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"Now, I Have a Body": Uses and Social Norms for Mobile Remote Presence in the Workplace

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ABSTRACT
As geographically distributed teams become increasingly common, there are more pressing demands for communication work practices and technologies that support distributed collaboration. One set of technologies that are emerging on the commercial market is mobile remote presence (MRP) systems, physically embodied videoconferencing systems that remote workers use to drive through a workplace, communicating with locals there. Our interviews, observations, and survey results from people, who had 2-18 months of MRP use, showed how remotely-controlled mobility enabled remote workers to live and work with local coworkers almost as if they were physically there. The MRP supported informal communications and connections between distributed coworkers. We also found that the mobile embodiment of the remote worker evoked orientations toward the MRP both as a person and as a machine, leading to formation of new usage norms among remote and local coworkers.

Author Keywords
Mobile remote presence, computer supported collaborative work, human-robot interaction.

ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

General Terms
Experimentation

INTRODUCTION

As work environments change, there are more cases where collaborators in work teams are not collocated [12]. Collaboration in geographically distributed teams is still challenging [17]. Remote workers have fewer opportunities to engage in informal communication, which is critical for successful collaboration [5, 9]. Informal communication plays an important role for supporting work-related tasks, coordinating group activities, transmitting office culture, building teams, minimizing ambiguity in communication, and mitigating conflicts [3, 7, 22]. The connection built via informal communication improves workers' readiness to engage in fruitful communication [14].

However, supporting informal communication is difficult for most collaboration technologies because informal communications are often unscheduled and brief; they also require highly interactive and expressive communication channels [3, 9, 22].

Addressing this problem, we explore the use of a Mobile Remote Presence (MRP) system in the workplace. (See Figure 1.) In the context of remote collaboration, the MRP is a physically embodied audio-video system that remote workers can drive around the workplace. Using the MRP, remote coworkers, which we call "pilots," can wander the hallways and engage in impromptu interactions, increasing opportunities for connection in the workplace.

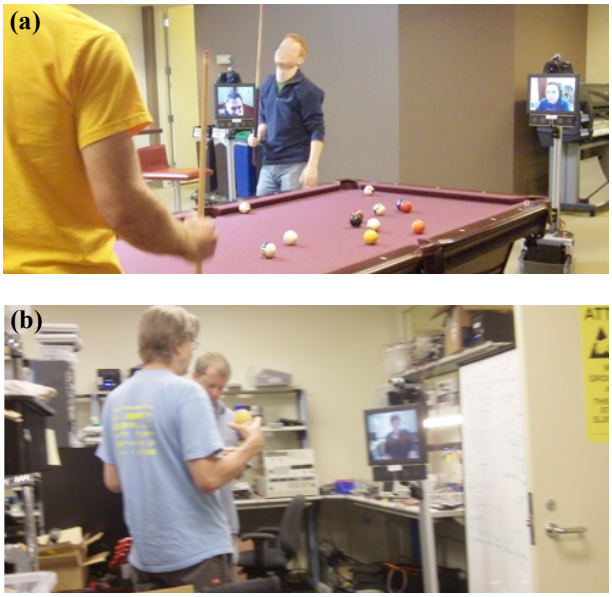

Figure 1. Using a MRP system in the office place for work and play: (a) hanging out with coworkers playing pool (b) having an impromptu conversation in a lab

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RELATED WORK

Numerous systems have been developed to assist distributed team collaboration, aiming to facilitate informal communication and mutual awareness between distributed teams [16], particularly video conferencing systems [2].

Systems that support audio-video communication are particularly relevant to the MRP. Among the drawbacks of immobile videoconferencing systems is the lack of support for the informal, but critical, types of communications that take place outside of meeting rooms [2]. Shared audio-video portal systems have been developed to increase awareness among distributed teams by connecting shared spaces in different office locations [1, 9, 11]; the premise of this approach is that persistent audio-video communication channel will facilitate informal communication. Longitudinal fieldwork of such a system found that it was frequently used to check coworkers' availability, check project status, and coordinate meeting opportunities, but it was not used as a primary medium for problem-solving [9].

Another approach to supporting information communication in distributed teams has been to use a physical embodiment of remote coworkers with audio-video communication channels. One of the advantages of using an embodied representation is that it increases the presence of a remote coworker [19]. Using an embodied video conferencing system with remote coworkers reportedly helped listeners to selectively attend to speakers and helped speakers figure out who was paying attention to them [20]. Such embodied video conferencing systems also improve meeting participation and interpersonal social connections between hub and satellite teams [21].

MRP systems have been built (e.g., [18]), adding mobility to the equation. Similar to the MRP presented in this paper, these systems allowed a remote person to move throughout a distant location and engage conversation with others. However, to our knowledge, these systems have not been studied and reported upon in terms of long-term use, emerging work practices, or social norms. Improved WiFi technologies have enabled the current system to be used for over a year now, which has provided us with the opportunity to learn from experiences beyond first-contact, novelty effects, and initial impression.

