did not work well for the couples. The interview began with one-on-one interviews with each participant regarding their experiences and how they felt in the role of user or interactant (i.e. the local person interacting with the telepresence robot). For example, we asked, "Tell me a story about your most memorable usage," and then probed with questions about the reported experiences. For the second half of the final interview, both partners were interviewed together. They were asked about usage patterns, comparisons with other tools, and feelings of connection through the telepresence robot. For example, we asked "What kinds of activities did you engage in with the Beam and why?" We also explicitly asked for moments and experiences where the Beam did not work well. We started by interviewing the partners separately for the final interview to ensure that each partner would have the opportunity to share their honest opinions without being influenced by their partner, or worrying about upsetting the other partner with sensitive responses.

Both the first and final interviews were conducted in person at the local partner's home (with the remote partner joining through their choice of CMC tool). For the check-in (i.e. second interview), we asked the couples whether they wanted to have the interview in-person or remotely (all couples chose to do the interviews remotely). For consistency, the same interviewer conducted all the interviews.

Couples were asked to use the telepresence robot a minimum of four times during the first week, and then to use it however they wanted after that. We chose to set a minimum usage in the first week, so the couples could familiarize themselves with using the telepresence robot, by utilizing it at least half the days of the first week. Following the first week, we had no usage rules, because we wanted to see how the couple would use the telepresence robot naturally, when there were no requirements. Due to the privacy challenges with observing a couple in their home over a period of time, we did not conduct extended observations of telepresence robot usage. However, we did observe couples using the telepresence robot during our initial visit and then during any interviews where participants connected in via the telepresence robot.

3.3 Data Collection and Analysis

All interviews were recorded. The recordings of the interviews were transcribed and the participants' names were changed to protect their identities. Memos were written during transcription as interesting points came up. The primary analysis was performed by the interviewer as this researcher had worked closely with the participants, including visiting their

homes for interviews, and seeing how the couples interacted with and responded to the telepresence robot during the visits. A combination of open, axial, and selective coding was used to extract important themes from the interview data. Our axial coding revealed categories around daily life interactions, normalcy, family, and privacy. From these, we used selective coding to group codes and choose our main themes, which are described in our results section. Themes were generated, then refined as content was added under the themes. Analysis discussions were held between the interviewer and other project members about the codes and themes periodically throughout the analysis period to ensure that a variety of aspects were being considered in the analysis. We also discussed the results and themes in comparison to the related literature on long distance couples, telepresence robot usage, and computer-mediated communication. We did not test for interrater reliability because only one researcher actually performed the coding. Thus, even though one researcher conducted the primary analysis of the interview transcripts, multiple researchers reviewed the codes and themes and there were critical and detailed discussions at all stages of the analysis. Throughout our results, we report stories and quotes from our participants whose names have been anonymized.

	Couple #1	Couple #2	Couple #3	Couple #4	Couple #5	Couple #6	Couple #7
Average Call Duration (min.)	10.53 (SD: 12.39)	10.00 (SD: 11.33)	7.93 (SD: 8.32)	44.10 (SD: 55.63)	26.69 (SD: 28.76)	10.19 (SD: 13.33)	14.64 (SD: 14.17)
Range of Call Durations (min.)	2 - 44	1 - 47	1 - 26	1 - 180	1 - 120	1 - 60	1 - 48
Total Use for 30 Days (min.)	179	220	111	485	934	438	322

