

An Autobiographical Design Study of a Long Distance Relationship: When Telepresence Robots Meet Smart Home Tools

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ABSTRACT

Long distance couples often face challenges in maintaining their relationship over distance because computer-mediated communication tools typically only support a limited range of relationship maintenance behaviors. To explore a broader design space that might help combat this problem, we conducted an autobiographical design study that explores the usage of a telepresence robot coupled with voice-activated smart home devices. The telepresence robot provided an embodiment for one remote partner who could talk through the robot to control the smart devices in the remote location. We studied how the setup was used by a long distance couple over a three month period to share their home and nurture and maintain their relationship. The study revealed how such a setup can promote feelings of ownership, belonging, and normalcy, as well as a diversity of interactions and social connections. Implications for design include the importance of supporting effortful, personalized, varied, and shared interactions.

Author Keywords

Telepresence robots; computer-mediated communication; smart home; long distance relationships.

CSS Concepts

- Human-centered computing

INTRODUCTION

Long distance relationships are a common experience for many people as a result of situations in life, such as work relocations, family obligations, moving to attend a specific school, etc. [31]. The distance makes it difficult to maintain relationships as partners become limited in how they can interact with and support one another when they are physically apart [8]. Computer-mediated communication (CMC) tools are important for long distance partners because these tools enable partners to see, hear, and write to one another, thus allowing partners to express positivity, assurances, and support [31]. These are a subset of actions termed “maintenance behaviors”, which are necessary for the continuation and health of relationships [31]. However, current remote communication tools are limited in the types of maintenance behaviors that can be performed and the extent to which they can be performed. For example, it can be particularly difficult for long distance partners to share

tasks and engage in joint activities using traditional CMC tools, such as video chat [4].

Our work builds on existing research on the potential for telepresence robot usage for personal/private interactions over distance. We chose to study the use of telepresence robots in conjunction with smart home tools because past research has found that while telepresence robots support long distance partners in sharing home life, being largely unable to manipulate the environment meant that partners were still very limited in ways they could help one another, express their affection, or participate in activities together [33,34]. We were interested in how the ability to control various items in a home would affect the experience of sharing a home over distance through a telepresence robot.

Our research focused on answering the following questions: a) how might long distance partners more flexibly express mutual care beyond just verbally conveying it? and b) how does this influence the experience of sharing a home? In order to answer these questions, we used autobiographical design, which is a research method that involves the researcher as the user and designer of the system being studied [25]. The choice of this method stems from the need for an exceptional level of access to a couple’s private life and home. Having the researcher be the user allows us to monitor the day-to-day interactions in the home space, including access to intimate details of usage that might otherwise be kept private. This method serves to reveal the complexities of usage in daily life and supports the ability to quickly iterate on designs [25]. We were able to utilize the method of autobiographical design because the researcher had a genuine need for a long distance communication solution and a real stake in designing a telepresence home setup that could help her maintain her relationship with her fiancé.

The telepresence home setup involved various smart home tools (e.g. vacuum, lights) controlled by the remote partner by voice projected through the telepresence robot (Figure 1). We selected smart devices to specifically support four types of relationship maintenance behaviors: joint activities, support, sharing tasks, and affection. Through our study, we found that by coupling a telepresence robot with smart home devices, remote partners were able to expand on the ways

that they were able to support their relationship over distance. This included feeling ownership and belonging in the shared home space, as well as a sense of normalcy, diversity of interactions, and continued involvement in social groups after moving away. Our findings illustrate the value that designs can bring when they support effortful, personalized, varied, and shared interactions.



Figure 1. This figure shows the household items controlled by the telepresence robot over distance in our telepresence setup.

RELATED WORK

Mediating Intimacy Over Distance

Maintaining relationships is challenging for long distance couples as it limits the options that couples have for sharing with and caring for one another. It has been found that the availability of CMC tools makes the separation more acceptable to partners [1]. The variety of CMC tools, such as video chat and instant messaging, support different communication needs that couples have [18]. However, CMC tools typically transmit only visual and aural information and thus limits flexibility in expressing mutual care and support.

As mentioned in a previous section, the relationship literature has defined a core set of behaviors that couples perform to nurture their relationships (for example, sharing tasks, joint activities, and support). These are called “maintenance behaviors” because these are behaviors that partners continue to do throughout a relationship in order to *maintain* the relationship [31]. Using current CMC tools, the relationship maintenance behaviors that couples can use are mostly ones that can be expressed verbally. For example, through video chat, partners can express positivity and affection, provide assurance and advice, and engage in small talk and humor. However, research on “always-on” video communication (i.e. when partners keep a video call on even when not directly engaging with one another) shows the importance of non-verbal communication as long distance partners often use video chat even when not talking to one another [24].

Research on designing artifacts for mediating intimacy suggest that such artifacts support factors like expressivity, memories, and awareness [12]. Early work in mediating intimacy explored devices that expressed emotion and supported awareness without any exchange of information [32]. This has included a large range of devices, often focused on simply letting one’s partner know they are thinking of them [2,11,15,22]. There are also devices, such as Cubble [19], Sensing Beds [10], and Flex-N-Feel [29] that support awareness and expressivity through touch sensations of heat or vibration.

