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Mixing Metaphors in Mobile Remote Presence

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ABSTRACT
Metaphors for making sense of new communication technologies are important for setting user expectations about appropriate use of the technologies. When users do not share a common metaphorical model for using these technologies, interpersonal communication breakdowns can occur. Through a set of three 8-week-long field deployments and one ongoing observation in-house, we conducted contextual inquiries around the uses of a relatively new communication technology, a mobile remote presence (MRP) system. We observed many nonhuman-like metaphors (e.g., orienting toward the system as a robot, an object) and human-like metaphors (e.g., a person, or a person with disabilities). These metaphors influence people's expectations about social norms in using the systems. We found that there is a serious risk of creating interpersonal conflict when the metaphors are mismatched between people (e.g., locals use nonhuman-like metaphors when remote pilots use human-like metaphors). We explore the implications for understanding remote pilots' rights and responsibilities and present design guidelines for MRP systems that support geographically distributed groups.

Author Keywords
Mobile remote presence; metaphor; source orientation.

ACM Classification Keywords
H.4.3. Communications Applications: Computer conferencing, teleconferencing, and videoconferencing. H.5.3. Group and Organization Interfaces: Computer-supported cooperative work.

General Terms
Human Factors.

INTRODUCTION

Metaphors can (often unwittingly) influence the ways that we perceive and act [17]; we use metaphors to make sense of other domains (e.g., LIFE is a JOURNEY), drawing from basic source domains (e.g., journey) to make sense of target domains that are more difficult to conceptualize (e.g., life). Similarly, we draw from basic source domains to figure out how we could and should use the new technology. This is the case with mobile remote presence (MRP) systems. As a relatively new technology, people have not yet formed a conceptual model for exactly what the MRP is, what it is not, and how they should use it. As such, people mix metaphors when encountering MRP systems. More critically, one interlocutor sometimes holds a mismatched metaphor from the other interlocutor, which is a potential source of interpersonal conflict.

Geographically distributed work teams already face more behavior and project management challenges than collocated and virtual teams [24]. In a study of collocated vs. distributed synchronous teamwork, Olson and Olson found that there are many factors that must align in order for communication technologies to improve distance work; they include sharing common ground, doing loosely coupled work, and having a culture of openness to collaboration and collaboration technologies [26]. Attaining this combination of factors is not easy. However, because we experienced the benefits of mobile remote presence in our own office, we chose to explore the possibility of supporting distributed work teams in other companies, too. We conducted an 8-week-long field trial at three different companies, along with an ongoing in-house observation of our own usage of the system.

The research questions in the current study and analysis are: How do people make sense of MRP systems in the workplace? How do the metaphors they use influence the

Figure 1. Remote pilot (in Boston, MA) talking with a local colleague (in Mountain View, CA) via an MRP system

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ways that they interact through (and with) the MRP system? What are the underlying disagreements that cause interpersonal conflict when using MRP systems?

RELATED WORK

The most common question we hear when demonstrating our MRP systems is, "What is that?" Once they notice the live video feed of the remote person piloting the MRP system, they ask, "Who is that?" Knowing who (or what) we are communicating with is important. That is why "source orientation" is such a critical issue for human communication research.

Source Orientation

Source orientation refers to who (or what) a person believes is the source of the message. In the case of MRPs, people could orient toward the source of an utterance as being a "robot" talking, a person talking, or something else. People have a tendency to orient toward media (e.g., televisions, radios, and other communication tools) as if they were actual sources [28]. Furthermore, people orient toward the computer as if it were a source [34]; that is, people interact with the system as if it were a person in-the-moment, even though they do not reflectively believe that the system is a person [36]. Scholars such as Latour reflectively look upon nonhuman objects (e.g., doors [14] and speed bump [18]) as being actors, similar to humans.

Although many norms for how people interact with each other transfer to how people interact with computers, there are some differences in the degree to which these effects hold true. In human-robot interaction, there are individual differences in the ways that people orient toward robots (e.g., receptionist vs. informational kiosk [20]). Assertive people engage in more hostile power struggles when they believe they are interacting with a person as opposed to a computer [31]. This suggests that source orientation is affected by individual and contextual differences, which is explored in the current work.

Videoconferencing Systems

Aside from having remote mobility, MRP systems are similar to videoconferencing systems. As such, we examined the metaphors people use for talking and thinking about videoconferencing.

