University of Nottingham
UK | CHINA | MALAYSIA

The practical realities of Mobile Robotic Telepresence: understanding experiences, interactions and the implications for use in organisational spaces

Thesis submitted to the University of Nottingham for the degree of **Doctor of Philosophy, June 2024.**

Andriana Boudouraki

20206633

Supervised by

Joel E. Fischer
Stuart Reeves
Sean Rintel

Signature: Andriana Boudouraki

Date: 3 June 2024

Abstract

This thesis presents an in-depth examination of Mobile Robotic Telepresence (MRP). The work uncovers the social organisation of interactions and highlights the practical considerations of using the technology in organisational spaces. MRP systems are remotely controlled, mobile robots with video-conferencing capabilities. A remote user can drive the robot from an online interface whilst projecting their face on the robot's screen. Thus the remote user is (in theory) able to move independently.

Capitalising on the shift to remote work, commercially available MRP models are often marketed as the solution to maintaining presence at the workplace. Research on MRP has explored the applications in a variety of settings, with unclear conclusions as to its value. Whilst studies claim that the technology allows users to feel a sense of presence in the mediated environment, several limitations and reports of unsuccessful deployments raise questions as to its value. There is little critical examination of what a 'sense of presence' means in that context and what role it plays in hybrid interaction. Moreover, there is a lack of in-depth information on what exactly occurs when MRP is used in everyday, real-world contexts.

The present thesis seeks to address that gap by showcasing the practical realities of MRP experiences —both within interaction and in the broader deployment of the technology— and then applying this understanding into

assessing the suitability of the medium for hybrid organisational spaces. To this end, the thesis employs various qualitative research methods (interviews, video-data, autoethnography and deployment studies), to examine the subject from multiple angles and at different levels of detail. The broader approach to research is inspired by Ethnonmethodology and Conversation Analysis (EMCA), aiming to bring to the foreground the taken-for-granted details of how MRP works.

The empirical work of this thesis is divided into two parts. The first part consists of three studies which focus on developing a detailed understanding of MRP experiences and interactions. These include an interview study of long-term users, a video study of user pairs engaged in a collaborative task and an autobiographical study of the author using an MRP in her home.

The second part of the thesis looks into the application of MRP in organisational settings. This includes a case study outlining the work of deploying MRP in an office, and a follow-up interview study examining the fitness of the technology within that setting.

The thesis contributes to the literature by showcasing the practical realities of MRP use and deployment, providing a detailed description of MPR as a distinct category of mediated interaction and drawing out implications for its use in hybrid organisational settings. Furthermore, this thesis contributes to future work by introducing the use of auto-ethnographic methods in HRI research, by respecifying the focus of telepresence research away from presence and towards participation and, lastly, by identifying the functions and implications of mobility in computer-mediated communication technologies. Future work might thus benefit from moving away from the existing tablet-on-a-stick design paradigm and envision forms of robotic mediation that truly meet the demands of meaningful participation

in hybrid spaces.

Acknowledgements

First, I wish to thank my PhD supervisors, Joel Fischer, Stuart Reeves and Sean Rintel. Their consistent support throughout this journey has been vital in helping me develop my ideas and grow as a researcher. For the last four years, they have given me feedback and guidance on improving my work, as well as invaluable advice on navigating the world of academia. Their encouragement has empowered me to strive for more opportunities to share my work and engage with the research community.

I would also like to thank the Engineering and Physical Sciences Research Council (EPSRC) and Microsoft Research for funding my PhD work.

Beyond that, I wish to thank Sean for the opportunity to conduct the deployment project at Microsoft Research and examine the subject of my thesis in a real organisational setting. Thank you for giving me that level of responsibility and for being such as supportive manager and mentor. I will always remember very fondly the time I spent in Cambridge and the people I met there. From MSR, I wish to thank John Tang for taking the time to share with me his personal experiences with Mobile Robotic Telepresence, and for inviting me to use his Beam robot (which was my first ever trial of the technology). In addition, I want to thank Payod Panda, Lev Tankelevitch, Ozumcan Demir-Caliskan and Bo Kang for being a wonderful team to work with, Bill Buxton for helping spark interest in the technology during the project, Cecily Morrison, Martin Grayson, Ida Larsen-Ledet and Harshadha Balasubramanian for their enthusiasm in testing the robots and sharing their feedback, and Nathan Jones For his support on all the technical elements of managing the robot deployment.

I wish to thank my internal reviewers, Dr. Ayse Kucukyilmaz and Prof. Graham Hutton for their feedback which helped me view my work from different perspectives.

I also wish to thank my examiners, Dr. Helena Webb and Prof. Jon

Hindmarsh for assessing this thesis, for giving me valuable directions for improvement and for their overall examination approach which made the viva a truly enjoyable experience for me.

I am thankful for the Mixed Reality Laboratory. Here I have met like-minded people and felt supported throughout this otherwise solitary endeavour. I am particularly grateful for my MRL friends and colleagues; Edgar Bodiaj, Johann Benerradi, Kevin Glover, Dimitri Darzentas, Hanne Wagner, Petros Ioannidis, Stine S. Johansen, Gisela Reyes Cruz, Juan Martinez Avila, Giovanni Schiazza, Eike Schneiders, Pablo Lopez-Custodio and Horia Maior. I will cherish the memories we made together at the Lab, at conferences and beyond.

I also wish to thank to my dear friend Eleanor Poppy Reeve for cheering me on throughout this journey, and for taking on the arduous task of proofreading this work.

Moreover, I am hugely thankful to my partner, Jack Hamilton; my endless source of emotional support and a place to rest and unwind. And for helping me create the figures shown in this thesis.

And lastly, I wish to thank to my mother, Thalia Constantinidou, for always encouraging my academic interests and allowing me to grow into the person I am today.

Contents

List of Tables

List of Figures

Chapter 1

Introduction

The use of communication technology for work and social connection became prominent in recent years, as part of the societal shift brought about by the Covid-19 pandemic (Ozimek, 2020). In the knowledge industry, workers want options for flexible and remote working (Bloom et al., 2021; Bloom, 2021) and organisations have to develop strategies to accommodate this (Mark et al., 2022). The future of work is expected to be largely hybrid, with people collaborating from different physical locations and through a variety of media. Beyond the workplace, other organisational settings, such as museums and schools, are increasingly more keen to explore avenues for reducing travel costs and making their spaces more accessible (e.g., Ahumada-Newhart and Olson, 2019; Solly, 2022). Still, despite innovations in video conferencing, certain challenges persist. Among other issues, remote working entails the loss of spontaneous and informal workplace interactions (Bleakley et al., 2021; Miller et al., 2021; Lal et al., 2021; Methot et al., 2021), as well as video conferencing fatigue (Bergmann et al., 2023). Papers on the aftermath of the pandemic call for more research on technological solutions (e.g., Jacks, 2021; Bergmann et al., 2023).

Despite this seeming like a recent trend, Human-computer Interaction (HCI) scholars have been envisioning the changing nature of work and have been studying computer-mediated communication practices for decades now. Since the emergence of Computer-Supported Cooperative Work (CSCW) in the 80s, researchers have examined technologies for shared and collaborative work and how those ought to be deployed within organisations (e.g., Dennis and Reinicke, 2004; Grudin and Palen, 1995; Grudin, 1994a). The study of computer-mediated interactions has also garnered interest from scholars concerned with Ethnomethodological and Conversation Analytic (EMCA) approaches, such as Licoppe and Morel's (2012) examinations of Skype calls and Heath et al.'s (2000) workplace studies. Beyond commonplace technologies such as videoconferencing, the scope of exploration has also included more complex and immersive ones, such as hybrid interfaces (e.g., Butz et al., 1999), Virtual Reality (VR) (e.g., Davies, 2004), Augmented Reality (e.g., Lukosch et al., 2015), and robotics.

Within robotics, one proposed avenue is Mobile Robotic Telepresence (MRP). MRP describes systems which generally consist of a tablet with videoconferencing capabilities, mounted on a mobile device which can be remotely controlled. A remote user then drives this robotic device from their desktop or phone interface, whilst displaying their face on the robot's screen (see Figure 1.1). Thus, the **remote user** is able to independently "move" in the location of robot, the **local environment**, whilst having a video call with people located there, the **local users**.[1]. As outlined in the next chapter, several MRP prototypes as well as completed, commericial models have been developed over the last two decades for applications across work,

[1]Adjacent to MRP is the field of teleoperation, which is also concerned with remotely controlled robotic systems, but these are usually aimed at accessing hazardous environments or performing specific work tasks (e.g., Kofman et al., 2005). MRP is distinct form teleoperation, as its aim is primarily to provide presence in the physical world for social interaction and collaboration (Björnfot, 2022). However a system can, in some cases, fulfil both functions (e.g., Yang et al., 2020).