Sharing Activities Over Distance

Researchers have also studied how people can share activities over distance. Mobile video chat is being used in progressively more scenarios, such as sharing graduations, weddings, and family reunions over live video calls with remote family and friends [23]. The perceived value of being able to share these experiences with loved ones is high enough to justify taking on the burden of making the connection happen [23]. However, the challenges of the mobile video work can diminish the experience for both the local attendee that is managing the video connection and the remote attendee [5,14,23]. For example, it can be difficult for the local sharer to maintain a good framing of the activities for the remote viewer [14,23]. Furthermore, the remote viewers can feel that they are creating a burden for the local sharer who has to carry a device to the event, manage the camera view, and troubleshoot the connection [23].

A central challenge with sharing activities over distance is the lack of embodiment [13]. There is a limitation to how much one can explore a space and interact with others when one does not have a physical presence and autonomy of movement. We have seen from past research how remote partners want to view things from different angles and approach spaces in a way that helps them build an understanding of the environment [16,23]. Previous research has also shown that remote partners could benefit from an embodiment in social interactions as they could be better acknowledged by people in the surroundings [26]. As well, the autonomy of a mobile physical embodiment can support more interactivity [33,34].

Telepresence Robots

The telepresence robot is a communication tool that provides a physical embodiment for the remote user, alongside audiovisual channels of communication. The typical design includes: a display that shows the user’s face at roughly human height; a front-facing camera which provides the user with a view of the environment; a floor-facing camera which shows the ground to aid in obstacle avoidance; a microphone for hearing the environment; and a speaker for the user to communicate through [9,20]. This is used in scenarios where audiovisual communication is deemed not enough to support the needs of the social interactions in that context. For example, telepresence robots are used in the workplace to allow remote workers to have a more normalized working

experience, including spontaneous meetings and conversations with co-workers [21].

More recent work has explored the use of telepresence robots for connecting loved ones in sharing activities and daily life [13,33–35]. Reported benefits were the support of autonomy and spontaneity, and reported challenges were situations where partners felt limited in how they could help one another [13,33]. The constraint of not having appendages continues to be a limiting factor for interactivity through telepresence robots. However, the telepresence robot form factor is simple for a reason – having a conversation while driving a telepresence robot is already a distraction without added appendages [21] and further controls would add cognitive load that would impede on communication. Thus, in order to give the remote user more control over their surroundings, while maintaining the simplicity of controls and focus on communication, this study explores the use of voice controlled smart home tools.

In this study, we explore how couples can share a home and perform relationship maintenance behaviors through a telepresence home setup (i.e. a home outfitted with smart home devices that can be controlled by voice through a telepresence robot). To our knowledge, no other study has explored the pairing of a telepresence robot with voice-controlled smart home tools. There has been research similarly exploring the control of remote devices through a telepresence robot, but the method was using a computer plugin which added to the user’s cognitive load, and the context was for remote work [17]. As well, other researchers have explored systems of smart homes which interact with a service robot to create automated home care [3,28]. While these papers share our concept of robot-environment integration, the direction of their work differs greatly as they are moving towards the removal of explicit human input while our work encourages human involvement and focuses on social interactions. There is also research exploring remote control of devices to support long distance relationships [6], but without exploring the remote control as an embodied experience through a telepresence robot. The goal of our work is to explore the complementary potential of telepresence robots and voice-controlled home devices in the context of sharing a home and maintaining a relationship over distance.

AUTOBIOGRAPHICAL DESIGN STUDY METHOD

To explore the aforementioned design space, we utilized autobiographical design: “design research drawing on extensive, genuine usage by those creating or building the system” [27:514]. While autobiographical design does not allow one to generalize study findings, it is highly suited for early design explorations such as ours where little is known about how a technology will be used. Autobiographical design also allowed us to gain exceptional access to a real-world long distance couple, rich data collection, and uncommonly candid insights into possibly sensitive topics. There is also the chance that we could have put one or more

couples’ relationships in jeopardy with technology setups that may have not actually helped their relationship or, worse, caused them to deteriorate. Our method also provided us with the ability to rapidly iterate on home device implementations. While some autobiographical design studies involve large amounts of programming and development efforts to create new software or hardware (e.g., [7,25]), our design and iteration efforts were focused on choosing and altering which smart devices we coupled with the telepresence robot and setting them up within a home environment. Autobiographical design work has been found to range from weeks to years of extensive usage [27]. Our autobiographical design study lasted three months, given the needs of the couple, and the telepresence home setup was used extensively due to the necessity for the long distance couple to stay in close contact.

Participants

This autobiographical design study involves the first author, Tessa (alias), and her partner, Stanley (alias). Tessa is a PhD candidate in human-computer interaction and her partner is a software engineer. They met through mutual friends and have been together for 7 years. When living together, they share a one-bedroom apartment and are currently engaged. Tessa and Stanley spend most evenings and weekends together. The couple became physically separated and in a long distance relationship for three months while Tessa was away for an internship. During this time, Tessa and Stanley lived in two major metropolitan cities in Western North America, separated by ~950 miles but in the same timezone.