Videoconferencing Metaphor: Spaces

Spaces are a particularly powerful metaphor for setting videoconferencing user expectations about sharing a territory that spans across physical spaces. The Xerox PARC Media Spaces system connected the commons areas (i.e., shared workspaces) of labs in Oregon and California. Similarly, the EuroPARC RAVE system was networked throughout rooms in the EuroPARC building [12]. These researchers defined a media space as "an electronic setting in which groups of people can work together, even when they are not resident in the same place or present at the same time. In a media space, people can create real-time visual and acoustic environments that span physically separate areas" (p. 30) [4]. In the same vein, the CAVECAT (Computer Audio Video Enhanced Collaboration and Telepresence) was also conceptualized as a media space. It consisted of enhanced workstations that were connected via a digital-audio-video network, including a videoconferencing system for enabling small work teams to collaborate without leaving their offices [22].

Videoconferencing Metaphor: Windows

In contrast to the metaphor of being a space, other videoconferencing systems relied upon the metaphor of interacting through a window that separates two spaces. Most notably, the Bellcore VideoWindow system framed videoconferencing as interacting through a virtual window [11]: "imagine that you and your colleagues… are separated by a large sheet of glass that does not interfere with your ability to carry on a clear, two-way conversation" (p. 1). This system consisted of a very large video display and full-duplex audio connection between two geographically separate sites. The window metaphor also raised the saliency of transparency in the VideoWindow system.

This metaphor is carried on through similar projects such as the Xerox PARC and EuroPARC project, Portholes [9], which supported awareness across geographically distributed work groups. It provided images (updated every few minutes) of one or more sites. A lower bandwidth alternative was named "Peepholes," a system that created a virtual community of collaborators (from one's electronic address book) and provided activity/inactivity information about each of the collaborators [13]. Based on lessons learned from how people used the Cruiser system [5] to "ambush" colleagues (i.e., pounce upon them when they seem to be available enough to a conversation), the Peephole was built to enable awareness without requiring always-on video connections.

Videoconferencing Metaphor: Surrogates and Proxies

The most similar systems to the MRPs are ones that have actuated physical embodiments. These types of videoconferencing systems tend to rely upon the metaphor of being a surrogate or proxy. The Hydra, a small tabletop video conferencing system that each individual used to "take their place at the table" [6] set the stage for the notion of video surrogates. It was presented to users as a surrogate: "Don't think of the camera as a camera. Think of it as a surrogate eye. Likewise, don't think of the speaker as a speaker. Think of it as a surrogate mouth" (p. 8).

In this same line of thought, researchers have created many physical proxies that do not necessarily use video. Among these are the Surrogate motorized figurines and light patterns used to provide abstracted information such as the remote person's awareness and degree of interest [16]. More recent versions of these abstracted character figurines like the Cellular Squirrel [23].

This notion of a proxy is also visible in Microsoft Research's Embodied Social Proxy (ESP), a telepresence device that "represents the satellite coworker" in hub-and-satellite teams [39]; the ESP system sits on a rolling cart that can be pushed from location to location. Subsequent work has found that rotational control of the cameras is not as effective for increasing one's sense of social presence as being able to move the camera forward and backward [25].

Remote Mobility

The critical difference between prior work in remote video communication systems and the one presented in this study is that this system's motions are controlled by the remote operators, not the locals or the computer. The remote person is in control of what he looks like, where his cameras point, how loud his speakers are set, and where he goes. Thus, remote coworkers who use MRP systems can wander around the office, pounce on coworkers, engage in the hallway conversations, and participate in other informal communications that are critical to group work [42]. This difference breaks down the metaphors of spaces and windows. Being remotely controllable, the MRP systems are closer to the metaphors of surrogates and proxies.

Humanoid Robots

Android (e.g., Geminoid [30]) and humanoid robots (e.g., Wakamaru [25]) have also been used for supporting remote presence, using the metaphor of surrogates and proxies. While many of the same issues arise for humanoid robots as for the current system (e.g., identity mediation [33], movement increasing social presence [25]), there is one major difference. Unlike humanoid robots, the current MRP system uses the live video feed of the remote operator to represent the remote person; this enables anyone to operate the MRP system and look like oneself. The current MRP system is more likely to be perceived as an object or medium as opposed to an agentic robot because it is explicitly designed to project the remote operator's physical form (through live video) as opposed to only projecting the operator's voice and/or nonverbal behaviors.