Table 2. Usage data

4 RESULTS

Throughout the study, technologies such as text messaging and phone calls were used by participant couples to keep in touch during the day when partners were at work. Yet, in contrast, the telepresence robot was used by partners during the mornings before work, and during evenings and weekends when partners arrived at home. Table 2 provides data on participants' connection durations. As can be seen, participants varied in terms of how long they would use the robot for at a time ranging from only a few minutes to several hours. Couples 4 and 5 tended to have longer connections than the other couples where they would connect in and leave the link going for upwards of two to three hours. Couples 1-3 and 6-7 had many short connections of 10-20 minutes, to briefly talk and say hi, as well as a few longer sessions up to 30 and 45 minutes. The longer sessions are similar to how some partners have been shown to use always-on connections through video chat [21]. Many couples described a typical day of communication as starting off with a quick connection in the morning on the Beam 'just to say hi,' then text messaging throughout the day with perhaps a phone call sometime during the day, then a telepresence robot session in the evening. When couples used the Beam to hang out or have conversations, the remote partner would sometimes move the Beam to a location and then park there, facing their partner, and other times, they would move around the home. While three couples reported time zone differences as their greatest challenge in being in a long distance relationship (Table 1), time zone issues were not often mentioned in our interviews. The couples mostly accepted the time zone differences as a fact of life and simply made small pockets of time to interact directly with one another (and at other times left each other messages). Most partners knew one another's schedules and typically conversed at somewhat regular times using the telepresence robot. This was similar to their communication patterns prior to the study.

In our final interview, we asked participants about the asymmetry of the connection, where only one participant had a telepresence robot and not both. Responses from participants showed that many never thought about the asymmetry during the study and therefore had no strong feelings about it. It was possible that partners could resent either having to control the Beam or

not having the control/access the Beam provided, but this was not what we found. Nonetheless, the asymmetry of the connection is something that did indeed influence behaviors and actions, whether participants realized it or not. We elaborate on this point in subsequent sections.

Within the aforementioned behaviors, we found five themes emerge around the telepresence robot usage, where each theme exposed both the strengths and weaknesses of the technology. We describe each next.

4.1 Participating in Everyday Routines

First, most of the couples talked about how using the telepresence robot opened them up to the mundane parts of daily life. These were the activities that they generally carried out without even thinking about them. For example, this included getting ready in the morning or tidying up around the home. We found that these small, seemingly unimportant activities were in fact important, because there was a sense of intimacy and connection that came from knowing specific details about a partner's activities. Similarly, a sense of comfort came from seeing the predictability of routines. Prior to using the telepresence robot, participants relied almost exclusively on messaging, audio calling, and video calling through various apps, such as WhatsApp, Skype, Facebook Messenger, and WeChat. These interactions were largely limited to just talking and lacked what the couples felt were everyday mundane experiences that couples who lived together would see and participate in together on a daily basis. The types of experiences that were discussed included the experience of routine activities, as well as the experience of shared spaces. When participants talked about routine activities, they included things like being a part of chores (e.g. washing dishes or cleaning one's room), cooking and eating meals, spending time with family, and waking each other up in the morning. When participants talked about the experience of shared spaces, they spoke of how noticing things in the environment could spark conversation, and remote partners often mentioned connecting to the robot just to check in on the space. Our participants had all explored their remote partners' spaces initially when connecting in to the telepresence robot, yet now they were able to obtain real-time updates and an ongoing awareness of the remote space. This fulfilled their desire to experience what their partner's environment was like *at that time*. As one remote partner phrased it, she would sometimes connect in to her partner's place just to "...see how it is over at his side of the world..." [Couple#5 remote partner - Mirna]. The following scenario illustrates the above points by exploring how Couple #5 used the telepresence robot to experience the everyday ordinary things that were not captured using other forms of CMC.

Alan is awake early in the morning and connects in to Ellie's apartment to check to see if she is still sleeping. Just as he expected, he sees that she is still in bed, so he wanders around her room. Before using the telepresence robot, he never had access to this part of Ellie's life - he couldn't look over at her while she was sleeping, and wander around the home checking on things like one might do when living with their partner. He does these same things when they are together in person visiting each other, including checking in on her pet birds to see what they are up to. It feels nice for him to be able to experience the simple sensation of being *there* with his partner in the *same* home, and to have the certainty that everything is okay, because he's seen it for himself in the telepresence robot. Eventually, he decides to wake Ellie up. For some reason, calling her cellphone doesn't work, but he's able to wake her up using his telepresence robot. He moves around with her through the room as she gets ready. These are the moments when the telepresence robot allows him to feel really connected to his partner - when he can see her going about her morning routine. It is so familiar to him that he feels he can even guess her next move.