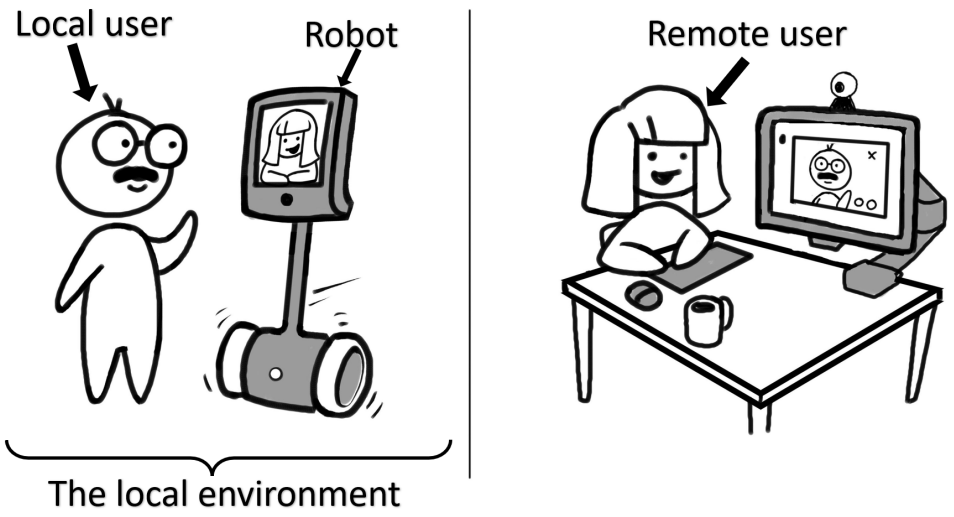

Figure 1.1: The MRP set up. On the left, the local environment includes the robotic device, displaying the remote user's face, interacting with a local user. On the right, a remote user operates the device from their computer interface and is able to see the local user through it.

education and healthcare.

In this thesis I focus on the generic, commercially available MRP models which are primarily marketed for use in offices and other organisational spaces. Such MRP devices are presented as a solution to the challenges of our new hybrid reality (see Figure 1.2). With MRP, the remote user moves out of the stationary videoconferencing screen and into the actual environment. The robots' mobility allows for more expressive, embodied communication. The user takes up space and can not be ignored so easily. Freely wandering around the space, the remote user might even have spontaneous social encounters with their peers; they can have that 'casual' office presence which is missing when working from home. At least that is what the common narrative around MRP suggests.

However, despite commercial MRP models having been around for more than a decade, it is far from a mainstream technology (Kristoffersson et al., 2013a; Virkus et al., 2023). The websites of companies selling such de-

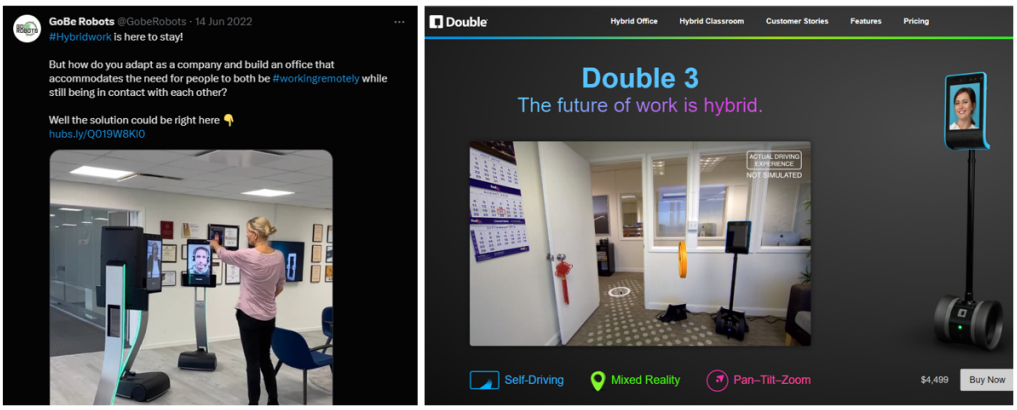

Figure 1.2: Marketing by MRP companies. On the left, a post made by GoBe Robots on X (formerly Twitter). On the right, the main page of the Double Robotics website for the Double 3.

vices present cases from organisations that have adopted their technology (mostly offices, but also schools, museums and healthcare)[2], yet little is shared about the reality of use post-adoption. Existing HCI literature has identified some of the benefits and limitations of the technology, but there a knowledge gap regarding what actually happens during MRP use and what role MRP can hope to fulfill in hybrid organisational spaces. This is what this thesis seeks to address.

A common underlying notion in proposing technologies such as MRP and VR — which afford more than traditional video conferencing (e.g., embodiment, movement) — is that a richer range of capabilities, and especially ones that mimic the capabilities of being in-person, will allow users to feel more present and thus improve remote communication. This approach follows the reasoning that the solution to hybrid challenges lies in allowing people to do remotely the things they could do in person in largely similar ways. For example, in-person conversations involve body language, therefore a hybrid solution should support expression through embodied movement. Within this paradigm, a relationship is also implicitly drawn

[2]see https://www.doublerobotics.com/stories/
https://gobe.blue-ocean-robotics.com/applications

between having a greater sense of presence and achieving better communication (e.g., evaluations of MRP often measure sense of presence (e.g., Kristoffersson et al., 2013b; Tsui et al., 2012). However, the relationship between presence and the quality of interaction remains un-scrutinised. The present thesis draws on existing criticisms of the notion that media ought to simulate in-person capabilities, and explores such claims through a close study of MRP experiences. Hollan and Stornetta (1992) argue that media for communication can not reach true fidelity to being in-person, and in so far as this is the aim, they will remain inferior to it. Such media put people who rely on them at a disadvantage compared to people who are able to communicate in person. Instead, they suggest that we ought to approach communication technologies as their own distinct media that provide unique affordances which are useful regardless of the degree to which they imitate being in-person. Taking on this approach means moving away from striving to achieve a mediated sense of presence informed by how in-person presence is done, and moving towards understanding mediated communication on its own terms. Based on this, I examine MRP not with the aim of assessing how well it simulates in-person capabilities, but by taking it at face value and seeing what kind of interactions it fosters.

Moreover, I study MRP in this thesis with the aim of understanding the broader implications around mediated communication through robotic, embodied and mobile medium. From an interactional point of view, as a modality, MRP sits somewhere between in-person interactions and traditional video conferencing. The remote user is able to express some non-verbal, embodied cues (such as head turning, leaning closer or looking around) but their movement is still rudimentary and limited. The robot takes up physical, three-dimensional space in the environment, but the remote user's face is still only shown though a two-dimensional screen.

Studying how these features (or limitations) of MRP shape (or hinder) interaction is itself interesting. It can also provide insights into how people do in-person interactions, and what capabilities are relevant in those. Furthermore, the dissonance between the reported benefits of MRP (as will be discussed in the next chapter) and the lack of mainstream use suggests that there are still significant shortfalls in our understanding of embodied mediated presence. This, in conjunction with the limited available reports on the details of real-world deployments, suggests there are unknown implications regarding the reality of use. As such, this thesis is concerned with understanding MRP, as a route towards understanding robot-mediated communication.

To that end, I will be studying MRP using a combination of qualitative research methods, in order to examine the details of use but also the broader implications of real-world deployments. My approach is informed by Phenomenology and EMCA studies, as well as through the hands-on perspective of Action Research. I will be going beyond general claims as to the benefits of MRP, to explore the practical realities of the medium; how it is used within interactions and the implications this has for deploying the technology in organisational settings. Employing concepts and approaches from EMCA and CSCW work, I will be looking at interaction as the efforts made by users on both sides to establish a common understanding of the situation and communicate their perspectives to one another. I will be examining how users act, how they utilise movement in the environment, and how their actions are responded to, in order to achieve shared communicative experiences. In line with that, this thesis will be concerned with whether and how MRP can support participation in hybrid spaces —where participation is understood as the capacity of users to be actively engaged in the mediated activities— and with understanding the broader

implications of having this technology in an organisational environment.

The remainder of this chapter outlines the research areas this thesis is situated in, the research questions my work addresses, the empirical studies that were conducted and the resulting contributions. The chapter ends with a list of the published articles that correspond to studies presented here.

