Shopping Over Distance through a Telepresence Robot

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Computer mediated-communication tools (CMC) support loved ones in maintaining connections with one another over distance, yet it can be difficult to actually do activities together. We studied the use of telepresence robots for supporting distance-separated loved ones in engaging in the joint activity of shopping over distance. One partner shopped in person while the other used a telepresence robot from a remote location. As a point of comparison, we had a second group of participants use video chat on a tablet, instead of a telepresence robot. Compared to the tablet group, we found that when partners communicated through a telepresence robot, the remote partner's personality and presence were strongly expressed through the movements and physicality of the medium. However, the use of the telepresence robot introduced tension between partners regarding responsibility, dependency, and contribution to the act of shopping. These results demonstrate the benefits of a mobile embodiment for remote partners, as well as the need for greater physical capabilities to support both physical connection and remote contribution to leisure activities.

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

KEYWORDS
Telepresence robots; video communication; social presence; relationships; leisure activities.

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1 INTRODUCTION

Many family members, couples, and close friends rely on computer-mediated communication (CMC) tools to maintain their relationships over distance [3,17,25,43]. CMC tools such as video chat are used to keep updated on one another's lives through conversations and the viewing of remote activities [17,25]. As the ability to share activities through video streaming has become more convenient and portable, people are sharing a greater number and variety of activities over distance, e.g., playing outdoor games, visiting zoos, sightseeing, attending weddings [13,22,26]. Yet the practice of sharing activities over distance using current CMC tools has repeatedly shown challenges. This often relates to camera work—continuous efforts to provide remote users with a good view—and a lack of embodiment in the remote space [4,15,22].

Our research focuses on efforts to address these problems. We explore how distance-separated loved ones can participate in activities *together* over distance through the use of

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telepresence robots with a particular emphasis on leisure activities. Telepresence robots are CMC tools that mediate audio, video, and motion via a physical embodiment [35]. Studies have explored varied contexts, including workplaces, conferences, schools, etc. [20]. However, there is a lack of research that explores if and how telepresence robots might support shared leisure activities by family members or close friends in public settings, an important context for supporting the maintenance of family and friend relationships. We also see a lack of research studies that explore the effects of telepresence robot design on social relationships and relationship dynamics, from the perspective of both the remote and local user in dyadic situations.

To build on the existing research, we conducted an exploratory study that investigates the use of telepresence robots for joint leisure activities in a shopping mall. We imagined a future where people may bring their family or friends on shopping activities from remote locations where telepresence robots may be made available by malls or shopping venues somewhat similar to how mobile scooters are presently available for those with mobility challenges to rent or use. This idea builds on suggestions from prior work on family communication over distance (e.g., [22]) and also reflects the increasing amount of shopping that people do remotely from physical stores, albeit via online web pages and not robots [10].

Our study focuses on couples as an exemplar form of a close relationship as this type of relationship typically requires a broad range of communication requirements. We focused on the joint activity of shopping as it contains a variety of activities important for relationship maintenance [43] and is a common activity [41]. This includes joint decision-making (e.g., about items to purchase and which stores to visit), shared tasks (buying items on a shopping list), and conversing. We had partners shop together with one person physically in the mall while another used a telepresence robot from a remote location. We compared this experience to the use of video chat on a tablet, a more common method for sharing experiences with people remotely [22] . Our study focuses on understanding how a telepresence robot supports or hinders people in jointly participating in the shopping activity over distance and what design factors are important for the design of telepresence robots to support close personal interactions during the shared activity. Our goal was to understand how to design telepresence robot solutions to better support remote leisure activities between family and close friends over distance.

Our results reveal that the use of a telepresence robot for joint activities over distance can allow loved ones to express their personalities and affection through familiar behaviors and playful interactions. Yet our findings also reveal lingering challenges and shortcomings related to a lack of full autonomy when using a telepresence robot and issues related to responsibility, dependency, and the ability to contribute to the activity. We conclude that when designing telepresence robots to support joint leisure activities over distance, designs should empower the remote partner with unique abilities that contribute to the joint activity, so that the remote partner's virtual presence is more valued by the local partner who is with the robot. In addition, telepresence robots should be designed to allow for more intuitive control, making spontaneous acts of playfulness easier to perform, and to better support intimate interactions.

2 RELATED WORK

2.1 Sharing Activities over Distance

There is a rich body of literature on the use of video mediated communication systems for sharing activities over distance amongst family and friends. Within the home, this has involved studies of shared television watching [6], working jointly on homework amongst teenagers [5], children reading books with grandparents [39], and more. Together this research has shown the challenges around keeping people engaged in shared activities over video [39] and supporting

the camera work necessary to present desirable views to the remote viewer [4,5,6]. Outside the home, researchers have studied and designed systems to support sharing activities where a remote person watches via a video link (e.g., weddings, picnics, sightseeing) [13,22]. We have also seen the study of parallel activities where two people both engage in an outdoor activity and stream video to one another so they can see what the other is doing, e.g., geocaching, bicycling [26]. Furthermore, researchers have explored augmenting shared video/audio streams with additional information, such as contextual information provided by an additional camera view and a mapping of partner locations [18]. In all of these cases, video was supported through the use of mobile phones or tablets with relatively small displays. Camera work was again a challenge and sometimes took away from participating in the activity [13,15,22,34]. Holding a mobile phone to show a good view was sometimes socially awkward [15,30] and it was hard to gesture at particular objects or locations in the scene [15]. Remote users also wanted to have more control over what they saw [15]. Work on 360-degree cameras has shown that they can help overcome this issue as they allow remote users to independently look around, yet this creates the new issue of not knowing where the remote user is looking [46]. The use of mobile video streaming in public settings also raises issues around privacy and surreptitious streaming of video [34].