"So usually when you are sleeping or when you are doing something in the room, I log in to the Beam to see what is happening around the room - like usually what I would be doing in the house, I try to feel the same experience, like moving around, maybe like making fun of you or looking at the birds and then I can stare at you, what you are doing. I mean things that you usually do in the house I can't

see from the mobile right? But when I'm in the house, like when I used to be, right? Like when we were together. It feels good to see you moving around, walking around, you doing your stuff, cleaning the bed or maybe things like that." Couple #6 (Remote Partner - Alan)

Other couples had similar experiences to Alan and Ellie. For example, Mirna and Arnie (Couple 5) enjoyed being able to hang out with one another in the kitchen as Arnie made dinner. This was something that the couple had previously never experienced together while being apart. While seemingly mundane, both the remote and local partner said the experience was special to them.

"One time, this was the first I actually used Beam to follow him out and see how he was having dinner and just watching him like uh move around the kitchen, washing dishes, that was a very intimate moment..." Couple #5 (Remote Partner - Mirna)

"...I was cooking and she just followed me around and it was actually one of the very first days that we had Beam and she just followed me around the house where I was cooking and she hadn't seen the house before that..." Couple #5 (Local Partner - Arnie)

The specific time zone differences each couple experienced determined which parts of each partner's life the other could share in. As an example for Mirna/Arnie (separated by 13 hours), if Mirna was up in the morning around 8AM, she could Beam in and accompany Arnie if he made dinner around 7PM. That said, while certain time zones aligned in a way that let remote partners share in the local partner's experiences using the telepresence robot, these asymmetric experiences were still not ideal. Time zone differences have been previously reported to be a challenge for long distance couples and families more generally [21], and while telepresence robots may enrich the leisure times that overlap, the difference in experiences remains.

We also found that having a telepresence robot for communication could lead to small and meaningful interactions that were more spatial in nature when compared to the sending of a text message or having a phone call. Because the remote partner could physically move through the space, items or messages could be left in locations throughout the home where the locations might provide additional meaning. For example, one local partner left Post-It notes with messages on them around the home for the remote partner to find if she connected in while he was not at home.

"He left Post-Its around the apartment with notes on them so I could find them with the Beam even if he wasn't there...ya, it was just really sweet to be able to interact that way. I don't think, you know, it's not something that we could have done with Skype or through email so ya that was really sweet." Couple #3 (Remote Partner - Laetitia)

Naturally, the telepresence robot was not able to support all of the everyday, mundane acts that couples might like. Physical interactions like hugs or gentle touches between partners was not possible, though some couples did try to recreate them using the telepresence robot. For example, Alan offered his girlfriend a hug to celebrate moments when she was particularly happy as well as when she was sad. Ellie hugged the telepresence robot and noted that it felt nice because of the warmth, but that it was still just 'hugging rods.' She told us that "something fluffy if not something interactive" would feel better for hugging.

Another challenge when using the telepresence robot for participating in aspects of everyday life was the limits to mobility. While the telepresence robot could handle various terrains, it could not go up stairs or even raised floors. This meant that the telepresence robot could not get to certain parts of the home for couples with certain home layouts. Couple #6 was especially restricted by this and the remote partner was never able to visit the kitchen, study, or bathroom areas using the telepresence robot, thus missing out on all the interactions that take place in these spaces. The local partner resorted to using her phone in these locations of the home.

Furthermore, there were social implications because of the asymmetrical dynamic of the telepresence robot being in one partner's home and not both. Going back to the scenario with

Alan and Ellie, we learned that Alan (who liked to check in on his partner) also wanted to be the one who was checked in on sometimes. Using the telepresence robot, Alan is able to show care through attentiveness and interest in Ellie's life by connecting in to see her go about her day, but Ellie could not reciprocate in the same way.