Mobile Remote Presence Systems

Mobile remote presence (MRP) systems are not new. They have existed for over a decade in the form of UC Berkeley's Personal Roving Presence (PRoP) [27], HP Labs' BiReality [15], PEBBLES for hospitalized children [10], and other robotic telepresence systems in hospitals [40]. Commercially available MRP systems are being explored in the field, including the VGo and the Anybot QB [38]. From these studies and from observations of film-based physical avatars, researchers are generating design guidelines for such telepresence robots [8,29]. These telepresence robots take on many forms, not only as roughly human-scale systems; they also exist in tabletop forms (e.g., MeBot [1]).

Earlier research on this particular MRP system [19] was run in parallel with the current project. The current work was conducted by a separate and larger research team, started before and ended after the shorter-term study, included a larger set of companies, and used different empirical methods. The past work [19] focused upon interview, observation, and survey results gathered in parallel with this longer-term field study; the data sets remain separate.

SYSTEM

The MRP system used in this study was an Alpha prototype of a Texai remote presence system. It stands approximately 1.57 meters tall, consisting of a "head" that is supported by a metal stem on a motorized base. The "head" is a videoconferencing system with a color LCD screen, pan-tilt web camera, audio speakers, and a microphone. The motorized base has a remotely controllable active caster in the back with two passive wheels in the front; the base also has a polycarbonate bumper, a computer, and a large battery that lasts for approximately eight hours on each charge. Remote pilots control the MRP system via an Internet connection, video chat application, and web-based graphical user interface. See this MRP system in Figure 1.

Because we did not want to push any particular metaphor for understanding or using the system at the field sites, we framed the MRP system as a "system," not as a "robot." "Local" is the term we use to describe a person who is in the same physical location as the MRP system. "Remote pilot" is the term we use to describe the person who is remotely operating the MRP system.

FIELD STUDY

The current study presents a critical set of issues and breakdowns that were observed during the 8-week field study trials, focusing upon the metaphors that people seem to use when interacting through MRP systems and the breakdowns that occur when there is disagreement about those underlying metaphors. We conducted a contextual inquiry [3] to explore the ways that people would use and make sense of these MRP systems in the workplace. We recruited several companies that had hub-and-satellite work groups with the hub in the San Francisco Bay Area. See the other demographics for the sites in Table 1.

Field sites A-C participated in the following activities:

1. Intake interviews with remote pilot(s) up to 2 weeks before the MRP systems were delivered to the site
2. Contextual inquiry field observations on the day of MRP system delivery and every other week after that
3. Email, phone, or video chat interviews every other week before the field observations

Sites A and C also had ballot boxes left at their local sites, where local participants were invited to anonymously drop comments for the researchers.

Site	Dedicated Remote Pilots	Pilot Roles in Each Company	Distance From Local Site (Miles)	# of MRP Systems Available	Office Has Persistent Video Connection to Remote Site(s)?	Commonly Used Communication Tools
A	A1, A2	Executive, VP	50, 15	2	No	Email, Telepresence room, Skype
B	B1, B2	Software Developer, VP	>1200, >2900	1	Yes, but they turned it off	Internal Project Tracker, Skype
C	C1, C2, C3, C4	Project Director, Senior Engineers, System Admin	>2500, >800, >3000, >8000	2	Yes	Email, IRC
D	D1	Electrical Engineer	>2,000	5	No	Email, Skype, Phone

Table 1. Overview of MRP Field Study Participant Population and Communication Tool Usage.

Site D was different in that it was the company where the MRP prototype was originally created; this site had used the system for approximately 9 months longer than the other sites. While we did not conduct a formal field study at Site D, one of the coauthors works at this site is a full-time employee and has taken notes, videos, and pictures of events as they occurred in the workplace.

OBSERVED BREAKDOWNS

While our prior work discussed how MRP systems are used when interactions were working smoothly [19], this work focuses upon the common and major breakdowns we observed at the four field sites.

Hanging up

A common and problematic situation occurred across several sites: MRP systems would be found in the morning with dead batteries, sitting far away from their charging stations. This was typically caused by pilots thinking of the MRP system as a normal videoconferencing system that they simply "hang up" at the end of the conversation; however, MRP systems run on battery power so their batteries run out of charge if they are not parked in their charging stations at the end of the work day. At Site B, when one pilot did this, a frustrated local said to the MRP system, "You can't just turn off the robot in the middle of the floor!" Then, "Who's there? Wake up!" It was clear that the local felt a norm had been broken. Frustrated locals are not inclined to help move them back to their charging stations so some MRP systems were left with dead batteries for more than few days at a time.