Our work expands on this research by moving beyond wearable cameras and handheld devices for video chat to explore the use of a telepresence robot that can provide autonomy and mobility for the remote viewer that is not dependent on others. We compare this experience to the use of a tablet, commonly found in the related literature.

2.2 Telepresence Robots

Telepresence robots have been studied in a variety of settings, including offices, schools, elderly care, healthcare settings [20], and conferences [27,36]. Studies have found that the physicality and mobility of telepresence robots can create strong feelings of social presence [27,35]. Telepresence robots used for remote office work have been shown to allow remote workers to join social events and have impromptu conversations [21]. Similar findings have been found for remote conference attendance [27,36]. Telepresence robots are also beneficial for supporting awareness of the activities of others in the workplace given that they require explicit movement between locations [21]. They can also help people strengthen social connections over distance [21]. In educational contexts, telepresence robots can support varied remote student needs, such as extended absences [28,29].

Many challenges exist when using telepresence robots. These include difficulties in understanding body language [27], grasping objects [28], driving while performing other tasks [21,35], and understanding how one sounds and looks in the remote space [21,27,31,45,48]. Remote collaborators (via a robot) are also at a disadvantage compared to in-person collaborators who tend to focus on each other more than the remote user [44]. Wide field or panoramic views are needed for supporting peripheral awareness [14,16,19], varying audio levels are needed for conversations [16], and adjustable heights can be valuable for supporting persuasiveness [37]. Often, users require help when operating a telepresence robot in order to avoid obstacles, overcome connectivity issues, and navigate tight spaces [14,21,27]. Telepresence robots can also create undesirable attention from others [21,27,28,29,36]. Remote users often face privacy challenges from being in mixed contexts (e.g., connecting home to school) [27,28,29]. Sometimes telepresence robots need to be transported to different locations in order to be used by remote users [8].

While focus has been placed on use within organizations, there has been growing interest in the use of telepresence robots as a part of domestic life, such as use between long distance partners [49] and an elderly person and remote family members [1]. Telepresence robots have been shown to support displays of affection or displeasure through robot-based body language

[49], yet interactions still raise challenges [1]. While there is limited work that explores telepresence robot usage for leisure activities occurring outside of the home, a notable exception is work on the use of telepresence robots in a museum and restaurant [38]. A series of studies raised questions around how users may depend on each other when using a telepresence robot and how this may affect relationships. We build on this work to directly explore such questions.

2.3 Commerce and Shopping Over Distance

There is a broad range of research that explores shopping behaviours and practices. People shopping in physical stores sometimes take pictures of items they want to purchase and send them to family or friends for suggestions [24,47]. Sometimes it is difficult for people to take pictures of themselves wearing clothing items because of camera work issues (e.g., framing, flash) [24]. People also enjoy connecting with friends and family through online shopping [9] and often take recommendations from them [11]. This reflects the growing volume of people who shop online through ecommerce web sites and mobile commerce applications on phones [10]. Despite these research studies, we do not know of any that explore remote shopping through a telepresence robot.

3. STUDY METHOD

We conducted an exploratory study on the use of telepresence robots for remote shopping with a focus on couples as an example of a close personal relationship. We compared this experience to remote shopping using a tablet and video chat software. The comparison allowed us to more clearly draw out the benefits and pitfalls of telepresence robots. Overall, our focus was on understanding how telepresence robots supported or hindered the experience of shopping over distance, and what design factors were important for the design of telepresence robots to support shared leisure activities, like shopping, over distance. The study was approved by our research ethics board.

Fig. 1. Telepresence robot (left) and tablet (right).

3.1 Participants

We recruited participants through various channels at our university including posters, announcements in undergrad classes, and emails to student lists. Flyers were also distributed in the nearby mall and recreation centre. We recruited couples in order to focus on a specific type of close relationship that often requires communication with greater nuance and depth. Fourteen couples participated in the study. *Seven couples used a telepresence robot* (6 female/male, 1 male/male; age range = 19-46 years old, average age = 24.6, SD = 8.7; relationship

duration range = 4-120 months; average relationship duration = 33.5 months). Information for relationship duration was missing for one telepresence robot couple. *Seven couples used a tablet* (5 female/male, 1 female/female, 1 female/gender non-binary; age range = 19-30 years old, average age = 22.3, SD = 3.1; relationship duration range = 1-48 months; average relationship duration = 18.1 months). One couple (using the telepresence robot) was in a common law relationship (i.e. in our country, this is a couple that has lived together for 2+ years and has assumed the same legal rights as married couples). The rest of the couples were in dating relationships. Thus, we studied participants in both new and longer-term relationships.

3.2 Procedure

We had couples use either a telepresence robot or a tablet (and not both) in order to avoid participant fatigue, as the study took up to 2 hours per couple. Driving a telepresence robot through large spaces like a mall can be time-consuming given the speed of the robot; thus, we were cognisant of the effect of task time on participants. In the first group, the remote partner explored the mall through a telepresence robot. The driver used a computer in a private room in our university to control a Beam+ telepresence robot (henceforth referred to as "Beam"). Our university is adjacent to the mall, but it is not possible to see the mall from the location of the remote viewer; thus, it reasonably reflects a situation where one might be even further away and shopping over distance. Some participants had been to the mall before, but had not visited all of the locations/stores that they had to in the study; therefore, they would have a basic understanding of the layout of the mall and know some of its stores. This is somewhat akin to situations where a long-distance partner would have visited the location of their significant other and spent some time there but not be present all the time.