We believe that the remotely controlled mobility of the MRP will enable different interactions in the workplace, using the advantages of rich audio-video communication channel and physical embodiment. As a pilot in our ongoing studies stated, "Before, I had no corporeal body [in the workplace]. I was handicapped. Now, I have a body." To better understand mobile remote presence, we took an exploratory approach that focused on the following research questions:

- How are MRP systems used in the workplace?
- What are the factors that influence MRP system use?
- What social and usage norms form around MRP systems?

STUDY DESIGN

At this stage of research, investigating a relatively new set of experiences in the workplace, we chose to examine these phenomena with several different methods, including open-ended critical incident interviews (to capture the most salient incidents from the previous year), surveys (to capture a wider variety of respondents than those we could interview and observe in person), and in-person observations (to capture actual interactions, not just ones recalled from memory).

MRP System

The MRP system used in these explorations was the Texai Alpha prototype [23], developed at Company A in order to work more effectively with a remote coworker, who lives approximately 1,800 miles away. Before the development of the MRP, the company had used phone conferencing and video conferencing systems to communicate with the remote coworker, but that was too limiting; the remote coworker was often left out of meetings and real decision-making discussions. Then the team put a laptop on a pushcart so that the video conferencing system could at least move around the building, but that quickly grew frustrating because the remote colleague had to ask local coworkers to push the cart around and to re-direct the laptop camera to locations where he wanted to look. In order to give the remote coworker control over his own location and viewpoint, they built the Texai Alpha prototype.

The Texai Alpha prototype consists of a mobile base, touch screen, microphone, speakers, pan-tilt webcam, wide-angle camera, and two laser range finders; it stands approximately 5' 2" tall. Remote pilots drive the MRP system by using a web browser and video conferencing application. (See Figure 2.) The Texai Alpha always shows the real-time video feed of the remote pilot when driving the system, following the design guideline of "If you see me, I see you." When it is idle, the screen saver turns to black. With the fully charged battery, it could be used for approximately eight continuous hours. At the time of the study, its current top speed was 1.5 miles per hour.

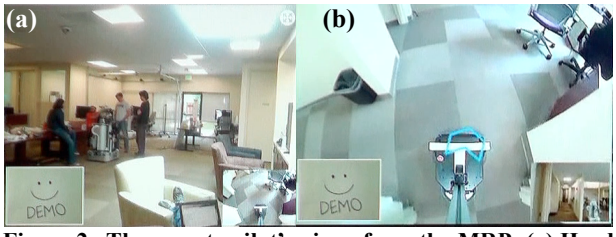

Figure 2. The remote pilot's views from the MRP: (a) Head view (looking up) and (b) navigation view (looking down)

METHODS AND ANALYSES

We investigated the MRP usage through interviews and observations in one company where the MRP system has been used longest, and evaluated whether these patterns are generalizable with two different companies through surveys.

Field Sites

The MRP system prototype was used in three different companies located in the San Francisco Bay Area for varying periods of time (2-18 months). Unlike the other embodied remote presence systems (e.g., [21]) where one system is dedicated to one remote pilot, the MRP system was used as a shared resource: anyone who had an account could connect to the MRP system website and use the system. To respect the privacy of our participants, we did not log audio-video recordings through the MRP system. Instead, we had permission to take photos and videos when we observed MRP usage in person.

Company A is a research and development organization that focuses on personal robotics; it also developed the prototype. Approximately ten MRP system prototypes have been used there for 18 months. The firm offered accounts to all the employees at the company so that anyone who was sick or away for a business trip could use the MRP system. The main remote pilots during the time of the study included one engineer who works with the rest of the team members (3-4 people) in Indiana, and a project leader who was working from Central America for an extended period of time. Most of the docking stations were located next to the main dining area, and two others were in a hallway.

Company B is a web development firm, and has used two MRP prototypes for ten weeks. The company comprises of highly distributed teams spread all over the world. The firm gave accounts to those who permanently live and work from remote locations. Three main remote pilots used the MRP systems: a product manager who resides in Canada, a web developer in Seattle, and a systems administrator in Singapore. Two docking stations were located in lounge areas on opposite sides of the building.

Company C is a design software development firm, and has used two MRP prototypes for ten weeks. The main pilots were two executives who reside in California but often work from home or from satellite offices; they travel frequently for business, spending most of their time away from the main office.

While there are many dimensions of organizations that could not possibly be covered by only three companies (e.g., industry, company culture, geographical distribution of employees, demographics of employees, degree of hierarchy), starting with three companies enabled us to learn about a wider range of uses, personalities, work practices, company cultures, etc. than we could have learned about with only one site.