"...[S]ometimes I also want her to like come check me, like what I'm doing, maybe interact with me. When I'm cooking something or when I try to show her things outside from a balcony I just have to carry my mobile around." Couple #6 (Remote Partner - Alan)

4.2 Sharing A Home

Second, interacting through a telepresence robot at home led to moments where couples felt like they were actually *sharing* a home. This was very different than the feelings they received from connection with apps on their phone or laptop, which did not provide the same sense of a shared space. For local partners, this feeling came from the spontaneous and fluid nature by which their partner could come and go. For remote partners, this feeling came from being able to experience the home in an embodied and unrestricted manner - looking around as they pleased and being in the home even when their partner was not there. This worked well for partners who were separated across large time zones because it meant they could feel like they were sharing a home with their partner even without the partner having to be there when they connected in. When connected into the home, remote partners felt a strong sense of presence when they bumped into things, and when they were able to move things around in the local partner's home. The following scenario illustrates some of these points by exploring how Couple #1 used the telepresence robot to be home *together*, and how both purposeful and unexpected interactions through the telepresence robot led to feelings of presence in a shared home.

Ron is home working on his graduate thesis. At around 5PM, he sends a good morning message to his partner on WeChat, knowing that she will be up soon. Their time difference is 15 hours, so it is 8AM the next day in South Asia where she is living. Unexpectedly, Ron hears the familiar melody of the Beam activating. When he realizes that Kelly is connecting in, he feels happy - this is a nice surprise. Kelly moves over to talk to him through her telepresence robot and accidentally bumps his chair, pushing it back. In the moment of surprise, Kelly feels fully present in Ron's room. It is such a familiar physical interaction that Ron also feels like his partner is there with him, rather than a day ahead and halfway across the world. A few minutes of conversation pass and then Kelly moves away to let Ron work. She settles herself behind Ron's chair where she can see both him and his computer screen. She cannot clearly see Ron's computer screen through the telepresence robot, but she still gets the opportunity to glance every now and then to see if he is working and feel like she is involved in his life. When Kelly starts to feel bored, she pushes Ron's chair with her telepresence robot to get his attention. Ron likes that his wife can interact with him in this way.

"Sometimes she used the Beam unexpectedly, like I didn't know she would Beam in ... I was focusing on my work and she was standing by using the Beam. She can use the wheel, bump my chair, and push me forward, so I cannot really neglect her. Sometimes when we do the video chatting, although the audio is going, but I'm too focused on my work and sometimes neglect her and she says, 'hey, you don't even know what I'm talking about, you weren't listening,' but this way you always have to because she can really interact with your life so you can get really a sense of she's being there and you cannot really neglect her ... that's one of the better, one of the best experiences I have." Couple #1 (Local Partner - Ron)

"When I can walk around his room, I feel like a little bit. Cause I can investigate his room. I think it's...sometimes I walk on, I mean the device walks on some of the stuff he just put on the floor or when I accidentally hit something, it feels like I'm walking in the room. I think it's the interaction between the Beam and other things makes me feel I'm there." Couple #1 (Remote Partner - Kelly)

The above scenario also begins to reveal the potential privacy challenges that can arise with a telepresence robot, given its mobility. Unlike the other technologies that participant couples used, the telepresence robot gave them autonomy and access to the remote partner's space in an unencumbered way. For example, with video chat over Skype, participant couples could purposely choose the camera's direction to show certain aspects of their location. With the telepresence robot, the remote viewer was in control of the camera and its location. This was more similar to the way a person would see and move through a space when they were there in person, but was not preferred by some couples and would sometimes create concerns, albeit mostly mild ones. While not a concern for Ron, who enjoyed having his wife watching over him while he worked, this was a concern for Stan from Couple #2 who was very aware of his partner seeing how messy his home was. Mirna from Couple #5 was concerned about contacting her partner too much and invading his personal space. Thus, even though they felt like they were *sharing* the remote environment, there was still some sense that it belonged more to the partner local to it. Here we see the asymmetry of the telepresence robot setup and living situation coming into play. It should be noted that neither Couple #2 or #5 had lived together prior to becoming long distance. While none of our participants reported concerns with their partners connecting in when they were not home (e.g., due to time zone differences), it is certainly a possibility that such behaviors could bother some partners, particularly those early on in their relationships.