The Beam was 52.9 inches tall (134 cm), with a 10-inch (25.4 cm) LCD monitor, two HDR cameras (one pointing forwards and one pointed downwards), a 4-microphone array for high fidelity sound, and a 15-Watt speaker. In the tablet group, the remote partner connected to a participant in the mall using Skype on a tablet. A tablet (3rd generation 64GB iPad with a 9.7-inch display (24.6 cm) and a resolution of 1536x2048 pixels) was chosen for this group based on precedence set by similar work [38] and the goal of assessing the usage outcomes that result from mobility, while keeping screen sizes approximately equal across both groups. We attached a small (1.7 inches/4.3 cm long) Leadsound Crystal 3W speaker to the iPad to make it audible above the ambient noise of the mall (Fig. 1, right).

Two researchers were present to run each study session, which consisted of one pair of participants at a time. Our study followed several stages:

1. Introduction: First, the researchers explained the study procedure to the participants. Vignettes were then given to participants to describe a long-distance relationship scenario which would necessitate the need to shop over distance together as opposed to collocated couples who would likely just shop together in person. Participants were instructed to imagine they were in the described relationship. The scenario explained that the partners were in a committed relationship and that the remote partner had moved to Denver, USA for work, about a 3-hour flight away and in the same time zone. They were using a telepresence robot to spend some quality time together by going on a shopping trip. Given the lack of any extreme time zone separations, this type of activity would be plausible for long distance couples in the future. Once the partners had read their vignettes, we gave both partners a brief training session on the telepresence device that they would be using. This was to ensure that participants had a basic level of competency.

2. Tasks: After training, the partners were given three tasks to complete in the mall. These included: finding a gift for the remote partner's mother's birthday (maximum $30); trying on a piece of clothing to show the remote partner (for the mother's birthday party); and, buying a drink at Starbucks. They were instructed to do the tasks in any order, as long as they completed

the Starbucks task in between the other two. This ordering allowed for flexible shopping, the need for some joint decision making around what order to perform the activities in, and the requirement to have to use the telepresence device both with and without holding other objects (e.g., a beverage). We felt that buying a coffee would also lead to two regular shopping experiences: 1) waiting in line with not much else happening, which can lead to idle conversation with one's partner and 2) being burdened by carrying an item while trying on and assessing clothing. The second point explicitly raises the issue of the remote person not being able to physically hold the item in order to better support (and collaborate) with one's partner while trying clothes on.

Overall, the tasks were chosen for their normalcy as part of regular shopping trips and because they would likely require some joint input from both partners. The local partner was given a shopping to-do list as a reminder of the tasks and a $5 Starbucks gift card. We framed this as a lunch-time shopping trip and told participants that they had 45 minutes to complete the tasks.

3. Interviews: When the tasks were completed or time ran out, the partners were separately interviewed so we could understand each person's (possibly) unique perspective. Interviews were semi-structured, and participants were asked for their perspectives on the tasks and their experience of presence through the telepresence device they used. For example, questions included, "What did you like/not like about using the telepresence robot/tablet?", "What types of things made the tasks a challenge?", "Did you feel like your partner was in the mall with you? Why or Why not?", and "How was this experience similar/different to shopping in-person with your partner?" We also asked participants to tell us about the last time they went shopping with their partner so we could understand how the activity was commonly performed in relationship to how it occurred during the study. Interviews lasted 10 to 30 minutes. Each participant was compensated with either one course credit per hour or $15. The study lasted 1.5 to 2 hours in total.

3.3 Data Collection and Analysis

We collected three sources of data. First, we recorded the screen of the remote user's computer. This recorded their actions when using the Beam telepresence robot or the tablet. Second, we wrote down observations about participant behaviors, interactions with the environment and with their partner, and bystander reactions in the mall. One researcher followed the person physically in the mall (from a distance) while another researcher observed the participant operating the telepresence robot/tablet in a private office. We were unable to perform video recording of the participant in the mall due to mall regulations around video capture. Thus, our method brings the risk that the researcher observing each participant could be biased in their observations. To combat this, we had both observers discuss what occurred in the study after each session since the remote observer could also see the mall context through the Beam. Third, we collected audio recordings of our interviews. These were transcribed for analysis.

We began our analysis of the data with open, axial, and selective coding on the interview transcriptions, observation notes from both researchers, and screen captures. Analysis was completed by the researcher who accompanied the couples in the mall and observed the interactions in person. When there was uncertainty regarding interpretations of observations, the researcher who accompanied the remote partner was consulted for their perspective. During this process, we looked for connections between the interview answers and the observations. Our axial coding revealed categories around expressions of familiarity and closeness, interactivity between partners, autonomy, responsibility, dependency, contributions to the joint activity, and interactions with bystanders. From these, we used selective coding to group codes and choose our main themes, which are described in our results sections. When presenting our findings, we identify each couple with the technology they used, followed by a numerical

indicator. *Local* refers to the participant physically in the mall. *Remote* refers to the participant driving the robot or using the tablet.