Violating personal space

Problems often arose for pilots when locals broke the remote pilot's expectations about respecting "personal space" around the MRP system. Pilot C2 mentioned, "My boss hugged me. I don't know that he would have done that normally." Similarly, Pilot C3 was bothered when his local coworker was examining the base of the MRP system too closely; he exclaimed, "It's like you're looking up my skirt!" with an uneasy, but humorous tone. Similarly, Pilot C4 told the locals who were investigating the MRP, "Stay away from my buttons!" because they were pressing the volume control buttons on the MRP speakers. When a remote pilot feels like he *is* the MRP system, it becomes uncomfortable when locals behave differently than they would behave around a person.

Incapacitating

The most extreme breakdown occurred when a local shut down the MRP system that a pilot was trying to use to talk with her. Since she did not want to talk with Pilot D1 and felt that he was being disruptive, she simply hit the run-stop button on the MRP prototype base, which turned off the power supply to the motors. She reasoned that it was like hanging up the phone on someone. However, Pilot D1 felt that this was much worse than having someone hang up on him by phone. It felt to him like he had been incapacitated.

A theme that cut across these breakdowns was a mismatch between the ways that different pilots vs. locals thought about the MRP system. Because they seemed to be using different metaphors for making sense of the MRP systems, we chose to do a more focused analysis of those metaphors.

METAPHOR DATA ANALYSIS

To examine those metaphors people used to make sense of the MRP systems, we used the TAMS qualitative data analysis tool to sort our field notes and interviews, inductively coding them for contents such as (1) what metaphors people used for interacting with or talking about the MRP system, (2) how those metaphors were mixed over time and between people, and (3) the implications of using certain metaphors for understanding the rights and responsibilities of remote pilots. The metaphor categories used in the current analysis were inferred from the observations. We do not claim that these metaphors are consciously invoked when interacting with the MRP systems, but we do claim that people are (either explicitly or implicitly) using these metaphors to make sense of and use the MRP system.

Categorizing Metaphors

We inductively developed the categories of metaphors with the goal of identifying the metaphors that shed light upon problematic interactions observed in MRP usage. Behaviors

and statements from participants that suggested the MRP system was a communication tool were categorized as "Communication Medium," e.g., using language about videoconferencing or calling in. Explicit mentions of the system as "robot" or references to science fiction notions of robots (e.g., "Rosie") were categorized as "Robot." The category of "Object" was used to tag behaviors and statements that referred to the MRP system as a thing, "it," or otherwise non-agentic entity. The last two categories of "People" and "People with Disabilities" were used to capture behaviors and statements that clearly referred to the system as a person (e.g., using pilots' names or behaving in socially appropriate ways in terms of how one would treat another person in the office, not objects).

RESULTS

First, we provide descriptions and examples of the metaphors people used to talk about and interact with the MRP system, along with potential sources of influence that might have encouraged the use of that metaphor. Second, we present the ways in which those metaphors are mixed and the sometimes negative consequences of mixing them. Third, we present the how the metaphor of MRP-as-person impacts issues of rights and responsibilities for MRP users.

The metaphors that people use for interacting with the MRP system changed over time, shifting from moment to moment, and varied widely between individuals.

Nonhuman-like Metaphors

Communication Medium

Technically, we consider the MRP system to be a communication medium. At Site B, a software engineer remarked to a colleague that this MRP system represented a logical step from Skype (online videoconferencing) to "Skype on wheels." At Site A, one local explained, "For me, with a bigger screen, it's more of a videoconference thing than a robot thing." When people used "robot in" as a verb, just as they might use the words "email", "phone" or "Skype" as verbs, it highlighted its role as a communication medium. They sometimes applied social norms from existing communication technologies to decide how to use the MRPs, e.g., "hanging up" the MRP as soon as the meeting ended. This presented the problem for locals, who then had to push the MRP system to the charging station.

Figure 2. Local participant showing us how he wants a remote control mute button for the MRP system

Robot

Despite our best efforts to refer to the MRP system as a "system," not a "robot," all of the field sites referred to the MRP system as a "robot" in the beginning. Both locals and remote pilots referred to the MRP system as a robot. When describing system breakdowns, a remote pilot from Site A explained, "My robot just got stuck." A local at this same site explained how this pilot would use the MRP system to be present in the office on the days when he telecommuted from the other office across the Bay: "So if … there's a meeting, we would go to his office and the robot would roll up in his place." At Site B, one local wrapped up a project team meeting by asking, "Anything else? Anybody? Robot?" (in a somewhat humorous way) to see if anyone had final project issues to raise. A little more seriously, a different local bystander, who was annoyed by the disruption caused by the MRP told us, "What you need is a robot mute button," as he demonstrated a remote control button press. See Figure 2.