Critical Incident Interviews

Because the MRP systems have been in daily use at Company A for over a year, this site was chosen for conducting a critical incident analysis [4]. We interviewed 20 respondents (4 women and 16 men), including four members of the Texai project development team. We asked respondents to recall specific incidences that were either very positive or very negative. Each interview took 20-90 minutes, depending on the respondent's experience with using the MRP system.

After transcribing the interviews, we extracted incidents and did a content analysis of those incidents in terms of the respondent's role (e.g., pilot, local), activity (e.g., attending planned work meetings, having an impromptu meeting), location (e.g., meeting room, hallway, office), etc. Each incident could have multiple codes assigned to it. Altogether, 79 critical incidents were reported (average incidents per respondent = 3.95, range = 2-8); we excluded 12 of the incidents that only reported technical problems that were unique to this system (e.g., network issues, software bugs). 56% incidents were reported from a pilot perspective; 22% were from a local interactant perspective; and 23% were from a local bystander perspective. For each activity that the MRP was used, we identified the upsides and downsides of using the MRP system, and factors that made the experience positive or negative.

Contextual Observations

To triangulate upon the self-reported findings identified in the critical incident analysis, we observed MRP usage in Company A, shadowing remote pilots throughout their workdays. These observations focused on two dedicated remote pilots, i.e., highly collaborative remote workers, who used the MRP to get their work done because they lived 1800 miles away from the workplace. One pilot, who had worked on building the MRP for his own use, had been using the MRP for 18 months at the time of the observations. The other pilot was not involved in building the MRP; he had been using the MRP to telecommute to work for one month. As part of our ongoing field studies, we also conducted shorter observations (half days, once every other week) at Companies B & C. Although the full results of the field studies are not reported, we have included some images from those field observations in this paper.

Surveys

The interviews and observation allowed us to identify common usages for the MRP, and the most significant benefits or issues that remain over repeated usages after the novelty effects wore off. Based on these findings, we generated a survey to understand the actual frequency of the activities, benefits and issues with a wider range of people who have experienced using or encountering the MRP. Thus, we conducted the survey at Companies A, B, and C.

The survey focused on: (1) The frequency and impact of the MRP use for collaboration activities; (2) Where, how, and why people have impromptu meetings using the MRP; (3) Perception of upsides (i.e., how the MRP improves remote communication and work) and downsides (e.g., noise, mistakes, difficulties of negotiating personal spaces); and (4) Politeness and embarrassment of usage behaviors. The survey also included questions about respondents'

demographics and how well they knew the remote pilot or local teams in the MRP location (1= did not know the team in the MRP location (or remote pilot) at all, 2=knew the team barely, 3=knew the team moderately, 4=knew the team, 5=knew the team very well). The median was 2, so we divided the respondents with an average score of less than or equal to 2 into an "unfamiliar" group and those with higher or equal to 3 into a "familiar" group. We also noted whether remote pilots were designated users (e.g., satellite team, frequent travelers) or ones who used it on their short-term needs based (e.g., being sick at home, temporarily working from remote offices).

Pilots and locals were asked to answer all of the questions, and bystanders were asked to only answer politeness ratings of usage behaviors. For locals, we asked respondents to name one remote pilot they interact with most, and to base their answers on experiences with that particular pilot.

Pilots, locals, and bystanders from three companies responded to the survey (N=54). There were 12 pilots, 26 local bystanders, and 10 local interactants; 28 were from Company A, 11 from Company B, and 10 from Company C; 6 did not report their company name. Respondent ages ranged from 23-65 years, M=34.0, SE=1.7, including 9 women, 36 men, and 10 with unreported genders. They had a range of experiences with using the MRP (2-72 weeks, M=15.0, SE=2.23). Respondents held positions such as intern, engineer, consultant, program manager, director, and vice president. The MRP systems were located in the San Francisco Bay Area (USA). The MRP pilots were physically located in other parts of the USA, Central America, Canada, Germany, and Singapore.

Our analysis shows that locals' prior familiarity with remote pilots influenced their perceived benefits. Also, whether remote pilots were designated pilots or not influenced pilots' responses. Thus we used these variables as control variables in our analysis.

The survey responses showed the respondents' communication patterns before the introduction of the MRP. Dedicated pilots reported that they communicated with local teams through face to face to meeting (M=1.8, SE=0.58; 0=Never, 1=Once or less per month, 2=A few times per month, 3=Once a week, 4=A few times a week, 5=Once a day, 6=A few times a day), phone call (M=3.25, SE=0.48), email (M=4, SE=1.15), text chatting (M=4.33, SE=0.56), and video conference call (M=2.86, SE=0.55). The pilots also reported that they used these communication activities slightly less frequently on average after the introduction of the MRP system (M=2.77, SE=0.23; 1=Use much less often, 5=Use much more often). The answers to an open-ended question on communication changes suggest the introduction of the MRP system increased the overall amount of communication, rather than replacing the existing communication activities (e.g., "Communication has increased overall. It isn't so much about transitioning communication as it is about increasing communication").