1.1 Research Areas

This thesis sits within and contributes to the fields of Human-Robot Interaction (HRI) and Computer-Supported Cooperative Work (CSCW), with research approaches informed by Phenomenology and Ethnonmethodology and Conversation Analysis's (EMCA) as well as by Deployment studies and Action Research.

- **HRI** Human-Robot Interaction (HRI) is the field of HCI concerned with the investigation of interactions between humans and robots. As such, the present thesis is largely relevant to this field. A significant part of the related literature on Robotic Telepresence, which informed this thesis, is derived from HRI publications (presented in chapter 2).

- **CSCW** Computer-Supported Cooperative Work (CSCW) is also a field of HCI which, as mentioned earlier, explores how technology can support communication and collaboration between people, within small groups or in larger organisational scales. Mobile Robotic Telepresence is one such technology. My thesis, whilst outwardly concerned with a robotic technology, is more acutely focused on how the interaction is conducted *via* it. That is, I am less concerned with how users interact with the robot, and more with how they interact with one

another through it (though inevitably that also means *with* it as well). The terms computer-mediated communication, and more specifically robot-mediated communication (Herring, 2015) can be used to describe this concept. Moreover, this thesis looks at the application of MRP technology within organisational spaces, and its suitability for supporting hybrid work interactions. Although little research within CSCW has examined MRP to-date, I draw on several other concepts from this field to inform my understanding (presented in chapter 2, specifically sections 2.2.3 and 2.2.4).

- **Phenomenology and EMCA** This thesis draws on the fundamental principles of Phenomenology and EMCA with regards to understanding the subjective and inter-subjective nature of interaction. In that regard, the influence of these fields runs throughout the thesis. Moreover, Phenomenology is more distinctly applied as an analytical lens in the study presented in chapter 4, and EMCA drives the analysis of the data in chapters 5 and 6 (this is explained in chapter 3, section 3.2 and section 3.3).

- **Deployment studies and Action Research** Whilst predominately focused on the phenomenological and ethnomethodological explorations of MRP interactions, this thesis also utilises approaches drawn from Deployment studies and Action Research to examine MRP applied in a real-world organisational setting. These approaches are used in the studies presented in chapter 7 and chapter 8 to look at the practical implications of deploying and using MRP in a company office (this is explained in chapter 3, section 3.4).

1.2 Research Questions

As already stated, existing work on MRP applications presents a mixed picture on the usefulness of the medium for hybrid work spaces and is unclear on the practical details of real-world use. In light of that, this thesis seeks to understand the experience of communicating via Mobile Robotic Telepresence (MRP) and uncover how interactions through this medium are conducted in practice. In addition, given the growing interest in enabling hybrid interactions in work and other public spaces, the thesis explores the potential role MRP can have in organisations, and the practical implications of deploying and using MRP in such settings. As such my research addresses the following Research Questions (RQ):

RQ1. How are MRP interactions conducted and experienced in practice?

- RQ1a. How is MRP-mediated telepresence experienced by users?
- RQ1b. How are MRP-mediated interactions socially organised in terms of the interactional methods employed by users?

RQ2. How suitable is MRP technology for supporting hybrid spaces in organisations?

- RQ2a. What are the practical considerations and challenges of deploying MRP technology in an organisational setting?
- RQ2b. How well do MRP systems align with the practices and needs of the organisations' members?

The two questions are related, as the first one is necessary in order to answer the second. Without a concrete understanding of what MRP inter-

actions entail, it would be unsound to draw conclusions as to its value in real-world applications. As will be shown in the Discussion chapter, evaluating the suitability (or unsuitability) of MRP in an organisational setting is made more complete when comparing the characteristics of a setting and its members against the backdrop of a nuanced understanding of the characteristics and affordances of the medium.

1.2.1 RQ1; Understanding MRP experiences and interactions

The first research question, "How are MRP interactions conducted and experienced in practice?", is concerned with understanding the details of what exactly occurs when MRP is used. This follows from a knowledge gap in the existing literature, which mostly presents superficial descriptions of what happens during use. For example, studies report that users felt "present" but do not explain what this presence felt like, or how it was engendered by the social circumstances or the medium's affordances (section 2.2.1). Or, studies report that a remote user was excluded from an activity but not *how* this exclusion came to occur (Stoll et al., 2018; Berisha et al., 2015). To address this, the research question asks to dig in more detail into the subjective and inter-subjective realities of MRP interactions.

I have divided this question into two parts. The first part, "How is MRP-mediated telepresence experienced by users?", focuses on the subjective. It is inspired from the Phenomenological tradition, which focuses on understating reality as it made available in our conscious experience of the world (Merleau-Ponty and Bannan, 1956). The question does not simply ask what the experience of using MRP is like for users, but also more specifically what the *telepresence* experience is like; i.e. what is it like to

be *tele-present*? Given that so much of telepresence literature is centred on creating a "sense of presence" (see section 2.2.1), we ought to consider how this is experienced by users and, taking it a step further, what role it has in supporting mediated interactions.

The second part of the first research question, "How are MRP-mediated interactions socially organised in terms of the interactional methods employed by users?", is then concerned with the inter-subjective. This question is directly drawn from the field of EMCA, as it asks about the things people do when they interact with one another through MRP (the members' methods), and how these work towards creating a shared understanding between the interactants. Once again, very little literature has approached MRP at this level of detail, resulting in a distinct lack of knowledge of the realities of interaction.

These questions are primarily explored in the first three empirical studies of this thesis (chapters 4, 5 and 6), which employ approaches drawn from Phenomenology and EMCA to present a detailed and multifaceted examination of what using MRP is like. The questions are further addressed in the discussion chapter, chapter 9, where insights are collected from the entire thesis to cumulatively build an understanding of MRP as a distinct interaction category.

1.2.2 RQ2: Understanding MRP in organisations

The second research question, "How suitable is MRP technology for supporting hybrid spaces in organisations?", is concerned with if and how the technology, once understood, can be used as a medium for hybrid spaces in organisations. I use the term organisational spaces here, rather than of-

fices, and organisation members rather than workers, as the matters raised through this work can apply not just to the spaces of private companies but also to other work spaces and the public spaces of institutions. The focus on such spaces involves taking into consideration the types of use cases that can exist there, but also the broader demands of such environments. The spaces of organisations are frequented by a wide variety of people who might come into contact with the technology even incidentally (Rosenthal-von der Pütten et al., 2020). In addition, organisations might be liable for meeting certain standards, in terms of the safety and accessibility, of the facilities they provide to their members. Further, there are factors relating to the organisational structure as well as the physical form of the environment that come into play. Assessing the suitability of MRP for organisations then involves also understanding how the features of the technology relate to these types of factors.

As mentioned earlier, MRP manufacturers commonly market their devices for organisational settings. Literature on MRP has looked at some use in organisational settings such as schools, museums and offices (see 2.1.2). With the exception of schools, where matters of infrastructure and resources have been briefly mentioned, there is no reporting or discussion on the practical, organisational realities of deploying such robots. For example, where does the robot sit in the space? How is use allocated? How are users instructed on how to use it? How are activities planned to account for telepresent attendees? The importance of these questions becomes apparent when one gains some familiarity with MRP. The studies that do report on use in organisations, such as offices, often present limited use cases, piloted for the purposes of the study (e.g., Tsui et al., 2011), or used by specific individuals (e.g., Wende et al., 2017) (see section 2.1.2). Therefore little is known about the possibility of making MRPs more widely and freely available in

an organisation as a part of the workspace facilities. Moreover, while the literature talks about the robots giving remote access to the spaces, there is a lack of discussion on what this access means (i.e. What is the value being in that space robotically? How does it fit within the activities or work happening there?). Whilst most studies report a positive reception of the technology, there is little evidence that such devices are successful in the real-world post-adoption. As such, understanding the practical realities of MRP use in organisations involves not just uncovering the details of interaction via the medium but also considerations of how the MRP is more broadly positioned in the space and how it fits within the routine practices and workflows of the people there.

To examine the suitability of MRP for organisational spaces, the second research question consists of two parts. The first, "What are the practical considerations and challenges of deploying MRP technology in an organisational setting?", is concerned with the issues around making the technology available and looks at the work and resources that are required in safely and effectively deploying MRP in an organisational space.

The second part, "How well do MRP systems align with the practices and needs of the organisations' members?", looks at the integration of the technology into the activities commonly practiced in that environment. That is, how well do the ways in which the robots work, as well as their limitations and affordances, align with what is needed and possible in organisational spaces? This question requires understanding MRP as well as understanding how things in a given organisation are done, what capacities and resources its members have and how their work is organised.