Initial Telepresence Home Setup

Before the couple became long distance, the initial set of voice-controlled smart home tools were set up and a telepresence robot was brought to their *shared home*. For the remainder of the paper, this is how we shall refer to the home shared by the couple before becoming long distance. The telepresence robot’s charging dock was placed in a corner near the front door where it would be the least obtrusive. The *remote partner*—Tessa—was granted 24/7 access to use of the telepresence robot. That is, she could connect into the robot at any point in time without needing her partner to ‘answer’ the call on the robot. The couple purposely chose their existing home to place the telepresence robot and devices in as opposed to the new home that Tessa would be moving to. This place already represented ‘home’ to them both and they wanted to maintain that aspect of their relationship. Alternatively, they could have chosen to place a telepresence robot in *both* homes so that both partners would have the same opportunities to connect in to the other’s location. However, this did not fit the couple’s needs nor the situation at Tessa’s remote residence which was an apartment shared with a roommate. The couple felt it would be awkward for Stanley to connect into a shared living arrangement.



Figure 2. The telepresence robot in the shared home.

The devices we chose to pair with the telepresence robot (see Figure 2) for the initial setup were chosen through consideration of both partners' inputs. Around a month prior to assembling the initial telepresence home setup, we began collecting a diary log of daily interactions and conducted a preliminary interview to discuss the couple's relationship i.e. how they interact with one another, what activities they do together, and what types of relationship maintenance behaviors they perform. These self-reflective activities led to the implementation of three initial smart home elements that were connected to a Nest Home Hub to enable voice control.

The first device to be set up was lighting. We set up voice-controlled lights in the couple's main work area, the front entrance, and the bedroom. For the partner staying in the shared home, going home to an apartment with the lights turned on and his partner present felt very important. In the past when he has come home to a dark and empty apartment, it has made him feel dispirited, so he recognized how impactful light was for the atmosphere of the home. For the partner who was moving away, she felt that being able to turn the lights on and off would support her in feeling a sense of belonging in the home. For example, when visiting through the telepresence robot, if it is too dark she would be able to turn on the lights to see, rather than being unable to control her environment and feeling like an intruder.

The second device to be set up was a Chromecast for TV control. With this set up, the long distance partner could go to the TV in her telepresence robot embodiment and turn it on or off, start specific Netflix shows, play and pause, and change the volume all through voice controls. For the couple, watching their favorite shows together is something they do every evening while having dinner. On a typical night, one partner would get the show ready to play while the other plated up food to bring over. Being able to control the TV through the telepresence robot was important as this could support the couple in maintaining their daily routine.

The third device was a vacuum. We set up a Roomba 895 so that the remote partner could ask it to start cleaning and also tell it to stop and go back to its charging dock. Both partners in this relationship take part in cleaning the home. Especially for the partner who was moving away, this was something she would do when she knew that her partner was having a rough day, since a clean environment helps him to relax

when he gets home. It was important for her to continue having the capability to help out around the home and to create a clean environment for her partner to enjoy.

During Long Distance

The remote partner moved away during summer and moved into an apartment with a roommate. She started using the telepresence robot on the first day apart. During the three months of long distance, the couple spent most of their evenings and weekends together sharing a home through the telepresence home setup. The remote partner moved around the home through the telepresence robot and could control the lights, TV, and vacuum through voice commands. In her remote apartment, she controlled the telepresence robot through various devices - she typically used her laptop to control the telepresence robot if she wasn't using it to work at home, her tablet if she was using her laptop, and her smartphone if she was at her workplace.

The couple also continued to use the communication tools they used to stay connected throughout the day while co-located (i.e. Messenger and text messaging) and added Discord (a chat app) to their daily communication routine in order to share video streams.

As a result of needs that emerged during the study, two devices were added during the course of the study. The first item was a printer that would allow the remote partner to print letters and photos for her partner in his apartment. We attached the printer to the telepresence robot (see Figure 3) so that the remote partner could move around the home and leave printed messages in specific places. We also attached a portable battery to keep the printer charged. This device could not be voice controlled but was controlled over distance through an app. The second item we added was a sous vide cooker that could have its temperature and timer set using voice commands. The reasoning for the sous vide cooker was to allow the couple to cook together as a joint activity.

Data Collection and Analysis

We collected data from several sources. Daily interactions were recorded by the remote partner (first author) in diary format starting prior to long distance (61/72 days logged) and continued to be logged during the three months of long distance (44/88 days logged). A camera with a view of the entire apartment (except the bedroom and bathroom) was on 24/7 and clips of notable interactions were saved. A semi-structured interview was conducted in person prior to beginning long distance in order to get the local partner's perspective on how the couple shows mutual care through maintenance behaviors, and which interactions are important for the relationship, as well as how the couple interacts and shares home life more generally. Then semi-structured interviews were conducted over video conferencing on most weekends when neither partner was travelling. The semi-structured interviews lasted an average of 17 minutes each and were conducted by the first author.