5. FAMILIAR PATTERNS AND BEHAVIORS

First, participants talked about the routine nature of shopping in-person and how they had familiar patterns of 'shopping behaviour' that they normally ascribed to with their partner. For example, some would normally walk side-by-side; some would enter a store, split up, and then reconvene; and, some always liked to stay together and look at items at the same time. Participants recognized and understood these behaviours and they were often an important part of their shopping experience. Through the telepresence robot, remote partners had a physical embodiment that they could use to explore the mall. As remote partners moved, some identifiable behaviors emerged through their movements and activities. For example, when shopping together in person, one couple said they would typically split up in a store to cover more ground, then reconvene after a period of time to share ideas. This familiar pattern of behaviors emerged when they used the telepresence robot to go shopping. For example, as soon as this couple entered a store in our study, they moved to opposite ends of the store, looked around, and then reconvened to discuss promising items for purchase.

> "That part also kind of…made me feel like she was there…The thing is, that's what we do! That's kind of like how we do things. We don't like necessarily go like individually at the same time looking at things. We just kind of like spread out and then convene." - Beam 6, Local

Participants also talked about in-person shopping in terms of the person they were with and placing value in being *with* that person. In addition to familiar behaviors, they valued the person's personality and specific mannerisms because they made them feel close to that person. For example, some enjoyed that their partners were extroverted and talked a lot with them while shopping. Others appreciated the sense of humor of their partner, or the fact that they were slightly clumsy. Local partners said they were able to recognize these familiar personality traits and mannerisms as they reappeared when using the telepresence robot. This made them able to relate to their remote partners in a natural way and fall into familiar patterns of being with their partner and shopping. Participants also felt that these nuances helped strengthen the feeling that their remote partner was actually physically present in the mall with them.

> "…[T]hat's pretty much how we are when we go shopping. We joke around a lot…What you see there was pretty much us in the store." – Beam 4, Remote

> "He mostly just ran into me a lot. It was definitely an accident, but it wasn't an unusual thing. We're both pretty clumsy. So it felt like it was supposed to happen." – Beam 3, Local

We observed that not all familiar behaviors were easy to achieve through the telepresence robot though. For example, most partners felt that it was important to them to be able to walk side-by-side with their partner while shopping, akin to what they would normally do. This was difficult due to the telepresence robot's limited speed options and its cameras' field of view (FOV). Walking side-by-side was important enough that some partners did so even though it was inconvenient—one could not see the partner's face on the screen. Others felt it was more important for the local partner to walk slightly in front to make sure the remote partner could see and hear them, but this was not how they normally walked together in-person.

> "The thing about standing next to someone is that it is a sign of like you are with the person, whether you're friends or you're in a relationship. There's this idea, like in the corner of your eye, you can see their body, you can see their head… If I had to talk to it I had to get in front of it and make sure that they could see me and hear me." – Beam 4, Local

> " [W]e couldn't like stand next to each other. Cause like I don't know where she's going to try to go. Right? She can't even see me unless I stand in front of her." – Beam 6, Local

Another familiar behavior that was unsupported by the telepresence robot was hand-holding. Many partners expressed that they missed this physical connection.

> "I think things like you can't hold his hand, you know, like I said 'you want to hold my hand?' he's like 'no I can't.' So I guess the physical stuff that you can't do…" – Beam 4, Remote

In contrast, remote partners using the tablet did not have an embodiment that they could control, and therefore in comparison to the telepresence robot group they had less opportunities to project certain aspects of themselves as part of their remote presence. Rather than having the autonomy to express personal interests (by approaching items of interest), displaying qualities such as clumsiness (by bumping into things often) or independence (by going off on one's own to explore other areas of the stores), remote partners in the tablet group were only able to express themselves through their voices. This was because they were being carried (via the tablet) by the participant in the mall. We observed that familiar behaviours and personality traits that were communicated by the tablet group remote partners were restricted to things that the participants would say through the audio channel. For example, some people utilized their sense of humor during conversations. Furthermore, because the tablet screen was most often held facing outwards so that the remote participant could see the environment and objects in the stores, the participant in the mall could not easily see the remote participant's face. This meant that any body language shown over the video link was nearly always out-of-view. These findings serve to highlight the value that the telepresence robot brought to the shopping experience for couples. Because of its physical embodiment and mobility, familiar behaviors were seen through the telepresence robot with physical 'body' movements, as well as in conversation, supporting a far more diverse set of behaviors. In contrast, the tablet only sufficed to support conversation-based personality traits.

6. PLAYFULNESS

Participants talked about the act of shopping as being a social outing where an important part of the experience was the interactions that occurred. That is, shopping was not just about looking at items and buying them, despite being under time constraints. It was also about being playful and enjoying time with others. When using the telepresence robot, we observed participants engaging in playful interactions that reflected this viewpoint. Because the remote participant had a moving 'body,' participants playfully prompted one another to engage in interactions that were physical in nature and utilized their entire body, be it the robot or the local participant's own body. For example, one local partner danced in front of his remote partner in a store (Beam 2 Couple), and another local partner jumped out in front of his remote partner as a 'jump scare' (Beam 6 Couple). Remote partners sometimes displayed playfulness by spinning or getting right up close to their partner in the Beam. The spinning prompted one local partner to engage by walking around the Beam in the opposite direction that her partner was spinning. These actions caused partners using the telepresence robot to switch their focus between the tasks and their partner repeatedly in an enjoyable fashion.