The survey responses from remote pilots showed that dedicated remote pilots used the MRP a few times a week to attend planned meetings (M=4, SE=0.33, 0=Never, 1=Once or less per month, 2=A few times per month, 3=Once a week, 4=A few times a week, 5=Once a day, 6=A few times a day), and to engage in impromptu work meetings (M=3.75, SE=0.56). They also reported that they used the MRP about once a week to greet and socialize, seek or follow local coworkers, and to be around in the workplace.

Overall, participants reported the MRP was useful (M=5.77, SE=0.15, 1=Very useless, 7=Very useful), and effective (M=5.46, SE=0.21, 1=Very ineffective, 7=Very effective); answers by pilots vs. locals or between companies were not found to be significantly different.

RESULTS AND DISCUSSION

Our results showed that the MRP allowed remote pilots to work with local coworkers almost as if they were there in person. The MRP supported informal communications (see Figure 3) and connections between distributed coworkers. We also found that the MRP's mobile, physical embodiment of the remote pilot caused confusion about whether to treat the system as a person or object, leading to the formation of new social norms among coworkers.

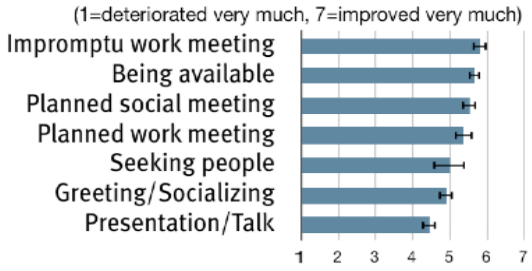

Figure 3. Impact of MRP usage on activities (M, SE)

USES OF MRP FOR WORKPLACE COMMUNICATION

The results of surveys, interviews, and observations showed that the MRP system was used for a wide variety of work and social activities in the workplace. Figure 3 shows the survey responses about the types of activities for which the MRP system was used and how much it improved each activity. While all the activities were improved, attending planned social events, having impromptu meetings, and being available to local coworkers seemed to benefit most.

Informal communication

The majority (76%) of positive incidents from the interview centered around informal communication activities. Impromptu activities using the MRP happened virtually everywhere in the workplace, including hallway, communal spaces such as lab space or kitchen, or individual offices. (See Table 1 and Figure 4.) The most frequently mentioned reasons for using the MRP for impromptu meetings are shown in the Table 2. The most common usages were

Location	Frequency
Hallway	28%
Communal space	27%
Office	26%
Conference room	11%
MRP dock	7%

Table 1. Locations of impromptu meetings via the MRP (Frequency of locations mentioned in the survey).

Purpose	Frequency
Get answers	18%
Exchange ideas	16%
Ask questions	15%
Project status check	14%
Socialize	14%
Show off the MRP	7%
Introduce coworker	5%
Show around workplace	5%
Others	7%

Table 2. Purposes of impromptu meetings via the MRP.

worked-related communication and socializing; this was consistent across companies.

These impromptu meetings and social conversations could show commitment, capture and maintain attention from local coworkers, and build social connections (affinity) among geographically distributed team members [14]. We explain these different types of impromptu activities in the following three sections.

Commitment: Being Present and Available

Commitment is "an engagement denoting scope for ongoing communication for projects of mutual interest" [14]. We found that the MRP allowed the remote pilots to be more present and available in the main office location, which demonstrates commitment to working with local coworkers. 6 out 12 pilots reported that they use the MRP to simply be around, once a week on average. In our observations, we also found that pilots logged in to the MRP even when they did not need to talk about anything in particular with the locals, consistent with findings from the ESP system [21]. Remote pilots who did not have their offices in the main location usually parked the MRP system in the shared lab space. Those pilots who were on business travel (or were working from home while sick) logged in to the MRP system and parked it at their own office desks. Having the MRP system allowed locals to talk with remote pilots without going through the additional coordination of

Figure 4. An impromptu conversation at Company B: The local person happened to be standing near where the pilot was trying to park the MRP system.

checking their calendars. One pilot who frequently traveled in Company C and parked the MRP in his office expressed:

Users come in to my "office" where the robot is, expecting to find me, and instead find my robot there. Without the robot, these meetings likely wouldn't have happened, as they wouldn't have taken the time to hunt down my whereabouts. It helps me feel much more "present" when I'm not in the office.

The roaming sound of the MRP also became an indicator that the remote pilot was around, so local employees would notice that the remote pilot was around even before seeing it. Hearing the MRP's motor sound or pilot's voice, local employees would go out of the hallway and interrupt the MRP pilot if they wanted to initiate a work or social conversation. Having the MRP roaming around also increased the perceived presence of the remote pilot, as reflected in the survey. R18 reported:

He always would say, "Good morning!" to me, every morning, because he was up early, because he was on a different time [zone]. So that was always nice; I always felt like I had company in the building.