"I think it was late on a Friday night and I was going to bed and [Laetitia] was at a party in [City], and so Beamed in from the party and so it was a very quiet apartment, like me on the couch reading a book, and then all of a sudden there was like a party in the living room, and like I was in my pyjamas. So it was something that like wouldn't have come up in a phone call, because there's not the video screen in the phone call, so, and it was something that I realized we had never talked about, was like what context is appropriate to like Beam into the apartment. Um so that was just like mildly uncomfortable." Couple #3 (Local Partner - Gary)

4.3 Connecting with One's Partner's Family and Friends

Third, using a telepresence robot, remote partners were able to connect with the network of family and friends around the local partner. The embodiment of the telepresence robot gave remote partners a physical presence and autonomy that led to acknowledgment and inclusion from the people nearby who might be visiting or living in the remote partner's home. This was not a common experience for the couples in our study prior to their usage of the telepresence robot, since their communication across other applications like text messaging or video chat were one-to-one conversations given the design of the technologies and their usage around them. In contrast, because the telepresence robot allowed remote partners to just 'be around' in the remote space, they might be connected in when family or friends visited the home. The following scenario demonstrates how the remote partner in Couple #4 developed meaningful interactions with his local partner's family member using the telepresence robot.

Beth lives with her parents and two sisters, and the whole family is currently at home. Carl connects in so that he and Beth can simultaneously stream a movie. This allows Carl to watch the movie with Beth and her sisters in the living room. Beth's dad notices Carl and comes over to greet him and they have a conversation. In the past, whenever Beth had him on video chat, he would say hello to her dad if he was nearby, but they never had a conversation. In the living room, Carl positions his telepresence robot next to the couch where the sisters are sitting. He uses his telepresence robot to look around at people to gauge their reactions to the movie. Beth's parents drop by intermittently and tease Carl about watching the movie through the telepresence robot. He feels involved in the family activity, and jokes around with Elsie and her sisters during the movie.

“I felt like they were more interested in interacting with him because without the Beam I know that they don’t have him on Skype since they don’t use Skype and they don’t have him on WeChat, so it’s kind of harder for them to communicate with him, so if they’re curious about something about him they would ask me instead of directly asking him, whereas like with the Beam here if they have a question and [Carl] is like out and about around the house then they can just stop by and be like ‘hey [remote partner] how are you?’” “...it makes like my whole family more playful and more sarcastic and willing to joke around more.” Couple #4 (Local Partner - Beth)

The above example shows how the local partner’s family members became more involved with the remote partner. We also found that this worked in the opposite direction as well – the remote partner’s family members could also become more involved with the local partner. In Couple #1, the remote partner shared the telepresence robot with her mother so that her mother could get a better sense of the local partner’s life in Canada.

“So she shared that Beam with her mom, which is my mother-in-law, so they both started watching me making a dough for baking...because my mother is the first time try this, so she’s very interest[ed]...so I show her around. How do I live in Canada, what my house looks like, and then I was making dough in front of her which is really interesting. So I was making food and she was kind of saying ‘What are you doing? What is this? What is that?’ It was pretty fun.” Couple #1 (Local Partner - Ron)

While the telepresence robot was able to support interactions with friends and family, the current design of the telepresence robot did not encourage remote partners to actively seek out these interactions and to initiate communication with the local partner’s family and friends. Only if family and friends happened to be coming by did the remote partners interact with them. Participants were sometimes hesitant to explore homes containing other people. For example, the remote partner in Couple #4, whose partner lived with her parents, explained that he felt it was intrusive to leave his partner’s room when she was not around. This was despite the fact that the parents did not have any concerns with robot moving throughout their home. Overall, this brings up possible concerns around access levels for remote partners that connect into shared homes, and not just a space used by their partner. The scenarios also bring up issues around asymmetric access to the technologies. There is a chance that only the remote partner is able to gain access to the local partner’s family and friends network since they are the only ones to connect into the remote space where family and friends might be. Ron, from Couple #1, was able to see his partner’s mom, but only because his partner made a special effort to bring her on-screen and in front of the camera.