> "We did have a bit of fun with that too, because it's like he was going in a circle and I was going the opposite way in a circle, so that was kind of cool." – Beam 7, Local

> "I would like run up to him and then stop, like I was just messing with him." – Beam 6, Remote

While such playful interactions were appreciated, the challenge was that telepresence robots are limited in expressivity and any actions performed by the remote user had to focus solely on turning the robot or changing speeds (e.g., rapidly stopping). These movements were not nearly as dynamic as those exhibited by the local person.

We observed that participants using a tablet were much more task-focused than the participants in the telepresence robot group. The tablet group partners focused on completing the shopping tasks without taking time to engage one another by being playful. While some

partners in the tablet group were more attentive than others and made the effort to include the remote partner in the shopping experience by giving them a good view of the mall, acts that could be considered playful were nearly non-existent. Any forms of playfulness that did occur were through the audio channel only, in the form of jokes. Again, participants in the mall did not often look at the tablet screen since they were holding the tablet facing outwards. Remote participants appeared to recognize this and mostly restricted their behaviour and interactions to the audio link as a result. This was sometimes coupled with looking at things in the environment, but it was not always easy to do so.

> "…[W]e make a lot of jokes so we definitely would have laughed at a lot of different things if they had been able to see them…" – Tablet 1, Local

As can be seen, the tablet experience highlighted the value of being playful through large-scale interactions (e.g., full body movements) with the telepresence robot. Such interactions helped shift the shopping experience from being just about 'shopping' to more of a social outing. However it should be noted that, while the tablet promoted utilitarian rather than playful behavior, this may be preferable to some partners that prefer shopping trips to be about efficiency over leisure.

> "I think this kind of setup is very good for the type of person like me who doesn't go for the shopping experience - just wants to you know go there and buy something. I don't want to get distracted by all the advertisements and all the other distractions throughout the mall." Tablet 9, Remote

7. ATTENTION

Because participants using the telepresence robot could move around, they were able to attract the attention of their local partner somewhat easily. For example, they could do this by moving towards them, or changing movement patterns such that they could be seen in the local participant's periphery. On the other hand, participants using the tablet had a much harder time gaining their partner's attention at times. Tablet users did not have the ability to move around like the telepresence robots to gain their partner's attention; thus, they had to solely rely on their voice. This was problematic and meant that they were sometimes ignored by their partner. Local partners tended to prioritize interacting with co-located people (who were strangers in the mall) over interacting with their remote partner (who was a close loved one). In all cases where the local partners were conversing with a co-located person, such as a shop attendant, we saw them lower the tablet with no observable concern for the remote partner's view or involvement. For example, the local partner from Tablet 3 did this when she was ordering from Starbucks. The remote partner was trying to get the local partner's attention, but she was being ignored.

> "Stop ignoring me! […] You just ignored me!" – Tablet 3, Remote (speaking to local partner during the study)

The telepresence robots also received a great deal of attention from bystanders in the mall. This is akin to what has been seen in research on the use of telepresence robots for remote conference attendance [24,32]. Many bystanders directly engaged the remote participants in conversation through the telepresence robot. Participants said that the acknowledgement of the remote partner by the bystanders in the mall made both the local and remote partner feel more strongly that the remote partner was in fact *in* the mall.

> "One thing I noticed right away was that when I would walk into a store, the cashier or whatever would be like 'Oh!' - they would notice me right away and it was kind of fun and I felt kind of included. Like I felt like I was part of the room…I felt like I had a presence." – Beam 6, Remote

> "Everyone seemed a lot friendlier because of the robot - like they seemed really accommodating…which I don't find in my normal life a lot." – Beam 3, Local

While bystander reactions were overwhelmingly positive and characterized by curiosity and friendliness towards the telepresence robot users, the few incidences of negative attention were found to be intimidating. These included one bystander who shouted "what the hell is that?" and people joking about kidnapping the robot. During one such incident, the remote participant appeared to be intimidated by the bystander and backed away. Furthermore, excessive bystander attention disrupted participants' ability to complete tasks, as participants were often stopped to engage in conversations.

In contrast, for the partners that shopped together through a tablet, the only attention received from bystanders was from store employees warning the local partner not to take photos of the merchandise. Thus, unlike with the telepresence robot group, bystanders did not reinforce the presence of the remote partner when the remote partner appeared through a tablet. However, the limited attention received by the tablet group did grant the partners using tablets with more privacy, which was valued during intimate communication. Again, it also afforded them with the ability to be more efficient with their shopping tasks, if desired.

8. RELATIONSHIP CHALLENGES

We found that at times there was a disconnect between how the local and remote partners viewed the remote partner's level of autonomy and competence. This created an imbalance of perceived dependency, responsibility, and equality in the participants' partnerships.

8.1 Dependency

First, we learned that remote shopping through a telepresence robot generated new feelings around dependency within some of the couples' relationships that was not normally the case when they shopped together in person. This meant that remote partners often depended on the local person to guide the shopping experience and take a leadership role. This dynamic was in stark contrast to the way participants normally interacted where a leadership role was typically 'passed back and forth' when shopping. The increased dependency and new power dynamic was typically a result of the local participant's increased physical abilities, e.g., the person moved faster than the robot, had better control over movements, had a wider FOV, and was not dependent on a reliable Internet connection. Two participants brought up the analogy of a pet/owner relationship, describing the local partner as the owner and the remote partner as the pet. Through our observations we found that the experience was often akin to how a parent might lead a child through a store when shopping with them. Remote participants only lead the way in cases where there were strong enough reasons to work past the limited physical capabilities of the telepresence robot. For example, one remote partner pointed out to her partner that "we're taking the long way back" (Beam 4, Remote) and lead her partner on a new path. It was clear that local partners did not resent the agency that their remote partners gained through using the telepresence robot, but instead appreciated it.