The use of "robot" extended beyond descriptions of the system, carrying over to greetings and verbs. At the end of one project meeting, one of the engineering team members said goodbye to Pilot C1 by calling out, "See ya, Rosie!" in reference to the Jetson family's robotic housekeeper.

Object

The most ambiguous form of reference to the MRP system was "it." Because we could not definitively categorize these references, we interpreted this as conceptualizing the MRP system as some kind of object. Whenever the MRP system was introduced into a new environment, the people who come to see it ask the inevitable question: How fast can it go? At Site C, a local asked Pilot C4, "Do you steer this thing?" while enacting driving with a car steering wheel.

For others, the MRP system was more like an unidentifiable object. Some locals were surprised by its presence, e.g., as Site A, "It just kind of snuck up on me and it was just kind of jarring, like, 'Oh my gosh! What is that? And why is it coming towards me?' [...] I was surprised there was this thing and then there was [Pilot A2] sort of in our conversation."

Even after many weeks of exposure to the MRP systems being used in the office, not everyone felt at ease with it. At Site C, one local bystander described it as, "It's big and loud and bangs into things like doors. It's also a distraction when it's moving around."[1] She did not seem to know who

[1] Sometimes the MRP system seemed too quiet because the ambient environment was noisy (e.g., computers humming, fans blowing, many people talking). Sometimes it seemed

was actually operating the MRP system and was not interested in finding out who it was.

Another common type of object metaphor was that of a container. Locals at Site C talked about having trouble with figuring out "who's in it that day" or who was "inhabiting" it. Remote pilots also used language to suggest this metaphor, reporting on conducting a job interview "inside of a tele-robot."

Consistent with the notion of the MRP being a mere object, we have observed people sitting on the MRP base like a chair and leaning on the MRP monitor like they lean on a porch railing. At Site B, we observed one local engaging in a very in-depth conversation with Pilot B2; the local was sitting in his desk chair, looking up at the MRP screen, and resting his feet upon the base of the MRP. See Figure 3. These are not typical interpersonal behaviors that one would see between collocated people in an office.

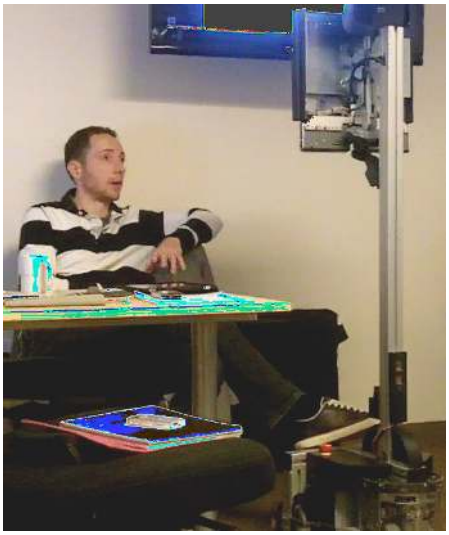

Figure 3. Remote pilot (in Colorado) talking with a local (in California), who is resting his foot on the MRP base

Human-like Metaphors

Person

Throughout the field studies, many people interacted with and talked about the remote pilots as if they were simply there. At Site A, one local participant described her interaction with a remote pilot this way: "When [Pilot A2] gets on the robot and goes around the building and stuff and we have a conversation, I argue with him and hand gesture. It's as if he's there. You know, the fact that the screen is that big, his face is almost kind of life size, maybe that adds to it, versus someone you're talking to on an iPhone or whatever. I treat him as if he's right there. I don't think I act any differently." Before anyone logs in, the MRP seems to be a robot, but someone logs in, the MRP seems to be a person.