4.4 Increased Helpfulness

Fourth, in relationships, sharing tasks is a form of relationship maintenance [32]. It involves helping one another finish tasks that need to be done as well as each partner taking on specific tasks such that there is a shared sense of responsibility across household tasks. There are many tasks that are difficult or impossible for partners to help with over distance, such as picking up groceries, or feeding the cat, so long distance partners are limited in ways they can help one another. We found that even with a simple, armless telepresence robot, remote partners were able to be more helpful to their local partners when using the telepresence robot compared to video chat and other communication technologies that they already were using. Some partners found creative ways to use the telepresence robot to provide help. For example, we describe a scenario from Couple #6’s experiences next.

Ellie is in her bedroom, and Alan is connecting in from Eastern Canada. Ellie’s birds have been making a racket, continuously screaming, and Ellie is tired of trying to stop them. In her frustration, Ellie asks Alan for help. To her delight, Alan moves over to the birds in his telepresence robot and manages to frighten the birds into quieting down. Ellie felt it was very nice that she could have Alan there helping her even while he was on the other side of the country. Helping her quiet the birds was something he would do when he was with her in

person, but he had never been able to help her in that way through video chat or text messaging.

“My birds were screaming and I was so tired of telling them ‘don’t scream, don’t scream,’ so I was like ‘[Alan] control them,’ and then he comes in the Beam and then he like goes towards the birds to scare them so they stop screaming. That was nice.” “If he had been here he would have been shouting at them, it’s like doing the same action through the beam, trying to scare them.” Couple #6 (Local Partner - Ellie)

For Couple #2, the local partner found his remote partner very helpful in the kitchen. Since his partner was a vegetarian, she was able to watch his cooking process and provide tips to help him with vegetarian dishes. The telepresence robot allowed her to move around to observe the whole process without him having to manage the camera view on a mobile phone while he was cooking.

While the telepresence robot gave remote partners slightly more capacity to be helpful, the opportunities to help out were still minimal. The lack of appendages on the telepresence robot was very limiting, and local partners told us that they would like telepresence robots to have arms and hands, so that their remote partners could help hold or carry things. The ability to help at the remote location was also limited to being only one-way help. This meant that while one partner could offer forms of help in the remote space (albeit still limited forms of help), the other could not. Again, this reflects the challenges with the asymmetric nature of the telepresence robot setup.

4.5 Quiet Companionship

Fifth, the physical embodiment and autonomy of the telepresence robot empowered partners to be near each other without feeling the need to necessarily speak to one another. This dynamic allowed partners to enjoy moments of quiet companionship. It is evident from past research that quiet companionship is something that long distance couples value [21]. We found that the experience of quiet companionship with the telepresence robots was similar to the experience of using a traditional video chat system for “always-on” connections [21] in that remote partners would find a place to ‘settle in’ with the telepresence robot and stay there. That is, they would move the robot to a specific location, and leave it ‘parked’ for a period of time, despite having the ability to easily move around the remote space. Compared to video chat and leaving a video stream open, with a telepresence robot, the remote partner chooses where to place themselves and has the option to reposition themselves if their partner moves around. When using video chat systems, participants tended to always position their device such that they could see their partner’s face and be face-to-face with them. With the telepresence robot, we found that the remote partner sometimes chose other positions, such as standing behind their partner and looking over their shoulder. For example, as previously described, this type of situation arose for Couple #1 when Kelly would position the telepresence robot and periodically watch Ron work.

One of the couples in our study talked about the social challenges that came with video chat calls where they felt obligated to stay on camera, much like the related literature has reported [7]. For this reason, they tended to only use Skype for shorter conversations, rather than leaving the connection open longer term to ‘hangout,’ as the related literature has found for some couples [21]. They told us that connecting in via a telepresence robot and leaving the video link open was less awkward and they did not feel like they needed to stay talking with one another while connected. Being able to move around using the telepresence robot made it natural to transition from having a conversation to hanging out silently.