These interviews discussed the experience of sharing a home over distance through the telepresence home setup. For example, “In what ways do you think the telepresence setup helped us share the home?” “What were some positive moments using the system?” “What were some negative moments using the system?” As well, the researcher asked questions about interactions that happened in the week leading up to each interview. For example, “So this week your mom came over...How do you think that our set up influenced that interaction?” “What did you think about our experience trying to cook together?” The local partner was also asked about his thoughts on how the setup could be improved. For example, “But off the top of your head, can you think of how a smart home telepresence set up could be improved for this scenario of having a shared friend group over?” “Can you tell me about incidents when you wish that not just the telepresence robot but also the smart home set up was done up in a way that could make things more helpful or interactive?”

To analyze the diary data that came from the remote partner, we coded each of the documented interactions by the relationship maintenance behavior that was being accomplished by the action. Furthermore, thoughts on the shared home experience were coded as positive, negative, and neutral. To analyze the interview data that provided the local partner’s perspective, we transcribed the interviews and recorded each of the interactions that were mentioned in the interviews that corresponded to a maintenance behavior. We gathered quotes from the transcriptions regarding any benefits and challenges that were identified by the participant. These were organized by the maintenance behaviors the responses pertained to. Photo and video data provided rich documentation that could be referred back to for clarification, for example, to see how the telepresence robot was positioned when partners watched TV together, but were not used beyond that for data analysis as the activities captured were already reported on in the diary and interview data. Data analysis was performed by the first author who was experiencing the system with her partner. Findings and themes were discussed with the second author and this led to further iteration on the categories and classifications identified. The analysis resulted in a list of maintenance behaviors that were performed, the specific activities involved in performing these maintenance behaviors, and the challenges and benefits that were reported regarding these activities.

RESULTS

Over the course of three months, the telepresence robot was used for a total of 226 hours and 54 minutes, averaging 3 hours and 14 minutes of use per day. On weekends the average use was 5 hours and 7 minutes a day, while during weekdays the average use was 2 hours and 29 minutes a day (see Table 1). Longer usage periods were seen over the weekends as the couple stayed home and spent time together. These numbers were taken from the telepresence robot’s usage log. The individual smart home tools did not log usage

time, however, we know that the lights were used almost daily while other devices were used a handful of times. The sous vide was only used once due to interaction issues (described later). Overall, the couple felt that the telepresence setup was preferential over traditional video chat but also had its own limitations.

	Sun	Mon	Tues	Wed	Thurs	Fri	Sat
Week 1				1hr 19min	4hr 14min	2hr 57min	4hr 17min
Week 2	2hr 53min	0	2hr 3 min	1hr 43min	2hr 27min	1hr 40min	4hr 3min
Week 3	10hr 21min	1hr 44	4hr 29min	2hr 48min	1hr 42min	41min	5hr 45min
Week 4	7hr 59min	21min	3hr 48min	1hr 12min	1hr 23min	3hr 44min	3hr 45min
Week 5	7hr 6min	1hr 42min	4hr 22min	4hr	local partner visiting	local partner visiting	local partner visiting
Week 6	local partner visiting	4hr	2hr 36min	local partner travel	4hr 48min	local partner travel	local partner travel
Week 7	1hr 14min	54min	3hr 42min	34min	4hr 13min	48min	7hr 36min
Week 8	9hr 39min	1hr 32min	2hr 3min	2hr 16min	2hr 11min	5hr 33min	24min
Week 9	55min	remote partner travel	remote partner travel	remote partner travel	remote partner travel	remote partner travel	remote partner travel
Week 10	remote partner travel	8hr 42min	4hr	1hr 51min	1hr 57min	35min	5hr 25min
Week 11	6hr 51min	1hr 1min	1hr 46min	2hr 43min	2hr 21min	1hr 49min	9hr 52min
Week 12	7hr 33min	3hr 59min	remote partner travel	remote partner travel	remote partner travel	remote partner travel	35min
Week 13	5hr 10min	0	15min	2hr 40min	4hr 19min	2hr 24min	57min
Average	5hr 58min	2hr 10min	2hr 54min	2hr 11min	2hr 58min	2hr 15min	4hr 16min

Table 1. The usage of the telepresence robot over thirteen weeks of long distance.

Ownership and Belonging

With the telepresence home setup, the remote partner was able to control the state of the home in many of the ways that the local partner could. Being able to control the state of the home meant that the remote partner could keep the environment a comfortable space to be in. For example, if it got too dark, she could turn on the lights, or if the music was too loud, she could turn down the volume. This allowed the remote partner to feel at home in the space, rather than feeling like a visiting guest or even an intruder.

Having not only a physical presence in the space (through the telepresence robot embodiment) but also having control of household features (through the smart home tools), the remote partner was not simply a presence in the home, she was someone who was living in it and adjusting it to her needs. Thus, the home was accommodating to both the local and remote partners, making it a space that both partners could feel a sense of belonging in regardless of their physical differences as human and telepresence robot.