The degree to which locals treated the MRP as a person was sometimes evident in how they observed social norms. Indeed, we often observed locals struggling with figuring out what was socially appropriate with the MRP. During a meeting at Site A, a local complained to Pilot A2 that he was too close and felt like Pilot A2 was staring at the back of his head; Pilot A2 then moved the MRP away. In another case, a local refrained from lowering the volume on the MRP speaker while the remote pilot was presenting to a group of visitors. The local reported, "There was an Ambassador training tour and the volume was scratchy. I had the idea in mind that maybe I should have stopped [Pilot A2] and play with the knobs, but I didn't do it…" In a voice conferencing setting, it is common for users to make adjustments to their speaker volume settings throughout a conversation. However, in a face-to-face conversational setting, it is less common to see people make adjustments to each other in the middle of a conversation (e.g., telling a group member to quiet down). This situation is an example of what happens when locals construe the MRP system as being something like a person.

In other cases, participants not only treated the MRP as a person, but also specifically identified it a particular individual (i.e. the pilot). MRPs that were piloted by C1 and D1 were referred to by a combination of their name and "Bot" (as in "JohnBot" or "SmithBot"). In both cases, the pilots had been the only ones using an MRP for a period of time, and used it extensively.

Person with disabilities

The most surprising, yet common, metaphor was that the MRP system was like a person with disabilities.

Because the MRP system cannot open doors, Pilot C1 had difficulty with exiting the conference rooms at the end of meetings. He reported, "One meeting ended and I had to sit there to wait around to get help with opening the door. I don't know how to deal with that really." Locals at that office also reported feeling awkward about having to let the MRP system out of conference room. Similarly, as Site D, pilots have started to wander back and forth in front of office windows or to gently bump into the door a few times in order to "knock" so that locals will open doors for them.

At another time, network latency issues caused the video feed to update very slowly, making it difficult for Pilot C2 to move through the office (as he was visually impaired by the network latency). His local coworkers helped him navigate by telling him directions such as "turn to the left forty degrees" to turn a corner.

Pilots and locals continually referred to how MRP needed help because it "doesn't have arms," was visually impaired, or "died" in the middle of the hall. Pilot A1 suggested the MRP should display a sign when it lost a WiFi network

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too noisy because the ambient environment was quiet (e.g., single person office, mostly empty meeting room).

connection; he compared it to a person wearing a "medical bracelet" so that paramedics know what to do if they find the person unconscious. The person with disabilities metaphor encompasses some of the limitations on what pilots would like to do with MRP, as well as how they relied on locals to help them.

Often in anticipation, locals adapted their behaviors to make up for the limitations of the MRP systems. For example, at Site A, one local drew a marketing diagram on the whiteboard much larger than normal just so that Pilot A1 could see it. Sometimes that same local would take high-resolution digital photographs of the whiteboards and email the photographs to Pilot A1 after the meeting adjourned. Many locals remarked at having to slow down their normal pace in order to walk with the MRP through the office. It was not uncommon to hear locals talking extra loudly so that MRP pilots could hear them better over the hum of office noises.

Mixing Metaphors

The metaphors people use for making sense of these MRP systems influence the ways that people form their beliefs about what is appropriate and inappropriate behavior for using these systems. We observed many instances of people mixing those metaphors between people and over time.

Mixing Metaphors Between People

As seen in the three examples of common breakdowns in interactions between people who use the MRP system, mixing metaphors can be quite harmful to interpersonal interactions in the office, especially when remote pilots vs. locals used mismatched nonhuman vs. human metaphors. In the "hanging up" example, pilots seemed to be thinking of the MRP system as a static communication medium, whereas locals did not agree. In the "violating personal space" example, pilots felt like the MRP system should be treated like a person, but the locals did not agree; pilots felt more like the MRP systems were more like people, but the locals experienced the MRP systems as objects that could be touched and handled. In the case of "incapacitating," the Pilot D1 experienced the MRP as an extension of himself, which is why it was so upsetting that the local had shut his MRP off; this local treated the MRP with more of a phone-like stance, finding it to be appropriate to shut it off just as one would hang up a phone.

Mixing Metaphors Over Time

Not all metaphor mixes work out so terribly. As one local at Site C said, "you can still walk with them…it," referring to his ability to walk and talk with the remote pilots as he could walk and talk with them whenever they visited in person. He corrected himself, saying "it," because he preferred to talk about the system as being an object, but found himself slipping into the language of a more person-like metaphor. Similarly, one local at Site C talked about how his perception of the MRP system changed over time. At first, he saw it and thought it was "so cool" that he got caught up in details like "how fast it can go," but later said that when he saw the MRP in the hallway, "it doesn't phase you […] now it's just a person."