These questions are explored in this thesis through a deployment of MRP devices that was conducted at the offices of Microsoft Research in Cam-

bridge. The deployment resulted in a case study which addresses RQ2a by reporting on the work of the deployment (in chapter 7). This is followed by an interview study (in chapter 8) which examined the employee's reasons for not using the robots in that deployment, primarily addressing RQ2b. The questions are further revisited in the discussion chapter in (chapter 9), collating broader insights from the entire thesis and outlining the practical implications of deploying MRP in organisations.

1.3 Empirical work

Limitations to the work due to Covid

Despite the increased interest in remote work technologies due to Covid-19, this work was in fact hindered by the pandemic. In March 2020, during the first year of my PhD, the UK implemented lockdown measures, which persisted in various degrees of strictness until the summer of 2021. Throughout this period, universities and other office spaces were closed, and individuals who could work from home were encouraged to do so. Even after the measures were lifted, social distancing was still encouraged, and many knowledge workers did not immediately return to offices. It may be counter-intuitive to claim that technology for remote work was not useful during a lockdown, but there is actually little use in deploying MRP in an empty office. Consequently, my original plan to deploy MRP in an organisation and conduct in-the-wild observations was delayed until 2022. In the meantime, I relied on alternative research methods that adhered to social distancing guidelines and could be carried out from home. I analyzed data that had been previously collected by other researchers, conducted user interviews online, and studied my own use of the robot. Nonetheless, these approaches

allowed me to collect data from more varied perspectives and thus build a more comprehensive understanding of the medium.

1.3.1 Part 1: Understanding MRP

The empirical work of this thesis can be read as two parts, corresponding to the two research questions. The first part is comprised of three studies (chapters 4, 5 and 6), which focus on understanding the complexity and nuance of MRP experiences and interactions and address the first research question. Given the aforementioned limitations, it was not possible to conduct a single, all encompassing study in-the-wild. However, these three studies, by each capturing different perspectives (remote user/local user), length of use (short-term/long-term) and type of data (user interviews/observations) (see table 1.1), taken together, provide a multifaceted understanding of MRP. The studies were conducted fairly simultaneously and could be read in any order (i.e., the findings of one did not inform the design of the next one). The order in which I present them here is simply meant to aid the reader by beginning with a broader look into the users' experiences and moving towards more the specific details of interaction.

The first study presents interviews of long term users of telepresence (chapter 4). It looks at longitudinal, real-world, familiar use through the accounts of remote users and focuses on examining their experience of presence and participation in the mediated environment. The study contributes to the literature by addressing realistic, mundane and familiar use. 'Mundane' is used here to refer to use that has become part of the users' normal way of life — whilst it may not be daily use, it also does not present a novelty. 'Familiar' refers to use characterised by the competency of someone who has had experience with the technology, and is not just now figuring

out how to use it. The study examines such use through a phenomenological perspective, that looks more critically at the experience of "presence" in the MRP interactions.

The second study is an observation study of remote and local user pairs performing a timed, collaborative task (chapter 5). While limited to looking at short-term use, in an experimental setting, it provides insights into the details of interaction and how it is socially organised in dyadic collaboration. The video data of the interactions is captured from the remote users' point of view but looks at the action unfolding in the mediated environment. This study contributes to the literature on MRP by pointing an EMCA lens on the interactions to show in more detail how users succeed or fail to communicate through the medium. The study also highlights the prominence of soliciting and giving assistance during MRP intentions.

Finally, the third study is also an observation study, but this time through an autobiographical approach (chapter 6). Conducted over 6 months, during the lockdown periods, I examine long-term, familiar use in my own home. Whilst limiting the number of users, this study observes use when mundane familiarity with the medium is reached — complementing the interview data from the first study with video data. The video data of the interactions is captured from cameras placed in the local environment, thus providing a third-person perspective into the action. The autobiographical nature of the study also offers insights into a local user's experiences. As with the second study, this study further employs an EMCA lens to showcase the complexities of interacting through MRP. In addition, taking the medium to the home setting opens up a broader scope of interaction incidents as the users are more motivated to connect and more forgiving of the robot's limitations (section 2.1.2). In addition, as we will also see in the last two studies, MRP use in a workspace setting can turn out to be

Chapter	Focus	Use time	Data
4	Remote user	Long-term	Interview
5	Interaction	Short-term	Observations
6	Local user/Interaction	Long-term	Observations

Table 1.1: The different angles of MRP use captured by the first three studies of this thesis.

limited. Thus, whilst the thesis is concerned with MRP for organisational settings, seeing use in a different domain, where it is less hindered by the practical limitations and work-related pressures, provides an opportunity to see more of the medium in use.

1.3.2 Part 2: MRP in office spaces

The second part of the thesis is comprised of two studies (chapters 7 and 8) which look at the practical application of MRP in organisations and address the second research question. The two studies are derived from an MRP deployment project which took place at the offices of Microsoft Research in Cambridge in the summer of 2021. The first study (fourth overall in this thesis), takes an Action Research approach and describes the process of the robot deployment. In doing so it highlights the unforeseen and unreported considerations of making MRP technology available in an organizational space such as an office. Then, following this deployment, which resulted in low use of the robots, the second study (fifth overall) presents an examination of the reasons behind the non-use of the robots. Through interviews with the office's employees, the study examines the ways in which MPR can fail to align with an organisation's hybrid needs and routine practices.

1.4 Contributions

This thesis builds a comprehensive understanding of the nature of MRP experiences and interactions and examines the implications of deploying such technology in organisations. Through a combination of Phenomenological and EMCA approaches, alongside an Action Research deployment study, this thesis uncovers the practical realities of MRP use. I present an in-depth examination of what happens during use and how it might be experienced. This highlights the roles of embodied movement and how it relates to the physical space as well as what communicative asymmetries exist during interaction, what troubles can occur, and how those issues are handled by users. I then apply this understanding into examining the implications of deploying this technology in an organisational setting and draw out practical considerations for use in such spaces. These include considerations for the work of the deployment itself, as well as for assessing the suitability of the technology against the participation needs and workflows of a given organisational setting. Beyond this, the thesis makes the following contributions:

- **Introducing the use of auto-ethnographic methods in HRI research.** For one of the studies in this thesis (chapter 6), I employ auto-ethnography as my data collection method. Whilst this is an established method in other fields, it is starkly under-utilised in HRI (Chun, 2019). Autoethnography, i.e., studying one's own lived experience, can be hugely beneficial in understanding the use of robotics, given that the inaccessibility of the technology makes it difficult to study its prolonged use by exert, real-world users. HRI researches, however, already have familiarity with the robots in their

institutions. Further, applying an analytical and reflexive approach to auto-ethnography (see 3.3.3), can allow the researcher to leverage their lived experience in a systematic and observable way, to arrive at insights that may not be available through user reports or observations. Through employing this method in my thesis, I demonstrate how it can be used as a way of gaining a deeper understanding of the realities of robot use, and in doing so I bring it into the domain of HRI.

- **Respecifying the focus of telepresence research away from presence and onto participation.** As previously mentioned, a large portion of the work on telepresence operates with a focus on measuring and improving a "sense of presence", or with an assumption that the movement of the medium is an inherent solution to the current shortfalls of hybrid work. Through this thesis, I call for research to move away from this paradigm, and focus more on understanding and designing for meaningful participation. That is, for supporting actions that are relevant in allowing a remote user to take equal part in a hybrid activity. Through exploring how MRP technology is experienced by participants, I argue that presence relates to the remote users' ability to feel that they are "geared into" the action of the activities in the mediated environment. Furthermore, participants' accounts suggest that a sense of presence is felt when remote users are able to take meaningful action and be treated by others as present. Presence is therefore a product, not a cause of successful hybrid participation. Moreover, through studying how MRP is used in practice and examining this against users' reports about their needs and workflows, I argue that whilst the key feature of MRP, embodied movement, is a huge part of MRP interactions and has the capacity to

improve users' autonomy, it does not inherently improve the remote users' participation. As such, I suggest that future research on MRP and broader telepresence technologies take a different approach; one that starts with understanding participation.