The remote partner felt a lot of comfort from spending time in her shared home, especially when she moved around the space and could see her things around the home. Sometimes she would purposefully go to a place to get a familiar perspective (for example, she would go to her side of the bed just to be there) or do something familiar (for example, she would turn on her desk lights even though she wasn’t working there). To allow the remote partner to spend time where she was comfortable, the local partner moved the robot’s charger to the remote partner’s desk.

“I really like seeing my stuff scattered around the home. It gives me déjàvu of stepping around my things in person.” – Remote Partner

Both partners were also able to take ownership of the space by keeping it clean and checking on things. For example, the remote partner could run the vacuum to keep the apartment clean, check if the front door was locked at night, turn the lights off when no one was going to be home, and check on the health of the basil plants in the kitchen. For the remote partner, this further cemented the feeling that she was not just visiting – this was still her home and she had the responsibility and capability to care for it. Furthermore, the remote partner enjoyed being able to help her partner with chores. In relationship literature, this is a maintenance behavior termed “sharing tasks”. Showing care through helping out felt more impactful than showing care through affectionate words.

“For me, I felt amazing that I could help my partner and make him feel like I could still be there for him” – Remote Partner

“[The vacuuming] made me feel like it was a nice thing to be able to, it felt like a normal thing, you know?” – Local Partner

Aside from helping out by vacuuming the home, the remote partner was limited to helping out in small ways, such as by turning off the lights when her partner was going out. There were several times when the remote partner wanted to help out, but could not. For example, when the local partner brought home a new bookshelf, the remote partner was able to contribute advice for where to put it, but she could not help move the bookshelf to where they decided to put it. Similarly, the remote partner often wanted to help take out the garbage but had no way to pick it up or throw it out due to the simple, appendage-free form of the telepresence robot. The limits to helpfulness were also felt by the local partner.

“In terms of like chores, I don't think there's a whole lot we can really split. It's more like we can do stuff together and that you can come along and like, you know, observe and like maybe I'll even ask you to look at something and just tell me if something is somewhere, you know?” – Local Partner

“I mean, I think without the ability to really physically interact with the environment, it's kind of limited, right? I mean like, you know, like the ability to run the dishwasher and to run the laundry would be nice because there's times where I can't do that at night.” – Local Partner

The couple also wished that the remote partner could help run the dishwasher and laundry machines, because these were tasks that she often took care of while they were co-located. Such voice-activated appliances exist, however, we chose not to pursue them because a malfunction could cause serious water damage with possibly nobody local to stop it. Together, these tasks reveal the limitations of the minimalistic form of the telepresence robot. The first

limitation has been brought up in other papers – without arms, telepresence robots can't help carry things [33] e.g. carrying food to the table, taking out the garbage, or moving furniture. The second limitation is that telepresence robots can not flexibly respond when devices malfunction or require troubleshooting. For example, if the vacuum got caught on a wire or if the internet connection needed to be reset, the local partner would need to take care of these issues.

A Sense of Normalcy

The telepresence home setup supported an atmosphere of normality in the home. It allowed the couple to interact in many of the same ways that they would in person. When the couple lived together in person, they would casually ask one another to help out in little ways and this continued when they were apart. For example, the local partner would sometimes ask his partner to help him check if the front door was locked while he checked the balcony door at night. On one occasion, the remote partner purposefully created a sense of normalcy by turning on the TV in preparation for her partner coming home after a workout, so that he would come home and see her in the home, doing her own thing, as he normally would when they were co-located (see Figure 4).



Figure 3. Stanley coming home to find Tessa watching TV.

Any day the remote partner could get home before her partner, she would rush home and make sure that she turned the lights on and waited for him. It was important to her that her partner did not feel like he was living alone and coming home to a dark and empty home. Instead, he often came home to his partner greeting him at the door and the lights turned on, just as it often was when they were co-located. Sometimes, for the sake of variety, she would also choose a song to play on the Nest Home Hub so that the home would be filled with music that he liked as well.

“The last little while you have been sometimes turning on the lights or putting on music for when I come home, which has been very nice cause it shows like, you know, it's like it makes me feel a bit more like I'm coming home to you actually being here and it also is like a clear indication of something nice that you're trying to do for me.” – Local Partner

The normalcy of coming home to a space that felt lived-in had a positive impact on the local partner's mental state,

slowing down the onset of anxiety that typically emerged when he was apart from his partner.

“Like I think, you know, like in the past when you’ve been gone for like any period of time, I tend to get anxious...[a]nd I think having like the [telepresence setup]...has like slowed that process.” – Local Partner

We asked the local partner whether he’d get the same benefit from an automated system that would turn the lights on when he was near, but he noted that having his partner be the one who turned on the lights was significant. The act of turning on the lights showed that his partner thought of him and put in the effort to care for him.

“...[H]aving the other person actually being the one who is putting in the effort to do that stuff matters.” – Local Partner

Even when things did not go according to plan, such as when the telepresence robot’s battery died while the remote partner had been waiting at the door, the show of effort was enough to make the local partner feel cared for.