At Site A, one local participant described her transition from thinking of the MRP system as a robot to thinking of it as the remote person: "It's kind of funny and amazing when you see the person rolling up towards you. Just like, wow, there's [Pilot A1] or [Pilot A2] on the robot. But you feel like they're kind of there, present. And wanting to kind of include them because you feel like, you know, a lot of people don't know how to react to them at first." Although she referred to the MRP system as a robot, she had become accustomed to interacting with the remote people in a way that compelled her to help others learn how to interact with them as people, too.

Rights and Responsibilities

When Pilot D1 was shut down by a local, was that assault? Probably not, but the incident raised questions about what kinds of rights remote pilots could and should have. Along with rights come responsibilities.

Person-like metaphors encourage pilots to take more responsibility for the MRP system. When pilots felt like the MRP really was them (using the person metaphor), it had serious impacts upon how ashamed and embarrassed the remote pilots felt when the MRP system was not operating properly. As C1 noted, losing WiFi connectivity "gets kind of embarrassing because you end up being dead." He knew that it made more sense to blame the "network guys" who are supposed to maintain the WiFi network in the office, but he still felt that it was personally embarrassing (and mentioned it to us several times) even though he did not have much control over the situation. In this sense, remote pilots assumed responsibility for the faults of the MRP system.

Some locals took responsibility for helping the MRP to overcome technical glitches, similar to the ESP system Handlers [39]. This was most apparent at Site A, where one person was designated as the robot aide. He was always the first person the pilots called when the MRP systems were not functioning properly; he would immediately drop his current activity to troubleshoot the MRP system until it was back in working order. This may have been because the pilots were executives in the organization (as opposed to peers), but we observed similar behaviors (though less immediately responsive) at Sites C and D. This difference between sites suggests that the local Handlers are treating the MRP systems as if they were more people-like than machine-like.

Rights and responsibilities encompass much broader issues than simply who should be allowed to turn off MRP systems and who is to blame when MRP systems do not work. These issues become more complex by adding in bits of autonomy (e.g., [35]) and computer-generated behaviors

(as in the Transformed Social Interaction paradigm [2]). As a social issue: If an obstacle avoidance system in the MRP makes a remote pilot drive straight down the middle of a narrow hallway, will the locals understand that the remote pilot did not intend to block their way? As a legal issue: If a semi-autonomously navigating MRP system bumps into a person or damages valuable furniture, who is to blame? The legal rights, responsibilities, and liability issues surrounding personal robotic systems in human environments are under active investigation (e.g., [7]). Autonomous robots already present challenges for existing legal systems (e.g.,[21,32]) and remotely-driven, semi-autonomous systems in human environments present an even more complex challenges.

DISCUSSION

Mixing Metaphors

The most problematic metaphor mixing seemed to take place between pilots and locals, using nonhuman-like and human-like metaphors. Unlike telephones and videoconferencing rooms, pilots have entirely different user experiences than locals. Pilots use their regular personal computers to do videoconferencing while using a typical point-and-click graphical user interface to move around. In contrast, locals encounter a very new, physically present entity that actively moves around in their office space.

The benefits for pilots tend to be more immediately obvious than for locals because pilots are typically isolated at satellite sites. Most of our field study pilots were quite frustrated with their existing solutions for communicating with the hubs (see Table 1), even if they had state-of-the-art solutions and were constantly connected. Thus, they were more patient and persistent with making the MRP systems work for their purposes, trying to be more present (as a person) at the hub site.

Contexts of Use

Although the current study does not include enough data to make conclusive claims about what aspects of what contextual variations influence MRP usage, we have formed several hypotheses about contexts of use.

Using the MRP system as a dedicated (one person to one MRP system) vs. shared resource influences how people conceptualize the system; dedicated MRP systems are more likely to get names like "JohnBot" than ones that are usable by more than one pilot. Similarly, the ESP system had dedicated pilots, which got names like "Virtual Fernando" [39], suggesting that having a dedicated system is more likely to be identified as the remote pilot himself.

The social status of the pilot within the organizational hierarchy is another potential influencer. The strength of that hierarchy likely matters, too. At Site A, locals seemed to feel more obligated and responsible for helping to keep the MRP systems up and running. When only the executives in an organization can pilot the MRP systems, we hypothesize that the MRP system inherits an executive status and becomes a symbol of organizational power, which can be intimidating for locals.