Our survey results also show that both pilots and locals in all companies agree that remote pilots have greater presence in the local office location. There was also trend that, when respondents reported that they were not familiar with the pilot before the introduction of the MRP, their perceived benefit about the greater presence was marginally higher (M=5.96, SE=0.33) than among people who already knew the pilot (M= 5.15, SE=.31), $F(1, 32)=3.19$, $p=0.08$.

Attention: Capturing and Maintaining Attention

Capturing attention is about "locating the intended recipient" and "attaining attention" [14]. In addition to simply being available, the MRP gave remote pilots more independence to initiate conversations with locals. Our survey shows that about 50% pilots and local users perceive that pilots usually initiate the impromptu meetings; the initiator reported in the survey: pilots 46%; locals 27%; equal split 27%. This contrasts against other systems where the communication is more dependent on the efforts of local coworkers (e.g., going to the telepresence room). Without having to schedule formal meetings, remote pilots

visited local employees' offices to have impromptu meetings, wandered around the office to find colleagues, continued conversations after the end of meetings, and joined ad-hoc meetings. One remote pilot reported that he sometimes drove the MRP to someone's office door and waited there to catch him/her to get answers to urgent questions, which is similar to "ambushing" observed in the video conferencing wall system [3].

Our survey found that both local coworkers and remote pilots reported that communicating with the remote pilot (or local coworkers) became easier since using the MRP. In particular, those who reported being unfamiliar with the coworkers reported greater benefits in terms of ease of use (M=6.05, SE=0.21) than those who already knew each other well (M=5.27, SE=0.21), $F(1,32)=8.33$, $p<0.01$. Interestingly, local coworkers expressed that the MRP had improved the process of setting up the equipment to meet with remote coworkers.

Pilots reported that they had greater awareness of activities going on in the main office (M=5.33, SE=0.41). Dedicated pilots reported that they could make faster progress on collaborative projects (M=5.67, SE=0.44), but occasional pilots did not agree (M=3.33, SE=0.62), $F(1,8)=9.53$, $p<.05$.

Affinity: Building social connections

Affinity is about "feelings of connection between people" [14]. The MRP allowed remote and local workers to build social connections. Using the MRP, remote pilots could attend social events (e.g., drinking beer) that they could not join without the MRP; remote pilots also frequently joined impromptu chats while working with local workers in the same room, passing in the hallway, or swinging by the kitchen. See Figure 5.

Our observation and interviews also showed that the MRP's rich modalities—user controlled movement [13], its approximate human scale body, and audio and video communication all seemed to increase the social presence of remote pilots, which led to relatively fluid social interaction among local coworkers and remote pilots. Experienced pilots used the mobile base to socially signal when they wanted to talk and to whom they were listening by positioning and orienting the MRP system. Many locals reported that meeting someone for the first time via the MRP was more natural than other communication media alternatives. One local coworker mentioned meeting the remote person for the first time (R4):

Figure 5. Locals chatting over coffee with a remote pilot. The pilot is showing a new prototype that his team has designed.

And he just rolls up to my office door and says, "Hi," which is great. If he had hopped on my computer screen through Skype, that would have been very awkward.

Being able to be physically present in a social milieu allowed a relatively natural social interaction between the MRP and others. R11 explained:

That's what I think I like about the MRP is that, you know, if [the remote person, R5] or whatever is just chatting in the [shared workspace], you have the complete symmetry of like I'll chat with [R5] as much as I chat with anybody else.

Using the rich communication modalities, the MRP enabled more nuanced communication between remote pilots and local coworkers, which strengthened their social connections. One local coworker, who did not know the pilot, explained how he got to know the pilot via the MRP. He reported that the pilot was no longer a "mythic character" and was struck by the fact that meeting the remote pilot in person was not very different from meeting him via the MRP (R18):

It was so cool to meet him in person, but I was also so amazed that the only difference was that he was taller… I mean, he can have his personality. He'll bump into things, and laugh about them [using the MRP]. You get all the different aspects of a person's personality through this robot [...] He could still be a jokester in the [MRP].

Our survey results also confirmed that the MRP can enable more casual and social interaction, and provide greater opportunity for remote pilots to get to know local coworkers and vice versa. Both pilots and locals reported that they could communicate with remote pilots and locals in a more casual and sociable way. Respondents who did not know each other before the introduction of the MRP reported greater benefits (M=5.77, SE=0.24) than those who were already familiar with one another (M=5.03, SE=0.24), $F(1,33)=7.03$, $p<.05$. Local coworkers and pilots, who were unfamiliar with each other, agreed with the statement that since they started using the MRP, they got to better know the remote pilot or vice versa (M=6, SE=0.29), whereas those who were already familiar with each other did not (M=4, SE=0.33), $F(1,32)=20.63$, $p<.001$, 1=Strongly disagree, 4=Neither agree nor disagree, 7=Strongly agree.