> "It did feel more personable. She was there. When I was changing, she was like, 'I'm going to go see if I could, you know, look at other things'. And she can do that right? I don't have to carry her around and like introduce her to things. She flips around, moves around at her own will. So that's kind of nice." – Beam 6, Local

For those using the tablet, the remote partner was completely physically dependent on the local partner who carried the tablet through the mall. This was not ideal as it meant that the remote partner's quality of experience was completely dependent on the amount of care their local partner put into purposefully directing the tablet's camera to provide a good view. When it came to leadership and taking charge, remote participants could sometimes dictate where they

went through conversation. Yet actions had to be negotiated first through conversation with the local participant. The remote participant's plan had to be carefully explained, discussed, and then acted on, if desired. As well, local partners in the tablet group felt that they had the final say in things, as was explicitly expressed by one local partner in the tablet group. *"I preferred to take the final decision of what we are buying because he is not with me so I can do whatever I want"* (Tablet 5, Local). In contrast, with the telepresence robot, it was sometimes enough to just tell the local participant that one had an 'idea,' and then begin to enact it through movements of the robot (e.g., telling the local participant to come 'here'). Furthermore, even if local partners in the tablet condition wanted to provide a good view for their remote partners, there were scenarios that made this challenging – notably the scenario of using changerooms and subsequently trying to show the remote partner one's outfit. One local partner in the tablet group noted that she put the tablet down in the changeroom, blocking the camera. Another local partner in the tablet group explained how she could not show her entire outfit with the tablet because holding it at arm's length was not far enough. As well, it is not possible to show the back of one's outfit without a mirror when using a tablet.

> "It was difficult to show to [partner] with the tablet, because if I show him with the back camera, the tablet covers a part of me, and if I show it through front camera, I cannot pull my hands really far away to show the whole view of how it looks with my pants. So it was not very satisfactory." – Tablet 5, Local

In contrast, with the telepresence robot, the remote partner could back up as much as they needed to in order to view the local partner's entire outfit, and the local partner could simply turn around if they wanted to show the back of the outfit.

8.2 Responsibility

Second, we found there was a disconnect in terms of who was responsible for whom. This was different than dependency and who directed or led the shopping activity. Instead, it related to if and how participants felt responsible for the telepresence robot, e.g., bumping into people, being in people's way, knocking over and breaking items in a store. During the interviews, we asked each participant about who they felt should be responsible if the telepresence robot (or tablet) broke an item in a store. In the telepresence robot group, all but one remote partner felt they should be responsible. Yet, similarly, all local participants claimed the responsibility for the remote partner's actions within the mall. Thus, while the robot embodiment gave remote participants a strong sense of agency in the remote environment, leading them to feel responsible for their own actions, their local partners did not recognize the same level of agency in their remote partners.

> "[I'd feel more responsible] because I drove into it and I broke it, not her. Although granted, she could spot for me, but I have two cameras at my disposal." – Beam 7, Remote

> "I have to take the fall for it ultimately, simply because I'm the one that's there that's more capable of handling the situation because of my actual presence." – Beam 4, Local

Without being prompted to, all local partners took on the responsibility of helping their remote partner navigate the space of the mall, which included the challenges of maneuvering around other shoppers and tight aisles in stores. This help was offered even when it appeared to be unnecessary or even perhaps unwanted. For example, one remote partner responded to the local partner's help with "*Don't worry about me! Just go!*" (Beam 1, Remote).

Overall, we found that the feelings of responsibility that local participants had were very different than how they normally experienced shopping. Normally, each person was solely responsible for their own actions because they were considered to be competent adults. Thus, the relationship dynamic shifted when using the telepresence robot and created the potential for additional strain between the local and remote participant.

When the idea of responsibility was discussed with participants using the tablet, responsibility for actions in the mall were nearly always mutually understood to be left with the local participant. For example, when asked who would be responsible for breaking an item in a store, local partners took responsibility. Similarly, remote partners believed that their partners should take responsibility unless the remote partner had been very distracting at the time of the accident.

> "If we're in a very like, we're really into this conversation and he suddenly bumped into something, I'd probably feel a little bit more responsible…but if he's not saying anything, he's just looking around and he accidentally bumped into something, I probably wouldn't feel as responsible." – Tablet 7, Remote

8.3 Ability to Contribute

While increased autonomy and ability to control one's view has the potential to increase a remote partner's ability to contribute—since it would give them greater agency to look around and develop their own ideas—the robot in its current form still had limitations that caused the remote partner to feel like they were not contributing as strongly to the shopping activity as they would have liked. The fact that the robot was slow and could normally not keep up with the local participant was one of those limitations. Remote participants also said that not being able to pick up or inspect items up close without the help of the local partner was another limitation. Pairs who felt that both partners contributed equally to the shopping activity reasoned that both partners contributed opinions that helped in choosing items for purchase. Thus, contributions had to be through verbal exchanges rather than physical help.

> "I would provide my thoughts on what my mom would like …and she provided the feedback about which store seemed more in that theme so there was that back and forth." – Beam 1, Remote

When it came to helping out with carrying shopping items, local participants using both technology setups obviously could not get help from their remote partners. Yet participants said this was an important part of the shared experience because it reflected their normal shopping behaviors and desire to feel like they were helping out. A lack of being able to contribute in this way created negative feelings with some participants. This inequality was more poignant for those using the tablet as the local partner struggled with completing the tasks with one hand occupied by the tablet.