“...[W]hen we’re Skyping there’s just that feeling that you’re always entertain- like you’re always making eye contact with the person on Skype and like it’s very intense conversation. When you’re Beaming in, like it is different, like it feels more relaxed and like if I’m bored, I mean if you get bored,

you just walk, Beam around. It's not like I'm feeling like I'm entertaining you...Like with Skype it was always if we're not talking it feels a little awkward, and then you know somebody would be like 'ok, well, bye'. But with the Beam, at least with the Beam if there was a silence, it wasn't weird, like it was kind of natural." Couple #3 (Local Partner - Gary)

Although using the telepresence robot supported more natural interactions than with traditional video chat systems, sometimes partners still chose to use their other video chat systems because using the telepresence robot was more work for the remote partner who had to look at their screen to control the robot. For example, even slight movements to the telepresence robot took cognitive effort and this took away from the feeling of quietly being with one's partner.

5 DISCUSSION AND CONCLUSIONS

The goal of our research was to understand how long distance couples would use telepresence robots in the home, and how the usage may influence their communication, in order to uncover the design factors that are important for developing telepresence robots for supporting long distance relationships in the home context. Overall, we found that communication became less reliant on verbal interactions, and broke free from the one-on-one/face-to-face convention of standard video chat. We now summarize our results and discuss design opportunities.

5.1 Mundane Life

First, our results revealed the value that participants found in being able to see and be a part of the mundane happenings within the local partner's home. This was one of the main ways that telepresence robots changed participants' interaction and communication over distance. While we do not know of telepresence robot research that has similarly drawn out this benefit, the concept of being a part of the 'unremarkable' aspects of domestic life is similar to findings from ethnographic studies of home environments [35]. In our study, we found that these were relatively well supported by telepresence robots. However, there were still mobility limitations (e.g. stairs and floors). These results suggest that there are open design opportunities to explore ways to better support being a part of and noticing things that may seem to be unremarkable in one's daily activities, but are still very important to feeling like one is part of another person's life. As suggested by other researchers, this may involve better cameras with a wider field of view [10,12,13]. Designs could also look at ways to improve mobility in environments that are small and cluttered, with the ability to safely navigate over common household features, such as wires on the floor, stairs, and narrow passageways. Designs could also support interactions with objects in the remote space in order to help out or to make the shared space more comfortable for oneself (e.g., turn lights on/off), or to lend a 'helping hand' to a remote partner.

5.2 Asymmetry

Second, our study revealed how partners accommodated the asymmetry of the telepresence robot setup (only one partner had a robot). We saw, for example, remote participants being able to watch others do activities (e.g., cooking). Remote partners were also able to check in on the home when their partner was not there. Even though our participants did not take issue with the asymmetry of the experience, there is a strong possibility that issues around asymmetry could arise over long term usage. It is possible that participants were still focused on the benefits of the technology, which brought them new and enhanced ways of communicating, thus they did not begin to think about or dwell on the fact that only one partner was able to perform some of the remote activities. This raises opportunities and questions around if and how symmetry can be supported. Reciprocity is important within relationships and without it, they can suffer [32].

Naturally, one could consider ways of allowing both partners to use a telepresence robot, one in each location. Yet introducing a second telepresence robot complicates the experience. Certainly, telepresence robots could be placed in both environments and users could take turns as to who remotely connects in. Yet this may create cost issues. Overall, this shows that there are design opportunities for exploring how two locations could be connected at the same time, especially in ways that consider if and how users are tethered to devices such as telepresence robots or not. Other research has explored symmetric connections of long distance partners through virtual reality-based video conferencing [25]; however, we have yet to see designs exploring these problems and potential solutions with telepresence robots.