- **Identifying the functions and implications of mobility in computer-mediated communication technologies.** The examination of MRP in this thesis provides an understanding of the various ways in which mobility matters in robot-mediated communication technology which were previously overlooked. Beyond the practical affordance of letting the remote user alter their position in space, this thesis identifies mobility as core driver of how MRP use is socially organised. Specifically, the studies in this thesis demonstrate that mobility serves as a form of communication in a manner seamlessly woven into the other features of interaction, that it brings the local environment into relevance, so that features of the environment and the movement it engenders shape the interaction, and lastly, that it produces a distinct dynamic between local and remote users in terms of the power and responsibility held by each side to shape and direct the activity. Also, this thesis shows that the type of movement afforded by existing models is not always relevant. To echo the point of the above contribution, the affordances (including types of movement) ought to match the desired activity. An important point is that mobility matters, not because it provides more 'human-like' affordances (or because it fails to), but because it affects many aspects of interaction in ways that are unique to this medium. These insights should inspire future work on telepresence to study mobility more critically, and also to envision forms of mobility in robotic mediation that appropriately align with the characteristics and demands of

hybrid settings.

1.5 Published works

The empirical work presented in this thesis has been published in peer-reviewed ACM venues. The studies presented in chapters 4, 5, 6 and 8, have each been published as research articles, whilst the deployment case study presented in chapter 7, as been published as an extended abstract. For the work presented in chapters 4, 6 and 8, I was responsible for the study design, data collection, main analysis and write-up of the results. For the work presented in chapter 5, I used data collected in another study and, as such, I was not responsible for the study design and data collection. However, I approached the data from a different perspective than that of the original study, and was responsible for the analysis and write-up presented in this thesis and in the corresponding published paper. Finally, the deployment project presented in chapter 7 was a collaborative effort, in which I was responsible for managing the project, acting as a bridge between the stakeholders and promoting the deployment. Approaching it as an Action Research study, I had the dual role of facilitating the deployment and writing up the findings. Below is the list of the publications.

Empirical work presented in chapter 4 has been published as:

- Andriana Boudouraki, Joel E. Fischer, Stuart Reeves, and Sean Rintel. 2023. "Being in on the Action" in Mobile Robotic Telepresence: Rethinking Presence in Hybrid Participation. In Proceedings of the 2023 ACM/IEEE International Conference on Human-Robot Interaction (HRI '23). Association for Computing Machinery, New York, NY, USA, 63–71.

Empirical work presented in chapter 5 has been published as:

- Andriana Boudouraki, Joel E. Fischer, Stuart Reeves, and Sean Rintel. 2021. "I can't get round": Recruiting Assistance in Mobile Robotic Telepresence. Proc. ACM Hum.-Comput. Interact. 4, CSCW3, Article 248 (December 2020), 21 pages.

Empirical work presented in chapter 6 has been published as:

- Andriana Boudouraki, Stuart Reeves, Joel E Fischer, and Sean Rintel. 2022. Mediated Visits: Longitudinal Domestic Dwelling with Mobile Robotic Telepresence. In Proceedings of the 2022 CHI Conference on Human Factors in Computing Systems (CHI '22). Association for Computing Machinery, New York, NY, USA, Article 251, 1–16.

Empirical work presented in chapter 7 has been published as:

- Andriana Boudouraki, Joel E Fischer, Stuart Reeves, and Sean Rintel. 2023. Your mileage may vary: Case study of a robotic telepresence pilot roll-out for a hybrid knowledge work organisation. In Extended Abstracts of the 2023 CHI Conference on Human Factors in Computing Systems (CHI EA '23). Association for Computing Machinery, New York, NY, USA, Article 408, 1–7.

Empirical work presented in chapter 8 has been published as:

- Andriana Boudouraki, Stuart Reeves, Joel Fischer, and Sean Rintel. 2023. "There is a bit of grace missing": Understanding non-use of

mobile robotic telepresence in a global technology company. In Proceedings of the First International Symposium on Trustworthy Autonomous Systems (TAS '23). Association for Computing Machinery, New York, NY, USA, Article 15, 1–10.

Chapter 2

Literature Review

This chapter presents the relevant background literature that situates this work within the broader research on robotic telepresence, motivates the research questions presented in the previous chapter and supports the approaches and analysis of the following chapters. The first section provides an overview of research on Mobile Robotic Telepresence (MRP), describing the differences between MRP systems, outlining the areas of applications that have been studied and summarising the existing knowledge. The second section presents a series of concepts that are useful for understanding MRP. These include literature on presence, embodied mobility and communicative asymmetries, as well as literature on the introduction of technology in organisations and on technology non-use. A concluding section summarises the identified knowledge gaps and relates them to the research questions presented in the previous chapter.

2.1 MRP systems, applications and research

2.1.1 Systems

This section gives an overview of the state of the art on MRP systems.

The development of MRP systems

The term telepresence as well as the conceptual idea are attributed to Marvin Minsky, who in an article for OMNI described a robot that could be remotely manipulated by an operator so as to provide them the experience of being present in the robot's location (Minsky, 1980; Tsui and Yanco, 2013). He conceptualised the technology as controlled via sensory-motor jackets worn by the remote users so that they could perform work tasks, and he imagined that such technology could match the experience of 'being there' so well as to make the user really feel as if they were there physically. Unlike Minsky's conception, existing telepresence models are usually controlled through simpler interfaces such as a keyboard or gaming controller, and their capabilities are much more rudimentary. Still, the original aim, of recreating 'being there' in as much accuracy as possible, remains an overarching drive.

One of the earliest models that could be considered the ancestor of contemporary MRPs was the PRoPs (Personal Roving Presences) system (Paulos and Canny, 1998). It was remotely controlled via the internet and designed for social interaction — allowing the remote user to move and gesture with a pointer. Another early model was presented by Jouppi in 2002, as a solution to reducing business travel. The design provided a front and a profile view of the remote user's face, and had head tracking to keep the head in

view (even expanding the view to show hand gestures).

Since then, more models have been introduced, each with slightly varied affordances. There have been systems designed for specific purposes (e.g., PEBBLES, Giraff), generic, commercially available models (e.g., Beam, Double, Temi) and many experimental prototypes (e.g., Jones et al., 2020b; Reyes-Cruz et al., 2023). Most models have two-way videoconferencing but some do not (e.g, the QB does not display the remote user's face). Some have a capacity for pointing or gestures —e.g, the MantaroBot has a laser pointer— (Kristoffersson et al., 2013a). In terms of movement, most models move as one piece, with no other degrees of freedom. However, there are tabletop MRPs with "neck turning" movements (Sakashita et al., 2022). In addition, models created for specific applications may have features aimed at supporting given activities (e.g., an MRP for schools has additional displays for students to show their work (Yeung and Fels, 2005). Some models aim for an anthropomorphic appearance (e.g., Saadatian et al., 2013) but the majority do not. Given this variety in models it is important to specify, when talking about MRP, what model is being studied and in what setting. Still, even within this variation most models follow a similar design; a screen, attached to a simple body, attached to wheels.

Generic, commercial MRP

As stated in the introduction, my focus in this thesis is on understanding MRP interactions and their value within organisational settings. Therefore, I will be focusing on the more generic, commercially available types of MRP systems. These models are more purposefully marketed towards organisations. Furthermore, these models present the most basic and archetypal MRP design, which other design improvement efforts usually add to, mak-

ing them a good starting point for close examination.

These types of models include the BeamPro by Suitable Technologies (from now on referred to also as just Beam) and the Double 3 by Double Robotics (from now on also referred to as just Double), which were used by participants in my studies (shown in Figure 2.1). Other similar models include Temi, GoBe and Ohmni. These a simple, non-anthropomorphic appearance without any special features or augmentations (such as pointing or arms). They allow for two-way videoconferencing and full-body movement (the whole robot moves as one piece). The Double 3, which is used in the studies for chapters 6 and 7, also has way-point navigation and adjustable height that can be operated remotely.