> "There was a part where I kind of felt bad because he had to hold everything […] whereas normally when we're out together, like I can offer to help him hold something. You know, if he has a lot of stuff, I'll like hold something for him. Or even when he went to go try on the shirt, it was like, I wanted to help him hold the coffee …" – Beam 6, Remote

> "When he is with me, he is a help for me, not a load. Right?[…] When he's with me he would carry my stuff, now when he's not with me, I need to carry him in my hand." – Tablet 2, Local

When it came to making decisions about purchases, the pairs using the tablet were less capable of making joint decisions as the local partner largely dictated the remote participant's view. Sometimes local participants would only show their preferred items to the remote partner. Shopping in this manner meant that remote partners could contribute less to the pool of ideas regarding what items the pair should consider purchasing.

> "It was a bit annoying because I wanted to give her more suggestions or my views, but I was actually unable to do that. Say I like something which I thought maybe it looks like this or maybe it's that, but when she picks it up it's like 'oh no' that's not what I was thinking." – Tablet 2, Remote

> "Yes, she listened to my opinions, but sometimes I think I keep my own ideas. For example, the dress - the style I want to wear in the mother's party. I think she probably want me to have skirt, have dress, but actually I just like wearing casual or simple style, and if it's not face-to-face, if it's just with a tablet, probably I can just ignore her ideas sometimes." – Tablet 3, Local

9. DISCUSSION

We now explore and discuss our findings to understand how they shed light on new areas of design thinking around the creation and use of telepresence robots during shared leisure activities over distance. To date, the research agenda around telepresence robots has largely been about designing telepresence robots for activities that one could argue are largely task-driven in nature, such as supporting distance learning (e.g., [29]), remote workplace interactions (e.g., [21]), or remote conference attendance (e.g., [27,36]). In contrast, we explore design themes that we feel are important when people participate in activities that are largely social and personal in nature, rather than utilitarian. While shopping does contain notions of 'tasks,' such tasks are interwoven with personal, social dynamics as a part of family and friend relationships. Overall, our study points to the expectations that people have for the ways they should socially interact and engage with others during leisure activities over distance, where there are strong needs to support familiar behaviors and routines, shared control over the activity, and contributions from both parties to the activity.

9.1 Familiar Patterns

First, it was clear from our study that shopping with family and friends involves familiar patterns of behaviors and personality idiosyncrasies. These are what help to make the activity social in nature. We found that, when separated by distance, being able to see these behaviors and idiosyncrasies can help people to feel like they are actually performing the activity with a remote person and that the person is 'there.' Other shared leisure activities performed by family and friends over distance that are similarly social in nature (e.g., hiking, sight-seeing) are likely to have similar traits. Here, too, one would expect that being able to recognize familiar behaviors over distance would aid the experience. To date, the related research around telepresence robots does not explore this aspect of experience, perhaps because of the focus on more utilitarian-type situations (e.g., workplace activities). The tablet in our study failed to support these acts in a rich way, while the telepresence robot benefitted participants because of its mobility. Yet not all desirable behaviors were supported (or they were constrained), which suggests opportunities for additional design explorations related to telepresence robots. Certain changes, which are also suggested by others, could help interactions. This includes a wider FOV camera [14,16,19] or faster 'walking' speeds [21].

Other needs are more complex, such as hand-holding, which would require additional features or add-ons to telepresence robots (e.g., vibro-tactile gloves [42] could be worn by people). Yet, while seemingly simple, such design changes are likely quite complex in practice. For example, they may introduce additional cognitive load or social expectations. It could also be very challenging to actually control a robotic hand remotely [33]. Given these thoughts, we feel what is most important is that designers and researchers begin to consider how telepresence robots can allow people to easily support familiar behaviors and controls that allow them to be performed in a lightweight manner. This may involve exploring input mechanisms beyond current telepresence robot controls involving mouse/keyboard or gaming controllers, to input modalities that allow for a richer set of small-scale mannerisms within a telepresence robot (e.g., nodding one's head, tilting one's body, gently touching another's hand). In turn, explorations are needed around the social implications of having these additional interaction and embodiment modalities.

9.2 Playfulness

Second, our results point to the value of being playful during a shared leisure activity that is social in nature like shopping. Playfulness enhanced the experience in our study by creating fun situations. It also made it so remote participants could draw in the attention of their local partner. These behaviors were very challenging to achieve with a tablet because of the size of the device, its orientation facing outwards, and the remote user's reliance on the local person moving the device. The telepresence robot used in our study supported basic levels of playfulness (e.g., turning, moving, changing speeds), yet beyond these actions, participants were limited in what they could do. Participants using the tablet had an experience that was not nearly as rich given the tablet's inability to support playfulness beyond conversational interactions. This further emphasizes the value in designing to support playfulness. Telepresence robot controls that are more intuitive and less time consuming to use may better support spontaneous acts of playfulness. Many of the playful behaviors we saw relied on quick, impromptu actions that may not always be easy to do with a telepresence robot given the current controls (with mouse/keyboard or gaming controllers).

Designs that focus on a richer set of playful acts would also benefit people. For example, when in person, playful acts often involve touching others. People might sneak up behind others, tap each other on the shoulder, 'high-five' one another, etc. Yet actions like these are not possible with most telepresence robot designs. Most telepresence robots lack arms and hands. Adding such features may begin to address the limitations our participants found in our study, however, they may also create new challenges around how to interact with such features. Other design approaches that focus on supporting a richer set of actions with the body of a telepresence robot could hold promise as well (e.g., making it easier to sneak up on a user for fun, supporting subtle rather than overt nudges). Existing research has explored this with head movements, for example [2].