5.3 Always-On Access

Third, we found that partners liked the direct access available to the telepresence robot and being able to connect in without the local partner having to accept the connection. This form of access could be likened to living with one's partner who has a key to the home. While this provided partners with the cozy feeling of sharing a home together, occasionally, the direct access caused issues where people's privacy was sometimes compromised (e.g., a 'house party' connecting to a partner in pajamas). Similar issues surrounding privacy and mixed contexts have emerged in the related literature for other settings [22,24]. The challenge is that homes are often considered to be private spaces [9], yet this privacy is brought into question with remote access by a partner at any point in the day. Partners could establish rules around using the telepresence robot, however, this could possibly constrain the relationship and present social barriers. Alternatively, technology could be implemented to ensure that the local partner is given ample warning about incoming connections in order to create peace of mind. For example, local partners could be given information on whether someone other than the remote partner is on the other end of an incoming connection, or local video feeds could appear obscured and slowly reveal themselves, giving the local party an opportunity to stop the connection from fully engaging. Other possible design solutions may include availability modes like "do not disturb," yet this could be too much of a restriction for an intimate couple. Telepresence robots could also be augmented with additional communication mediums. For example, a message board might allow partners to leave notes for one another such that they can explain if they are currently busy or not prior to a person connecting in (e.g., "trying to get my big project done – meet for dinner at 6PM?"). Placement of such messages within the telepresence robot system itself would make it so such notes would be highly visible when people tried to connect.

5.4 Family and Friends

Fourth, we found that using a telepresence robot made it possible for remote partners to connect with not only their local partner, but also with the local partner's close network of family and friends. This is similar to related work that found that some remote workers reported sensing greater acknowledgment of their presence in meetings when attending through a telepresence robot compared to video conferencing [36]. While the greater integration into the local partner's social network was seen as a positive, there were also concerns, again, about privacy issues coming from both remote and local partners. Couples mentioned concerns about the privacy of the family members and roommates living with the local partner, although no complaints from these parties were reported. This lack of conflict was likely due to the fact that couples were very sensitive to the possibility of privacy invasion, and therefore tended to keep telepresence robot usage away from common areas unless the local partner was also there. Again, these results point to design opportunities. In these situations, it could be valuable for telepresence robot users to have better awareness of who is at the remote home through mediums outside of the robot itself. This might, for example, allow them to know

if people are present in certain rooms before going into them. Similarly, local users could benefit from knowing if a person is connected into a telepresence robot in different rooms of the home before entering them. The telepresence robots we used tended to make motor noises when people were connected to them and so it was sometimes possible to hear if the robot was approaching. While this might be considered a design flaw, such noises are indicators of presence and may be beneficial in giving people a sense of whether remote people are 'present' in the space before seeing a telepresence robot.

5.5 Quiet Companionship

Fifth, we learned that people found value in the embodied way which the telepresence robot supported times of quiet companionship. Similar to what previous research has found, the embodiment of the telepresence robot created a strong sense of presence [17,22]. During times when the remote partner wanted to fully relax (e.g., as they were going to bed), it was preferable to not have to look at a screen and control a telepresence robot. This suggests design opportunities for automating control and movement of a telepresence robot in a remote space to alleviate the need for direct work by the remote partner. For example, it could be valuable for a telepresence robot to automatically move between a living room and a bedroom before bed so that partners could stay together while allowing the remote user to quietly share a moment with her partner without having to think about driving the robot. This could allow remote partners to better relax. As proposed by Koceski and Koceska, the telepresence robot's level of autonomy could increase from teleoperation (i.e. the user is in complete control) to safeguarded operation to shared control, and finally to autonomous control (i.e. the user transfers control to the telepresence robot) [15].

5.6 Limitations

While we feel our study has opened up and explored a valuable area for telepresence robot research and design, our study does come with its limitations. There is a chance that participant behaviors were influenced by the novelty factor of a new technology. Additional usage of a telepresence robot over a longer period of time than we were able to study would be valuable to validate our findings and extend them. Our couples were also quite similar in nature. They were all relatively young adults, in a heterosexual relationship, and had established routines that provided overlapping time periods of availability. Our convenience sampling method may have also skewed participants to be similar to us as researchers (e.g., more technically inclined), though we note that some participants were skeptical of the technology and their participation in the study at the onset. We feel this rendered them with a somewhat critical eye towards the technology and their experiences in the study. While our participants had a range of time zone differences, it could be valuable for future studies to explore more couples within the various groupings of time zone separation (e.g., small time zone differences, large time zone differences). This would help to understand whether our findings were tied to any particular idiosyncrasies of our couples, or if our findings were more generally applicable to a range of couples who might face similar time zone separations. Together, these points suggest further studies with a more diverse set of couples.

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