Improving MRP

It is worth noting that there are efforts to improve the capabilities of MRP with a variety of augmentations. Some work has looked at the addition of gestures to support non-verbal communication and pointing (Björnfot and Kaptelinin, 2017; Cabibihan et al., 2012; Sirkin et al., 2012). A considerable amount of research explores MRP enhancements through automation, such as semi-autonomous driving assistance (Kiselev et al., 2015a, 2014; Macharet and Florencio, 2012; Takayama et al., 2011; Riano et al., 2011; Kiselev et al., 2015b) but also automatic backtracking for recovering from connection loss (Jouppi et al., 2004), automatic size adjusting (Jouppi and Thomas, 2005), autonomous visual tracking, gaze turning and following local users(Mishra et al., 2019; Riano et al., 2011; Radmard and Croft, 2013; Cosgun et al., 2013; Cheng et al., 2019; Barua et al., 2020), automatic adjustment of interpersonal distance (Yokoyama et al., 2014) and attention guidance to relevant areas (Chandan et al., 2021). Improvements

Figure 2.1: The BeamPro (left) and Double 3 (right) on either side of a person.

are also explored with regards to the interface, including piloting through head movements (Khan et al., 2014; Kuzuoka et al., 2007), augmented reality and live video touch interaction (Mosiello et al., 2013; Yunde et al., 2015), contactless object manipulation Kaptelinin et al. (2017), sound and haptic feedback (Paepcke et al., 2011; Jones et al., 2020a), eye gaze control (Zhang et al., 2019) and brain control (Beraldo et al., 2018) for accessibility purposes. Further, work has looked at changing the size of the robot or the display screen to suit different needs (Gonsher et al., 2022), adding other tools for expression and collaboration, such as an additional screen for local users to interact with or to display work without hiding the remote user's face (Yeung and Fels, 2005) and features for attracting attention and expressing desire to speak (Zhang et al., 2018; Fitter et al., 2019). I mention the above research as an indication that some of the issues discussed later could be addressed with technological solutions, and as well as point out that studying the user experience of MRP could direct such efforts.

2.1.2 The applications of MRP

MRP studies have looked at the use of the technology in a variety of domains, such as offices, conferences, homes and in educational settings. This research is done mostly through observations, user interviews and surveys. Whilst each type of application has some of its own distinct benefits and requirements, MRP also presents some overarching benefits (remote access to spaces, autonomous movement) but also overarching concerns (e.g., considerations of infrastructure, remote user exclusion). Some of these domains are overlapping; for example MRP use in schools could be classified as education but it is also a workplace, and futhermore MRP used to care for older adults in their homes could also fall under healthcare. Use of MRP

in workplaces, such as offices, could inform applications in other organisational settings. Working on a shared project or attending a presentation can happen at an office or in a school. In line with that, whilst the empirical studies of my thesis look specifically at use in the home and office settings, their relevance extends beyond just these two.

MRP in offices

Several studies have explored the use of MRP in offices. Tsui et al. (2011) looked at the use of MRP for meetings and hallway conversations. They found that it made little sense to use the robots for meetings which are mainly static, and that people stopped using the robots when it interfered with accomplishing their work. They suggest that the technology is best suited for hub-spoke configurations: teams mostly working from one location with a one or few employees at a different location. A follow up paper also proposed some design guidelines, including improvements in video and audio quality but also graceful degradation, feedback to the remote user, movement flexibility and support in navigation (Desai et al., 2011). Venolia et al. (2010) looked at the use of an Embodied Social Proxy system (not a robot, but a videoconferencing system dedicated to a remote user, mounted on a cart), to support hub-and-satellite teams (teams with one remote member). They report that the physical representation of the remote colleague helped overcome the barriers of distance, and led to more turn-taking, social engagement and informal interactions. They also found that the system's value depended on the activities and the users' social standing within the organisation. Lee and Takayama's (2011) study reported an overall positive reception of the robots, which were also mostly liked for enabling informal interactions and creating a sense of being in the office. The remote users were perceived as more committed and available,

and were able to achieve feelings of connection with the on-site employees. However, the study also raised the issue of socially acceptable behaviours around the robot (e.g., with regards to touching and personal space). Following that, Takayama and Go's (2012) office deployment study looked at the language and metaphors people use about the robots and remote users. They found that there can be misalignment in whether human or non-human metaphors are used by the remote and local users, which result in interactional failures. More recently, Wende et al. (2017) reported on the deployment of MRP to support a manager connecting with their team from a remote location. The technology was seen as useful in supporting this type of team configuration for both planned and unplanned meetings. Björnfot et al. (2018), also looked at use in offices by non-technical users and reported that users found the experience positive and felt present but also wished for more flexible movement and ways of gauging their appearance in the local environment. These studies suggests that the suitability of MRP in organisations, such as offices, can vary greatly depending on the users, the team configurations and the tasks it is used in. Further, whilst this research has observed the use of MRP in offices, there is a lack of more detailed information on how it is actually used within those reported meetings. Moreover, these studies report on use that has occurred for the purposes of studies and/or by specific users, thereby not addressing the broader organisational context of deploying the technology.

MRP at conferences

Within the domain of work, some studies have looked at MRPs used to remotely attend academic or professional conferences. Neustaedter et al.'s (2016) study of the Beam robots used at Ubicomp/ISWC in 2014 showed that the robots supported attendance and provided a solution for people

with accessibility challenges. Taking the application to a larger scale event (CHI 2016), Rae and Neustaedter (2017), found that the remote users were more socially isolated, using the robots more for seeing the presentations than for socialising. Those users faced challenges around scheduling and navigating the large space as well as some social difficulties. The participating users reported enduring pranks and abuse form the local attendees, such as people stepping on the robot's base to stop it from moving. Comparing the experiences of MRP use at three conferences (ISWC, CSCW and CHI), Neustaedter et al. (2018) further point out some awkwardness in social interactions and suggest that the robots work better for smaller scale events. Nonetheless, Cogburn's (2018) Action Research study with specific focus on users with disabilities, found that while attendance via traditional videoconferencing allowed for clearer view of the slides, the robots allowed flexibility of movement, which enabled informal interaction, touring the venue and seeing booths. An interesting case was also presented by Lueg et al. (2020), of a whole classroom using a single MRP to attend a conference as a group, which calls for more consideration of multiple users. Finally, James et al. (2019) presented an autobiographical case study of a keynote speaker at a conference having a positive experience of mediated presence, explored through the lens of positioning theory. These studies indicate that context matters highly, with smaller, controlled social spaces having greater success. These studies also raise questions as to the causes and characteristics of these emergent impolite and socially awkward social interactions.

MRP at home

Regarding use within the home, a widely researched application is for supporting older adults. Studies find that MRPs can be valuable for family,

caregivers and nurses to visit older adults in their homes (or assisted living facilities) to provide them with more frequent care as well as the opportunities to socialise (Tsai et al., 2007; Cesta et al., 2013; González-Jiménez et al., 2012; Hiyama et al., 2017; Hung et al., 2022; Niemelä et al., 2021). They can also provide patients with dementia in nursing homes with more social connection with their families (Moyle et al., 2019, 2020). A lot of research has stemmed from the EU project ExCITE, which tested the use of the Giraff system by elderly people and their caregivers and looked at what specific design features make the system suitable for that setting (Orlandini et al., 2016). ExCITE studies included acceptance and attitude evaluations (Kristoffersson et al., 2011b), the training and experience of presence of caregivers (Kristoffersson et al., 2011a) and examined the movement of the robot in the space of elderly people's homes (Kristoffersson et al., 2011a). Studies in this domain point out that features of homes, such as carpets and stairs can be a challenge for robot navigation (Labonte et al., 2006; Michaud et al., 2010). Users in this setting have also voiced concerns over the invasion of privacy, as the remote user can "enter" the home without the local users having the option to answer or decline the call (Niemelä et al., 2021; Orlandini et al., 2016).

Research into MRP use in homes has also looked at how the technology can be used to support long-distance relationships. Yang et al.'s (2017) study of two long-distance couples who used MRP to communicate for a month found that the autonomy of the remote user helped foster a sense of connection. They suggest that the movement of the MRP offered a more enriched use of body language during interactions that allowed for more meaningful and serious interactions between the couples. The movement also allowed the remote user to have new perspectives into the life of their partner, resulting in them having more conversations. They also point at

the quality of unpredictability, which is not typically part of video calling systems. In that study, this unpredictability made interactions seem more real; as if the other person is just appearing from the other room. Notably, this was flagged as a concern by elderly users above, but it is seen here as a positive in this context. In a subsequent study with seven couples Yang and Neustaedter (2018), further found that the MRP was used for participating in everyday activities, creating a sense of sharing a home, fostering connectedness with the friends and family of the partner, helping each other with tasks, and experiencing companionship. Subsequently, Yang and Neustaedter (2020b) looked at the use of an MRP coupled with control over smart home devices (television, lights, vacuum, printer) in the local user's home. A three-month autobiographical study of the first author and her partner, shows that such a system enhanced the remote users' ability to help, participate in tasks and have a sense of sharing the home.