Hindrance to the utility of the MRP

While our research identified benefits of using the MRP, it also identified limitations of the MRP system. The most frequently mentioned downside was the burden of driving. Pilots reported that the hassle of driving the MRP to go to a

meeting room made the MRP system less useful and efficient. They reported that driving the MRP itself is not difficult (M=3.83, SE=0.49, 1=Strongly disagree, 7=Strongly agree with the statement "The Texai is difficult to drive."), but it was time consuming, which can make them late for scheduled meetings. In addition, pilots reported, when they were carrying out the conversation with local coworkers moving in the hallway, they could not focus on the social conversation as their attention was divided between driving the system and carrying on a conversation, as reported as a potential problem in a medical telepresence robot [15]. Gaze and head turn, a common issue in video conferencing systems [2, 16], were also problems with the MRP system, yet it was not reported as a showstopper. The large video display of a remote pilot helped mostly with reading the pilot's head/gaze orientation. The pan-tilt camera also helped, only if the locals noticed its movement. Sometimes the pan-tilt camera was a problem because pilots' cameras would be facing in a different direction than their video image appeared to be looking.

USAGE (SOCIAL) NORMS

We also found that the mobile embodiment of the remote pilots evoked orientations toward the MRP both as a person and as a machine, leading to the formation of new social norms among remote and local coworkers [8, 10]. These norms set expectations for how people believe that pilots and locals should interact. The MRP was sometimes perceived as being the remote pilot (e.g., referring to the MRP by the pilot's name), which can encourage social norms of face-to-face interaction; at other times, the system was perceived as being an object—furniture, a device, or a robot (e.g., addressing the MRP as "Robot" or "it," resting feet on its base, or leaning on it).

Usage norms drawn from other technology

As previous research has shown [10], many emerging usage norms seem to be drawn from people's previous experiences with existing communication technology.

Some of the social norms seem to come from face-to-face interactions. We observed numerous cases where people naturally made room for the MRP and adjusted their standing positions and orientations to incorporate the MRP into their group. Some local coworkers discussed their treatment of personal space around the MRP system with respect to how they treat personal space of a person (R10):

I can actually squeeze by in a way that if some person were standing there with their back turned to me, I'd be uncomfortable squeezing by them in the same way.

Negotiating personal space was also discussed in terms of how one would interact face-to-face: R2 explained:

If there were a person there and I were to walk up, he would—we wouldn't have to say anything. We wouldn't even have to exchange, you know, eye glances or anything. The person would move out of the way. He doesn't move out of the way. And so I either have to like step over him or explicitly say, "Hey [remote pilot's name], can you back up? I'd like to leave the room." And it's a surprisingly unnatural interaction.

When attending large group meetings or formal presentations, remote pilots will often join the audience and face the front of the meeting room to watch the presenter. In doing so, pilots sometimes inadvertently move the MRP directly in front of a local audience member, thereby blocking the local's view of the presenter. (See Figure 6.) As observed at both Companies A and B, this is usually remedied by someone speaking up for the local whose view was blocked.

At the same time, different local workers seem to have different mental models of the MRP. Some were hesitant to physically push the MRP to make it go faster toward its location, change its volume without asking for permission from the pilot, or touch the system; others did it without hesitation as if they were interacting with inanimate machines (e.g., resting feet on it). The violation of personal space, touching and control could be an issue from the remote pilot's perspectives. During a standing meeting, one local kept fiddling with the MRP, which was being piloted by R16. As R16 described it:

He just kept bumping my volume up, and bumping it down... It was just very distracting... I felt like... my personal space was being invaded.

Some of the behaviors of remote pilots seem to come from existing communication technologies (e.g., phone, chat), which are not always appropriate. Similar to hanging up a phone at the end of a call, some pilots just hang up the MRP system at the end of the conversation. This caused inconveniences or awkwardness to local coworkers.

One example critical incident describes this issue (R3):

And they just log out and they just run off and the robot is just left like in a conference room… If I don't put them on the chargers then the battery will be dead the next day.

Figure 6. The MRP in a scheduled presentation. The pilot put the MRP amongst others in the audience, but inadvertently blocked the view of a local, who was sitting behind him.

In the opposite type of scenario, participants reported that the pilot sometimes lingered for too long after the end of a conversation. Like in face-to-face conversations, these participants expected the pilot to drive the MRP system away soon after completing the conversation. Lingering for too long created an awkward situation for local coworkers as they felt that they were being watched by the pilots, even though the pilots were not usually paying any attention to the MRP system's audio-video feed. Some participants reported that they learned to explicitly remind the remote pilot to go away after they finished talking with each other.

Formation of new usage norms

While these usage norms seem to draw from previous experiences with face-to-face and mediated interactions, they are also forming new usage protocols to use the MRP system. For example, instead of standing at the side of the table and facing the projected screen as other meeting participants, the MRP system has a set location in the front corner so that the remote pilot can face the rest (Figure 7).