“There was like another time where like you had taken the [telepresence robot] off the dock to wait for me, uh, at the door and I guess the [telepresence robot] had died while you were waiting. Um, but it wasn’t a bad moment. Like I actually was like, actually it actually was very sweet cause I could see what you’d been doing.” – Local Partner

Diversity of Interactions

Over time, the long distance couple noted the value of being able to interact in diverse ways through the telepresence home setup. Both partners felt a desire to interact in different ways rather than being constrained to the same set of behaviors every day (e.g. coming home, watching a show together, then hanging out). When asked about whether it mattered to him that his partner could express affection in different ways, the remote partner responded that variety has value. If there was only one way to express affection then it would begin to feel rote and less meaningful.

“Like if you just do the exact same thing every single day, um, it sort of becomes like, it’s more like it’s a routine than an actual thought. So like, you know, if you don’t turn on the light some days I don’t think anything of it. But if you turn on the light like some days and like, you know, turn on some music some days it feels more like you’re actually thinking about it rather than just doing the thing that you do.” – Local Partner



Figure 4. Cards that Tessa printed for Stanley.

Normally very physically affectionate, the remote partner needed new ways to show affection over distance. She often left messages on the telepresence robot’s screen, such as “Stanley Rules!” or “You are so special”. However, leaving these messages did not feel satisfactory and instead felt similar to leaving regular text messages. As a result of the remote partner’s desire to express herself in more personalized and varied ways, we added a printer to the telepresence robot. This allowed her to print out physical cards and photos and to drop them where she wanted the local partner to find them (see Figure 5). The act of creating these cards (using a drawing app on her tablet) made her feel that she was doing something effortful and special for her partner and her partner enjoyed getting the cards and photos like little surprise gifts.

Aside from the messages, cards, and photos, the couple could also express physical affection, albeit in a limited way. The local partner would often touch the remote partner’s robot body. For the remote partner, this felt very intimate because she could see her partner’s hand on her “body” because of the downward facing camera which was meant to help with navigation. Thus, simply seeing the physical representation of one’s body being touched can be a powerfully intimate sensation.

“It’s just like for me it’s, it’s just like the way I would like reach out and touch you. Like obviously it’s not the, it’s not the same sensation, but it’s the same like instinct to do that. And it’s nice to be able to feel like I’m having a little bit of a physical connection.” – Local Partner

“Like I already feel like, you know, that you’re touching my body cause I can see it and that’s like a pretty strong sense for me, but like knowing that like you also feel that definitely like reinforces that.” – Remote Partner

For this couple, the physical presence of the telepresence robot was only used to support non-sexual forms of intimacy. Even though the local partner generally regarded and treated the telepresence robot as his partner’s representation, he did not want to engage with it in a sexual manner.

“Honestly it’s like I like being intimate with you and the idea of being like somehow like having some like intimacy with a machine, even though it’s a representation of you, it’s just something that I find uncomfortable.” – Local Partner

Aside from diverse ways of showing affection and support, the couple also wanted to do different types of activities together. Most evenings, they ate dinner together while watching a show. On special occasions, such as their anniversary, they bought the same type of food to enhance the feeling of eating together. Rather than watching the shows in the living room area where they would normally watch shows in person, they most often sat in front of their computers and streamed the shows through chat software. This was because the audiovisual quality of watching shows through the telepresence robot was low and the limited field of view (104 degrees) made it difficult to see both the local

partner and the TV at the same time. Furthermore, the local partner expressed that the telepresence home setup did not provide additional benefits to the couple's enjoyment of watching TV or playing video games together.

"...[M]ost of the joint activities we tend to do are things that can be done through like a remote share, right? Or like, you know, we play video games together or watch shows together so it doesn't help or hinder those things at all." – Local Partner

The partners' experiences suggest that for joint activities like watching shows and playing video games, the virtual space becomes the shared space, and thus a co-located physical experience is of secondary importance for these activities. While the remote partner delighted in the idea of watching TV in the living room as they did while co-located, she realized that she paid little attention to the physical surroundings once she was engrossed in the media.

While the couple enjoyed watching shows together each night, this routine lacked variety and they missed doing activities together. In response, they planned a night to cook a meal together. They used a sous vide machine to heat up the water for cooking chicken, asparagus, and carrots. The intention was for the remote partner to be able to control the temperature of the water using voice controls. However the system would not connect to the Nest Home Hub for voice control, so instead she took on the role of reading out the recipe to guide her partner through the steps. The remote partner could move around to get a closer look at the ingredients and process. She noticed that it was difficult to see the small numbers on the sous vide device that indicated the temperature. Given that monitoring temperatures and timing are the main contributions that a remote partner can manage in a long distance cooking scenario, the visibility of indicators is an important element to consider.

The local partner's biggest issue with the joint cooking activity was that the remote partner did not get to eat the nice meal at the end. He was particularly uncomfortable with the fact that the remote partner ate leftovers while he ate the nice meal they had made together. Thus the local partner noted that cooking the same meal in parallel with one another would be an option that would allow them to share the same meal at the end.