Looking at interaction between couples outside of the house, Yang et al. (2018) also studied the use of MRP for shopping together over distance. This study reported on the playfulness with which the mobile medium allowed participants to interact. Remote users felt better able to capture their partners' attention and contribute to the activity than if they were confined to a tablet handled by their partner. They also found that disparity in the abilities (the local user moved faster, more flexibly, had better vision and was not dependent on an internet connection) led to the local users feeling responsible for helping their partners, even if the remote users did not feel that they needed the help. Overall studies of MRP use between partners report more positive experiences, suggesting perhaps that limitations are easier to overlook —similarly to how couples deal with distortion in video calls (Rintel, 2013) Thus, use of MRP between partners or family

appears to open up an opportunity for different types of interactions (more playful and conducive to spontaneity). Studying MRP in this setting then can allow for an examination of how this medium fosters interactions in a more free and uninterrupted way.

MRP in education

Education is one of the most explored domains for robotic telepresence research. MRP has been found to help homebound or hospitalised children maintain their school life, alleviate the stress of being removed from their peers and be active participants in the classroom (Newhart et al., 2016; Soares et al., 2017; Fels et al., 2001; Schmucker et al., 2020; Bloss, 2011; Cha et al., 2017; Ahumada-Newhart and Olson, 2019; Perifanou et al., 2022; Jakonen and Jauni, 2021). Darling-Aduana and Heinrich (2020) reported that use of MRP gave college students more access to advanced courses and that students attending through MRP had higher scores. Beyond use by students, MRP has also been useful in bringing specialist staff to remote or underserved schools, such as instructors for hands-on, STEM subjects (Okundaye et al., 2019, 2020), and psychologists to assist in problem-solving consultations and interventions (Fischer et al., 2019).

However, Elmimouni et al. (2023) also question the suitability of MRP for education, noting numerous limitations in students' ability to perceive their environment and express themselves. There are also concerns over how remote users are perceived and treated by their peers. Berisha et al. (2015) looking at students preparing presentations, where one member was participating through MRP, observed that the students arranged their work according to the robots capabilities and did "work" to assist the remote user (e.g., emailing material that was hard to see through the camera, checking

if they could hear and see them). Still, the remote user reported feeling ignored and separate from the group while the local users also reported preferring interactions with the other physically present members. This echoes concerns over the inclusivity and acceptance of remote users, raised in studies of collaboration through MRP, which show that remote users can be perceived as less trustworthy or be less included compared to other local peers (Tsui et al., 2011; Stoll et al., 2018; Rae et al., 2012).

In addition, while MRP is well received in schools, Lister (2020) also mention the burden of work and need for infrastructure to support the technology. Similar to points raised about use in homes, sufficient classroom space and stable internet connection are necessary for MRP to be a viable option. In addition, the teachers need to create appropriate lesson plans that encompass the multiple modalities and help involve the remote user in the activities. Whilst this has not been brought up in the other organisational settings, we can imagine that the introduction of the medium might present similar challenges for an office admin, a team manager or conference organiser, who will need to re-structure their space and activities accordingly. Research in education then suggests that despite some benefits of the technology their are under-studied issues regarding the organisational support required for effective MRP use.

2.1.3 Concerns about MRP

Despite reporting a generally positive reception by users, studies of MRP also point at several forms of limitations. I summarise these here in order to contextualise the research questions and the findings presented later in the thesis.

MRP may not ultimately be the hybrid solution it is presented as. The existing literature identifies several issues related to technical limitations of the medium. MRP relies on internet connection to work, which limits where it can be used and common network latencies frequently disrupt interactions (Jahromi et al., 2020; Desai et al., 2011; Perifanou et al., 2022). Also, despite being a mobile medium, most robots only turn as one piece and their movement can be clumsy and inflexible (Björnfot et al., 2018; Tsui and Yanco, 2013). In addition, driving the robot is found by several studies to be burdensome and takes the remote user's attention away from the interaction (Tsui et al., 2011; Cogburn, 2018). Perception is also brought up as a limitation in several papers, noting that it can be difficult for users to hear and be aware of what is happening in the local environment (Tsui and Yanco, 2013; Elmimouni et al., 2023). Related to this, is that remote users do not have clear awareness of their own appearance in the local environment; they are not able to tell if they are being too loud or if the robot is causing obstructions to local users (Björnfot et al., 2018; Neustaedter et al., 2016; Lee and Takayama, 2011; Kristoffersson et al., 2011b). Studies even suggest that when the robot causes a disruption (e.g., loud noise, bumping against furniture), local users may attribute blame to the remote user and form a negative opinion of them (Lee and Takayama, 2011; van Houwelingen-Snippe et al., 2017). Whilst the literature mentions these issues, little is said about exactly how these technical limitations impact the ways in which social interactions are achieved through this medium.

Beyond the technical limitations of the devices, there are also social and interactional concerns raised about MRP. Aforementioned studies in offices, conferences and education show that users (local and remote) might struggle to agree on appropriate social norms —e.g., how to handle lower-

ing the robot's volume, how to gracefully enter and end interactions (Lee and Takayama, 2011; Neustaedter et al., 2018; Rae and Neustaedter, 2017; Muratbekova-Touron and Leon, 2023)— and sometimes behaviours can resemble bullying —e.g., local users intentionally blocking a robot's path (Neustaedter et al., 2018)— and exclusion —e.g., local users rating the remote user as less trustworthy (Stoll et al., 2018; Berisha et al., 2015)—. Beyond Takayama and Go (2012), who posit that part of the issue lies in remote and local users having mismatched orientations to the MRP as a person or as a robot, there are no studies looking deeper into the causes of this phenomenon.

Finally, it is worth restating that, as some studies in education and older adult care point out, the use of MRP requires certain resources; a proper environment, infrastructure and support (Lister, 2020; Michaud et al., 2010). That is to say, the use of MRP is not as simple as just purchasing and turning on the device. As I discuss later in this thesis, it requires considerable work to make it work, the practical implications of which are not well explored or even acknowledged.

2.2 Key concepts in understanding the use of MRP

This section includes a series of research areas that are relevant for understanding MRP and its role in organisations. First, I present literature on the concept of presence and discuss how the subject has been approached in existing MRP research. Following that, I present research on the role of embodied mobility in computer-mediated and robot-mediated interaction. After that, I present literature on communicative asymmetries and meth-

ods of addressing them, such as compensatory work and assistance. Then, I provide an overview of workplace studies concerned with the introduction of new technologies, touching on the concepts of group dynamics and workflows. Finally, I present literature on the subject of non-use.

2.2.1 Presence

Presence in HCI

Feeling present is considered an important element of mediated interaction experiences (e.g., Fitter et al., 2020; Bagherzadhalimi and Di Maria, 2015). Literature on presence contains a variety of definitions and approaches (Riva et al., 2011), often relating the individual to their sense of closeness with the environment and others.

In Virtual Reality research, presence has been thought of as a "sense of being there" or even as "the perceptual illusion of nonmediation" (Lombard and Ditton, 1997; Riva et al., 2014). Studies have measured this by asking participants if they experienced the virtual world as more real than the real world, and if they experienced the virtual world as a place that is visited or just looked at (Slater et al., 1994; Freeman et al., 2001). Such measures follow a rather ambitious definition of presence as a fully immersive experience. Further, these measures can only assess a medium with regards to the fidelity with which it presents the mediated environment, and are therefore of limited in use in further understanding a medium as it is used in practice.

It is also possible to view presence from perspectives more in line with examining interaction. For example, Giannachi (2012), draws on Ingold's notion of the environment as a relationship between it and living organisms

and sees presence as a process. She proposes the notion of environmental presence, arguing that the environment (the circumstances surrounding an occurrence) is constructed from the presence: the presence is what is other to the subject, which surrounds the subject. Ingold also uses "dwelling" to describe "being" as the intransitive act of producing our lives together as we live them—contrasted, for example, to the transitive act of "building" which has a planned, imagined outcome and which is often used to distinguish humans from other animals (Ingold, 2011). O'Hara et al. (2014) drew on this notion of "dwelling" in their study of Whatsapp conversations to show how people create a sense of togetherness (co-presence) through instant messaging. Licoppe (2004) also spoke of 'connected presence' as the awareness of others through access to them via instant messaging. Being present in that sense, is an outcome of peoples' actions, and the ways in which those actions are accessed and perceived by others. In line with that, Goffman et al. (1978) though not specifically talking about presence, describes the presentation of the self through a dramaturgical lens, as an act people make to influence the 'definition of the situation'. This involves projecting an interpretation of what is going which makes them be perceived by others in a certain, desired way. Being present then through that lens, depends on how well a person can act as if they are present. These approaches see presence not as a psychological state of experiencing the world in an immersive way, but rather, as something that happens when we interact with the world. Presence then can be understood as an experience closely tied to our capacity for action and interaction with others and with our environments.