Local coworkers also demonstrated their commitment to engaging with remote pilots by helping the MRP function in the workplace. R14, a remote pilot, said:

I have tried to get to other meetings and my [MRP] has not been like behaving well... If people know I'm coming to the meeting, they'll come looking for me and like grab my [MRP] and drag it to where I need to be, which is nice.

Pilots are largely helpless when they lose network connection to the MRP so locals sometimes help them by pushing or pulling the MRP around. Similarly, locals often help pilots with opening doors. As R17 reported:

It'd just be like if someone was in a wheelchair and you needed to open a door for them... but it's a lot less bulky, so it's almost easier than a wheelchair.

To gain a broader understanding of the social norms forming around MRP, we polled the survey respondents to rate how polite or impolite (1=very impolite; 7=very polite) they thought it would be for pilots and locals to engage in scenarios mentioned in the critical incident interviews and seen during MRP observations. (See Figure 8.)

A MANOVA showed that both pilot and local coworkers believed it was more polite to ask remote pilots to adjust their own volume levels (M=5.13, SE=0.15) rather than adjust the volume levels by pressing the MRP buttons directly (M=4.11, SE=0.19), $F(1, 42)=29.62$, $p<.0001$. Pilots rated locals adjusting the volume on their own as being more impolite than local coworkers and bystanders, on average. This social norm stands in contrasts against how people typically adjust the volume of other audio/video conferencing system without asking remote users for permission. There is something different about the MRP that makes this behavior seem rude.

People's orientations toward the MRP influenced their judgments of how polite it would be to play pranks on the MRP. In our survey, we asked respondents to describe the MRP in their own words as a way to gain insight into how they conceptualize the MRP system—as a robot or something else. 41% of the respondents used the word "robot" to describe the MRP, and the rest did not. Respondents who used the word "robot" to describe the MRP believed it was more impolite to play pranks on the MRP (M=2.60, SE=0.28) than people who did not call it a "robot" (M=3.34, SE=0.25), $F(1,44)=3.92$, $p=.05$.

Impact of technical embodiment of a remote pilot

Being represented as a physical machine in a social setting poses some challenges to a remote pilot. Remote pilots often mentioned that they were embarrassed by their driving skills or technical glitches of the MRP.

It's not as bad if you're driving down a hallway by yourself and the wireless cuts out for a few seconds and you keep driving. It's not a big deal, but if you're trying to, you know, communicate with some one, especially in a social sense, well… now you've got to wait five seconds for your wireless to come back so then you have to ask hem to repeat themselves or whatever.

When a system is an embodied representations of you, it can also come with the psychological baggage of embarrassing you when it fails. That has led some users to withdraw from social interaction when the system is not performing reliably. On the other hand, other users were not bothered by the malfunctions; they simply moved on to use a different MRP system, leaving the original one behind.

Even though remote workers could pilot the MRP system, they did not have full control over their representation in

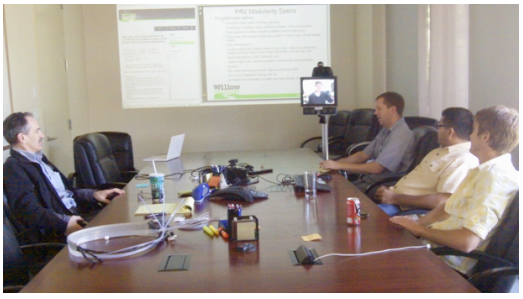

Figure 7. The MRP in a scheduled meeting. The pilot puts the MRP in the front corner, so that he can face everyone.

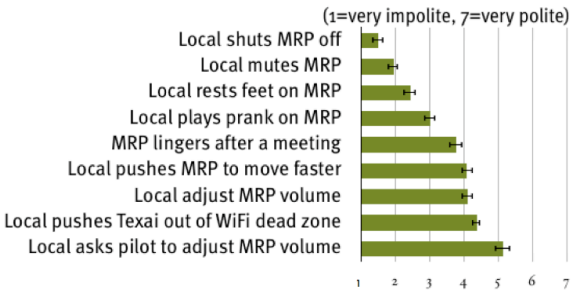

Figure 8. Politeness ratings of MRP usage norms (M, SE)

the MRP or its surroundings in the MRP location. Remote pilots also could not see what they looked like in the MRP, so they were not aware of any things attached to the MRP. The MRPs have been decorated (by locals) with hats, moustaches, posters, and leis, but the some pilots did not know about the decorations until being told about them or seeing pictures taken at the local site.

We also found some cases where the quality of the MRP was perceived as if it was the quality of its remote pilot. For example, the volume of the MRP was sometimes too loud, as the MRP system does not adjust volume automatically to the ambient sound level in its location. Even though remote pilots were not aware they were being too loud, many local coworkers described that the remote pilot (not the MRP system) as being too loud, thereby disturbing the workplace. This, in turn, upset the remote pilot as local coworkers began to shut their office doors in front of the MRP when the volume was turned up too high.