"I think that the only thing that I, that I that was I think a negative about it was that I felt very guilty at the end cause like I, we were like, we were making food but I was the only person who got to eat it, whereas you were just eating like a leftover sandwich, which I found like I felt really bad about." – Local Partner

Both partners agreed that they preferred to eat the same food for dinner as that increased their feelings of togetherness. However, it can be difficult to cook the same things when long distance as partners may have different access to ingredients, and in the case of this couple they had differing access to cooking appliances.

Social Connections

Having a telepresence robot embodiment made it possible for the remote partner to be present and part of the group when friends (see Figure 6) and family came over. For example, the couple's mutual friends visited for their usual game nights. The remote partner's autonomy allowed her to move around with the group and to direct her attention to the people she wanted to speak to. While she could not play the video games during games night, this was no different than how she would usually participate by watching in order to let the guests have the controllers. The challenge during the role playing game was that she could not turn the robot very quickly when her attention moved between players. However, she felt involved with the group in both situations even though her telepresence robot embodiment rendered her movements more sluggish than usual.



Figure 5. The remote partner with friends at home.

While the telepresence home setup was not designed to support connections outside of the couple, it could be adapted to do so. On one occasion when her partner's younger brother came over, the remote partner printed a photo of his family for him as a small gift which made him happy. The younger brother affectionately gave the remote partner's telepresence robot embodiment a hug when he left. This positive outcome for the remote partner and her relationship with her future brother-in-law shows that telepresence home designs should support the user in flexibly expressing affection not only for her partner but for family and friends as well.

While the telepresence robot embodiment helped the remote partner feel part of the group, the challenge in having guests over was that the remote partner felt that she did not contribute to hosting the guests. She wanted to help her partner tidy the apartment (beyond vacuuming) and move things around to create space, and she wanted to be able to offer drinks and make sure that everyone was comfortable when the guests arrived. Future telepresence home setups could benefit from considering how to support connections with not only one's partner, but also family and friends. This would involve supporting hosting tasks and also supporting joint activities and interactions with more than one person.

DISCUSSION

Unlike previous studies on the use of telepresence robots in the home space [34,35], we considered ways to provide

greater affordances to the telepresence robot embodiment through smart home devices. The following is a discussion of the design implications from our study.

Ownership and Belonging

Our findings reveal how having greater control over a remote home space through a telepresence robot embodiment can create intangible benefits, such as feelings of ownership and belonging. Having control over aspects of the environment, such as how bright the room is, allows the remote partner to make themselves comfortable in the space. This supports long periods of time spent in the shared home space, including time spent there even when the local partner isn't home. Given the ability to clean the shared home space, the remote partner can perform the relationship maintenance behavior of *sharing tasks* and thus maintain closeness with the local partner by jointly caring for the home.

These findings suggest that there is value in designing telepresence home setups that allow the remote partner to contribute to caring for the home. Of course, there are a growing number of smart home devices that might offer the types of support that couples would find valuable for their relationship. We studied only a small number. Regardless, what seems to be most important is that the devices that one is able to make use of when coupled with a telepresence robot are those that maintain relationship consistency. That is, setups will likely be particularly beneficial to couples when the shared tasks that are supported are the same tasks they shared when co-located, thus keeping the relationship dynamic stable. This is consistent with research on relationships transitioning between being long distance and being geographically close which has found that the shock of transitioning can result in breakups [30].

While pairing the telepresence robot with smart home devices allowed the remote user to accomplish more through the telepresence robot embodiment, the lack of appendages still presented challenges. First of all, the remote partner could not troubleshoot if devices malfunctioned, and, secondly, the remote partner could not move anything around. If these types of challenges are to be solved, there is a chance they could require complex robotics engineering as a solution if one was to look at ways of providing the telepresence robot with more capabilities and/or appendages. Alternatively, designers could explore ways of creating smart devices such that they can be further managed while remote, especially in the case of malfunctions. In our case, all devices were controlled via voice through the robot. Designers could explore ways to couple such controls with 'backup' interfaces (e.g., a web portal) if voice activation fails, for example.

A Sense of Normalcy

Another consequence of having an embodied presence which can utilize the amenities in the home is the ability to maintain patterns of co-located living. In our study, the remote partner continued to perform the relationship maintenance behavior of *support* even over distance by turning on the lights at the

shared home and greeting the local partner at the door when he arrived home from long work days. The ability to carry over a sense of normality after becoming a long distance couple alleviated some of the stress that came with moving apart. Furthermore, the acts of support were valued by the local partner because they were performed by the remote partner, rather than simply automated. The design implication is that, within the context of long distance relationships, a telepresence home setup should support initiative over automation. Activating devices in the home, whether it's a coffee machine or a dishwasher, are all opportunities for partners to take action and show care.

We also recognize that what was lacking in our couples' situation was the ability for the *local* partner to show support for the remote partner. Opportunities for providing support were mostly asymmetrical because the telepresence setup was only in one home and not both. This was done because of the living conditions in the remote home, which was shared. Yet it still raises interesting questions around how designers could create symmetrical setups and how they would be used. Would couples actually want to have telepresence home setups in both locations? Which home would they virtually cohabit, or would it be both? If telepresence setups were in both, would it create too much of a burden for both partners to manage and care for both locations? We leave these questions for future explorations.