The current study produced at least three other data points against which to compare the creators of the prototype, Site D. Being a robotics company, Site D had a strong tendency to orient toward the MRP system as a "robot" at first, but that changed over the span of several weeks; in that sense, it was no different from the other sites. One major way that Site D was different from the others was that people at Site D more explicitly argued about what was proper vs. improper etiquette for interacting with MRP pilots. Although the conflicts were explicitly discussed, those debates did not seem to affect the shifting and mixing of metaphors in MRP usage.

Implications for Design

There are many minor design implications for this particular system that could be listed (e.g., monitor ambient noise levels and play appropriately quiet sounds so that locals are aware of the MRP's presence without being distracted by it). However, we chose to present two high-level design implications with suggestions for how to address the approach those design issues.

Relatively novel communication technologies should be introduced with a consistent metaphor if the system designers care about quickly reaching a coherent set of social norms. This has worked out reasonably well for previous metaphors of spaces and windows, but has not yet worked out for MRP systems. This does not mean that a single source domain must be used as a metaphor (i.e., the MRP system should not necessarily be treated like a person in every possible way). A plurality of metaphors would be fine as long as the locals and pilots come to a shared understanding of the system. Since most of the interpersonal and usability problems we observed came from mismatches in the metaphors between locals vs. pilots, our primary design guideline is to encourage shared metaphors for locals and pilots.

Taking the metaphor of "Person" too far can be dangerous in that it would be easy to set user expectations too high for the MRP system. If one chose the metaphor of "Person with Disabilities," then one might mark out MRP parking spots at meeting room tables, notify locals when the MRP system needs to be guided out of WiFi deadzones or back to a charging station (perhaps with something like medical bracelet instructions), and notify locals when the remote pilot is experiencing poor video quality by displaying a red band around the MRP system base (like a long cane). These kinds of elements can encourage locals to interact with the MRP pilots like people, but also encourage them to understand that the MRP systems have different abilities than other people around the office.

A second design guideline is to encourage locals to quickly move beyond the "object" and "robot" metaphors for MRP systems, encouraging more interpersonal interaction with

MRP systems in workplaces. Remote coworkers are not trying to operate machines in the office or to "be robots"; they are trying to be present, to communicate, and to get work done. The pilots in our study preferred to be treated with the same kind of respect that they would expect if they were at the site in person so it is safest to design for supporting metaphors of MRP systems being more like people (or people with disabilities) rather than objects that can be pushed around, muted, or shut down.

By highlighting the remote person, one can encourage locals to treat the remote pilots more like the other people around the office. Unlike android robots, this approach calls for the remote person to be the focus of attention instead of the local robot. One way to encourage more human-human interactions (as opposed to human-robot interactions) is to make the remote pilot's identity readily visible, e.g., using a high-fidelity audio and live video. If the system is being used in a shared office space, then it would also be helpful to make the remote pilot visible from all angles around the MRP system (e.g., [15]) so that bystanders are more likely to enter into conversations rather than see it as a big, loud thing that bangs into doors.

The ultimate design goal for MRP systems is to become invisible-in-use [37]. Pilot A2 said this most succinctly: "we know that we're really successful when the robot becomes invisible and it's just about the people there."

LIMITATIONS AND FUTURE WORK

As an exploratory field study, these findings are necessarily preliminary. We have formed more hypotheses than answered questions, but have identified potentially fruitful paths for future research. The generalizability of this work can be tested by comparison with other studies of other forms of MRP systems, in other environmental contexts, in other cultural contexts, and with other types of user groups.

Our follow-up studies are investigating the causal relationships between different design decisions and the ways that people interact with MRP systems. This field work points to other future research directions, including exploring the contextual influences upon the adoption and conceptual models that people form around MRP systems, considering the implications for the design of systems that are viewed as something like people with disabilities, and ways of designing for inherently asymmetrical user experiences [41] for remote pilots vs. locals.

CONCLUSIONS

The current study presents empirical data and results from four different companies that used MRP systems for workplace communication. By analyzing some common and serious breakdowns in MRP usage, we found that remote pilots vs. locals were orienting toward the MRP system in conflicting ways, using human-like vs. nonhuman-like metaphors. Mixing human-like vs. nonhuman-like metaphors is sometimes innocuous, but it can also cause interpersonal breakdowns, particularly when conflicting metaphors lead to conflicting beliefs about what kinds of behaviors are socially appropriate when using MRPs. It has been revealing to explore the rich set of metaphors that people use for making sense of new technologies. For the sake of smoother interpersonal interactions in work teams, we recommend that new communication technologies (such as MRP systems) be designed and introduced with consistent metaphors that encourage convergence upon a shared set of social norms.

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