The MRP does not have arms or other manipulators. In a few instances, pilots improvised by pushing objects around with the mobile base of the MRP or bumping/knocking into doors to get attention from people on the other side of the door. However, pilots generally needed help from the local coworkers to manipulate its surroundings (e.g., opening a door of a meeting room, fetching a tool from a toolbox). One remote pilot (R5) expressed this experience as feeling disabled.

IMPLICATIONS FOR THEORY

The results of these exploratory studies suggest that the MRP could support informal communication and connection in distributed teams. However, we also learned, a technical embodiment of remote pilot creates confusion about who or what the MRP *is* (ontologically)—a person, an object, a robot, or something else. This raises theoretical issues of source orientation, entitativity, and agency. Because the MRP system is mobile and is controlled by remote pilots, its physical form somehow embodies the individual pilot. This contrasts against wall-mounted video displays, where the physical video display is not typically identified as being the remote people, but is more like a window or portal into their workspace.

In terms of theory, the MRP presents more questions than answers, but they could ultimately provide grounds for a deeper understanding of issues of agency, responsibility, and social norm formation. Should the MRP be treated as a person? When it is shut off by locals against the will of the pilot, is that an assault? When the MRP damages things, who is at fault? Does that change when autonomous features (e.g., obstacle-avoiding navigation features) are involved? At least some of these questions can be addressed empirically (e.g., which dimensions of MRP systems influence how people perceive the identity, rights, and responsibilities of remote pilots?), but some will require grounded conceptual work to articulate the boundaries that are being blurred between person and machine, physical and virtual, and being here vs. being elsewhere.

IMPLICATIONS FOR DESIGN

This MRP system and the current studies also raise practical issues about how to support users in making sense of these systems. In this section, we describe several design directions to address the issues raised by the current work.

Places

The places where most informal interactions took place were not spaces typically supported by stationary systems (e.g., videoconferencing), demonstrating that more informal remote communication can be supported outside of conference room and private office settings. Hallways are not typically construed as places for holding conversations, but they are exactly the places where information communication frequently occurs.

Strategically placing docking stations can influence the use of MRP systems. The docking stations should be placed in locations where there is a high traffic to increase the chance for impromptu meeting with local coworkers; it also should be in close proximity where other formal meetings happen, so that remote pilots can quickly drive to the meeting rooms. Each MRP system could also have multiple charging stations throughout a workspace.

Mobile Remote "Presentation of Self"

Features to provide remote pilots with more feedback about how they are presenting themselves (e.g., [6]) are important as these MRP systems become identified with the person, not just as a machine that is being driven by a person. Providing mechanisms to help monitor their volume levels, monitor their appearances, and communicate nonverbally could also improve the user experience for both remote pilots and locals. MRP sensor data could also be used to providing social (e.g., proxemic) information to pilots, e.g., when a person is trying to squeeze by.

As the MRP system is often used as a shared resource (like a landline telephone), it is important for locals to be able to quickly identify who is piloting the MRP so that it is not an anonymous lurker. While some local coworkers who have used the MRP for an extended period of time reported that they could infer the remote pilot just by hearing patterns in its driving noise, most people do not know who the pilot is until they check the front side of the MRP screen. Using either sound or visual feedback could let local coworkers identify the pilot from all angles. If one MRP is used by one dedicated pilot, then this is less of an issue. With earlier prototypes of the MRP system, when R5 was the one and only pilot, this was not an issue at all.

LIMITATIONS AND FUTURE WORK

A limitation of this work is the limited sample of participants; ongoing field studies will address this in future work, enabling comparisons across different types of organizations, individuals, MRP systems, use cases, etc.

Using Company A in this study may seem problematic, but only four people in the study actually worked on the Texai project; studying one's own prototype in different teams or divisions is not uncommon (e.g., [5, 9, 11, 18, 21]). There were several methodological limitations for this study. Unlike ethnographies, the current set of methods did not allow us to gain insight into the process of adaptation of the MRP or exactly how the social norms were forming over time. Unlike controlled experiments, these methods cannot identify causal relationships between variables. However, we believe this triangulation of methods (critical incident interviews that informed the design of surveys in combination with field observations) allowed us to observe the rich use of the system after novelty effects wore off, identifying key variables and hypotheses that follow-up controlled experiments can test.

CONCLUSION

We have explored the uses, interactions, and issues surrounding a mobile remote presence (MRP) system that was used by three different companies in their everyday work environments. People used the MRP system to engage in both formal and informal communication activities and used it in a variety of locations throughout the work spaces. By presenting the use cases, benefits, and issues, we hope that these findings will inspire and support the larger research community in identifying fruitful areas of research and design in the space of mobile remote presence.

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