Diversity of interactions

Over time, the value of variety became apparent. The same displays of affection became less meaningful when not adapted or personalized. Since we were using devices external to the telepresence robot, we were not limited to the functions of the telepresence robot. During the study, we were able to add devices (printer and sous vide machine) to the telepresence home setup so the couple was able to perform the relationship maintenance behaviors of *affection* and *joint activities* in a variety of ways. It was found that effort, variety, and personalization were factors that helped to make their interactions more meaningful. These findings suggest that when designing a telepresence system for couples, it could be valuable to support diverse expressions of care that convey effort and allow personalization. This could come from having a variety of devices that one can utilize over time, or the ability to easily add devices when couples begin to feel like interactions are becoming stale or they feel like they want more diversity.

Of course, one would not necessarily want to continue to buy new smart devices to keep having valuable experiences and creating a diversity of interactions. Here we feel what is valuable are smart devices that can support a range of behaviours as a part of relationship maintenance activities. For example, in our case, the printer appeared to work really well because there was nearly an endless amount of things that it could be used for by the couple. That is, the remote person could create any notes or drawings that she liked, and the robot could be moved to nearly any location to leave the

note there as it came out of the printer. On the other hand, smart items like lights are relatively fixed when it comes to their usage and could grow stale as a way to show support. Thus, designers could find great value in continuing to explore the design of devices, like the printer, that provide couples with a multitude of possible uses where one can creatively tailor that usage in the moment.

Social Connections

The telepresence home setup was beneficial for the relationship maintenance behavior of *social network* as it allowed the remote partner to maintain social connections with family and friends. However, the remote partner's inability to help host the guests presents a design opportunity. Future home setups could consider how a remote partner may want to be involved in hosting guests and participating in multi-person joint activities. This might involve, for example, further aspects of planning and preparation. We already explored sharing tasks such as vacuuming. Moving beyond this relatively simple activity, one could imagine other acts like checking what groceries are in the fridge remotely (via a smart fridge) and ordering them online for delivery, configuring a music list to play in the home, etc. In terms of multi-person joint activities, one could imagine activities such as board game playing over distance. Potential design opportunities are endless.

Together our findings demonstrate the advantage of designing a telepresence *system*, rather than thinking of the telepresence robot as a solitary unit. As Broxvall et al. explain, a decentralized system supports "piece-wise development" [3:213] that can be incrementally worked on. In our case, the voice-controlled devices expanded what the telepresence robot could do without having to solve the complex problem of adding dexterous, load-bearing appendages to telepresence robots, and managing to do so with simple enough controls that there is minimal mental load for controlling the robot. Moreover, this was done at a relatively affordable price.

Perhaps most importantly, our findings point to a direction for designing these devices without necessarily relying on automated initiation. For example, rather than having automated lights that turn on at a certain time, a remote partner can be given the ability to turn on the light for their partner. Long distance relationships benefit from the opportunities to perform actions that show thoughtfulness and caring. While we are not saying that automation should never be used, we are saying that there are places where user control and action can provide additional support for relationship maintenance.

Limitations and Future Work

While autobiographical design allowed for exceptional access to the private home life of a long distance couple, this method has inherent limitations. Firstly, the findings are specific to one couple with a unique relationship dynamic. The dynamics of other couples will certainly differ. As such, our research is best thought of as exploratory where we are

able to suggest directions for designers to explore that will likely have promise, given what we saw in our work. It is not the case that what we saw should generalize to other couples as this is not the goal of autobiographical design.

Secondly, self-usage reports often raise concerns about a lack of rigorous data collection and a potential bias towards the success of the system being investigated. Being aware of these concerns, we were very careful to collect extensive data about the couple's experiences through a variety of data sources. We were also careful to ensure that the researcher had a genuine need for the system, they used the system extensively, the data was collected in a structured manner, and design implications were reflected on [27].

Our study lasted three months, which is not as long as some pieces of autobiographical design research [27]. This is a fair critique, however, in our situation, studying this couple longer would have been impossible since Tessa returned to her home after three months. Alternatively, we could have studied a different couple over a longer time period, but this would come with the caveat that we would have reduced access to the couple's real activities. For example, with Tessa and Stanley, we were able to capture live video as data for analysis throughout the entire study period. It's unlikely that such data would be available for an external couple.

We also recognize that the telepresence home setup comprised of a small number of smart devices. In choosing the selection of devices, there were pragmatic constraints around concerns of damage to the home (e.g., flooding from a malfunctioning smart dishwasher). That said, we chose devices that represented the categories of maintenance behaviors that were particularly limited by traditional computer-mediated communication tools, such as sharing tasks (vacuum) and joint activities (Chromecast and sous vide machine). There were many smart devices that we could have chosen, but we wanted to be authentic in terms of what matched the relationship needs of the couple. The devices we chose were prioritized by their relevancy to the couple in the study. Other couples may value different ways of showing care, such as preparing coffee in the morning or making the bed, and we see value in exploring more devices in future studies.

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