Telepresence robots should also be designed to make it easier for the *local* partner to be playful with the remote partner. In our study, some participants touched the robot in playful or affectionate ways (e.g., head tapping); however, these touches could not be felt by the remote partner, even though, in some cases, the remote partners could see that their local partners were touching 'them'. Incorporating transmission and reception of touches through a telepresence robot could potentially enhance the experience of such interactions, similar to how touch has been shown to enhance more standard video calls [42]. Looking across the related literature, we do not see exploration of playfulness and physical touch when it comes to telepresence robots, perhaps, again, because of the largely utilitarian and work-centric focus of the research to date. There are also likely other ways to support playful actions with the remote user that move beyond just touch. This creates a ripe area for design exploration.

9.2 Autonomy and Social Relationships

Perhaps the largest difference that we see between our work and the related literature is the likely effect of telepresence robot design on domestic social relationships and the power dynamics that come with them. Past work has discussed issues with a lack of autonomy in relation to losing connectivity [21]; our research extends this to explore a broader range of challenges. Here we point to design challenges with telepresence robots focused on autonomy and agency where the device's limitations can create relationship issues between family or friends. These challenges relate to feelings and perceptions around responsibility, dependency, and contribution during a leisure activity. These issues tended to be exacerbated when participants used the tablets compared to the telepresence robots, given remote user's heavy reliance on the local user to hold and orient the tablet. Thus, telepresence robots created an improved experience over tablets, however, the problems still persisted. While our study does not draw out the long-term effects from negative feelings that might come with, for example,

feelings of dependence on others, it is reasonable to expect that such feelings could create relationship challenges over time. These issues point to an open and important design space that should be explored such that personal social relationships can be adequately supported and not hindered.

Over time, commercial telepresence robots are likely going to increase in their capabilities, which should help to lessen the discrepancy between the abilities of the local and remote person when participating in a leisure activity. Researchers should continue to explore ways to bring greater parity in skills between remote and local users. Alternatively, there would also be great value in exploring design options that bring unique capabilities to the remote user that map to particular leisure activities. This might allow them to contribute to the activity in ways that the local person is not able to, given their differing context. For example, with shopping, designs focused on giving the remote user enhanced capabilities to compare items or prices, or better determine store options could let them feel like they are contributing to the activity in important ways. Such solutions would need to be cautious though, so they do not take the remote user 'away' from the remote environment too much and ruin feelings of immersion in the remote space. Overall, this is a ripe area for design exploration that moves telepresence robot design beyond just the robot itself to explorations of designs that can augment the robot to provide new capabilities for the remote user.

10. CONCLUSION

Overall, we feel that our study has helped to open up an important design space that explores how telepresence robots can be used and what design opportunities exist when telepresence robots move beyond the more typical settings explored in the related work, such as workplace interactions, remote conference attendance, education, etc. In the case of shopping over distance, we see that when compared to tablets for video calling, telepresence robots are able to allow partners to see familiar patterns and shopping behaviors, engage in acts of playfulness, and more easily garner the attention of one's partner. Yet telepresence robots can also create challenges that stem from a lack of interaction modalities (e.g., touch, hand holding, easy body movements). There is also the chance that telepresence robot usage will create relationship challenges due to issues around dependency, responsibility, and one's ability to contribute to a shared task. Together, these challenges bring forward a range of design opportunities that warrant further exploration.

Our results likely generalize to other joint activities that take place in public settings and require a similar amount of joint decision-making and exploration of the environment. For example, it would be reasonable to expect that studies of remote site-seeing or outdoor walking would find similar results because they would both involve walking around a public area, deciding which direction to go, and conversing as one moves. For activities that differ (e.g., remotely attending sporting events or concerts where space is tighter and there are more people, the ambient noise is louder), further studies are needed to understand if and how our findings might apply given the change in number of people present and the nature of the activity.

Our results are limited in that we only studied people who were in a couple relationship. While it is likely that our findings around the benefits and challenges of performing certain types of interactions and actions with the telepresence setups generalize beyond just couples to other family member pairs or close friends, future studies should explore these relationships more specifically. Our study also comes with the limitation that partners were asked to imagine themselves as a long-distance couple. This was done to provide a stronger rationale for why the couple would want to shop together using a telepresence system rather than just going together in person. Yet it does mean that the situation may not have reflected their own relationship as well as it could have. It also means that our results may not be indicative of actual long-distance

couples. These limitations should be considered when interpreting our findings and design suggestions. Of course, there is also the chance that couples may not want to actually shop over distance in the ways that we have focused on in our study. The related research suggests that remote leisure activities are desirable [22], however, we do not know for sure if such technologies were readily available for usage.

Our study focused on one type of telepresence robot and clearly there are many other commercial telepresence robots available with varying capabilities. Some of our findings are likely specific to the particular type of telepresence robot that we studied. That said, we have presented our findings and design suggestions around several high-level themes that we feel represent important considerations for telepresence robot design more generally. These are likely to hold as design considerations regardless of the specific telepresence robot being used. Lastly, participants were experiencing shopping with a telepresence technology for the first time and it is difficult to know how behaviours and needs may change over time and with experience. This suggests longer-term exploratory studies as part of future work.

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