Presence in MRP

In studying presence in MRP then, this thesis will be drawing on these interaction-driven approaches and examining presence as it emerges within interactions and as a result of the users capacities to act. However, this examination is also informed by existing literature that has looked at presence in MRP.

While many MRP studies report that users feel present through the medium (Schouten et al., 2022), and some specifically look at ways of increasing sense of presence through MRP (e.g., Rae et al., 2014; Choi and Kwak, 2017), few examine what the experience of presence means more closely. Generally, studies have used questionnaires to measure presence, with questions such as "I felt that x and I were in the same place" (Kristoffersson et al., 2013b; Tsui et al., 2012; Rae et al., 2014). Some have also related presence to accuracy of perceiving the environment. For example, studying MRP in museums, Tsui et al. (2015), measured presence in the environment by asking participants to describe the exhibits they visited and noting the accuracy as well as vividness of their memories. Rae et al.'s (2014) study asked participants to mark on the map to indicate where they thought the activity took place. These studies then conceptualise presence as a measure of how much the user perceived the mediated environment as if they were really there.

Exploring presence in more detail, Kristoffersson et al. (2011a) surveyed healthcare personnel who used MRP in training sessions. Participants were asked to rate their experience in terms of how remote, emotional or personal it felt and whether they felt as if they were in the same place as the person and objects they interacted with. Their results suggest that users had a high experience of presence in terms of feeling sociable, lively and re-

sponsive, but did not feel as if they were really in the mediated environment and could touch the objects in it.

In another study, Kaptelinin et al. (2021) used questionnaire and interviews in conjunction with experimental tasks and found a statistically significant negative correlation between subjective ratings of presence and stops and bumps made whilst driving. In the interviews, participants also reported that they had a better experience and felt more present as they got better at using the robot over time, and that their sense of presence diminished when they bumped into obstacles. Notably participants stated feeling present both in the local and remote environments. There were also participants who reported not feeling present and comparing the experience to a playing a game. In light of these findings, the authors reference activity theory, which states that as skills develop they move from conscious actions to automatic. This allows for those actions to fade in the background of the location, and allow the person to feel engaged in other more complex or meaningful tasks, thus feeling more present.

Taking a different approach, through a self-study, James et al. (2019) looked at the experience of 'social presence' —the sense of the presence of other social actors— through the lens of positioning theory. They suggest that their experience of presence was achieved because of the remote and local users orienting towards the remote user as a person (as opposed to as a robot). In a similar line, van Houwelingen-Snippe et al. (2017) take the approach of evaluating presence by comparing behaviours to robots and to humans (i.e. if a local user feels that their personal space is violated by the MRP coming too close, then they must experience the remote person as present). Then looking at presence in the educational context, De Jong's (2021) phenomenological study used Whiteside's 2015 Social Presence Model, looking at the synchronization of interactions between

the instructor, students, content, and technology.

These studies seem to suggest that presence through MRP is unlikely to resemble the true sense 'being there'. Further the experience of presence may related to ease of use of the medium as well as with how remote users are treated by local users. However, apart from James et al.'s (2019) study, this phenomenon has not been studied in the real-world, in long-term, familiar use nor has it been examined in relations to the users' actions during interaction. In this thesis, I draw on the perspectives presented above, and attempt to understand presence as it arises during interaction. As the section below, which is about mobility, outlines, being able to move and act intentionally and autonomously may be a key element of being present in robot-mediated interaction.

2.2.2 Embodied mobility

Embodied cues and movement are an inherent part of human communication and interaction (Streeck and Jordan, 2009; Cook and Tanenhaus, 2009), and are performed by users even in non-embodied media —(e.g., gesturing and showing things on video (Heath and Luff, 1991). Still, what distinguishes MRP from traditional video conferencing is that it allows for certain forms of movement in three-dimensional space (moving and rotating the robotic device). Jakonen and Jauni's (2021) studies of visibility checks in classrooms, suggests that users can leverage the MRP's movement affordances as methods of communicating in their interactions (such as to communicate that the user is seeing, and what they are seeing).

Moreover, studies find that remote users tend to drive MRP devices in ways the mirror in-person behaviours. Pathi et al. (2019) find that remote

users tend to intuitively align with Kendon's F-formations and would welcome further support that would help them do that more easily. Similarly, van Oosterhout and Visser, (2008) found that MRP users respected Hall's personal space zone, and Shen et al. (2018) found that users exhibited proxemics behaviours in line with their in-person cultural norms (with US users stopping the MRP further away from local users compared to Indian users). Kristoffersson et al. (2013b) also found that there was higher comprehension of the interaction when the remote users formed the expected F-formations.

Other studies also suggest that controlled movement is generally a desirable aspect of MRP. Nakanishi et al. (2008) comparing several modes: fixed, rotatable, moveable backwards and forwards but un-rotate-able, completely movable, and automatic movement. They found that users felt more present in the user-controlled, movable robot conditions. Similarly, Rae et al. (2014) found that using a mobile robot —compared to a stationary one— in collaborative tasks led to increased feelings of presence, especially in tasks with higher mobility requirements. It did, however, also lead to decreased task performance. Another study by Choi et al. (2017), comparing no-movement, random movement and mimicry during a conversation, found that male participants and participants scoring high in self-monitoring preferred the movement conditions.

Movement is clearly important. However, as pointed out in the previous section, the movement of MRPs tends to be slow, burdensome and limited compared to in-person movement. Highlighting the movement limitations of MRP, and drawing comparisons from disability, Elmimouni et al. (2023), suggest that telepresence robots could be viewed as "differently-abled". It has indeed been further argued at that robots more broadly can be viewed as disabled (Williams, 2023). How then, is this reconciled with with fact

the users want and expect to move as when using MRP? To understand this, I draw on the ethnomethodological and autobiographic work of Robillard (1999), who wrote about how his experiences with paralysis shaped all facets of his interactions. For example, he describes situations where people's refusal to communicate with him using methods available to him left him unable to take part in discussions about the treatment of his own body. Even in family events, where he was among people familiar with his limitations and who were motivated to used his communication methods, he could be left outside of common activities. Such interactions bear some likeness —although of course of a much more trivial nature— to incidents reported by users at conferences (e.g., Rae and Neustaedter, 2017) and to descriptions made by participants in chapter 4, of being limited in their capacity to act and being treated by locals in inappropriate ways. Through his analysis, Robillard proposes that the disabled body is itself an interactional category, used and read as the text of the social structure it is involved in. Taking this way of examination on board, the presented thesis also sees the MRP as an interactional category, differently-abled in its mobility and other affordances, and attempts to identify its specific capabilities and way of interacting and being interacted with.

2.2.3 Communicative asymmetries

Another key aspect of mediated interactions, and one which relates to a user's limitations and how they become relevant in interaction is the concept of communicative asymmetries. As work in CSCW literature generally shows, participation through mediated communication may often be asymmetrical (e.g. Neumayr et al., 2022; Saatçi et al., 2020). Heath and Luff (1992) argued that video-mediated communication has asymmetries, which

do not exist in face-to-face interactions nor in other media such as phone calls, and which influence the users' visual and vocal conduct. In face-to-face interaction, there is symmetry as both parties have access to the same visual information and accurate knowledge of each other's perspectives. In telephone calls, while there is no access to visual information there is also no assumption of it being relevant to the communication. However, Heath and Luff demonstrate that in video-mediated communication people use visual information, such as embodied cues, in ways seemingly relevant to the interaction, but the access to these cues is asymmetrical for each side. For example, one person might turn their gaze on the other in order to get their attention, but the other person does not experience being looked at, because the direction of gaze is fragmented by the video cameras. They find that visual cues such as gesture and gaze, which people use to coordinate the interaction, are weakened in their effectiveness by the medium. Further, in face-to-face interaction participants know how their actions appear and therefore can adjust them effectively, but participants in video-mediated communication do not. For example, when looking at the other person does not result in getting their attention, the user does not know how they appear to the other person in order to adjust their strategy effectively. Luff et al. (2003) use the term "fractured ecologies" to describe the mismatch in access to the scene in which the action is taking place. Voida et al. (2008) outlined in more detail different types of asymmetries that can be observed in mediated spaces. These can include asymmetries of media (referring to the different kind of content shared by individuals), fidelity (amount of detail), participation, engagement, benefit and place (local and cultural norms). Saatçi et al. (2019) also point out that hybrid video meetings contain not only technical asymmetries but also socio-cultural asymmetries in language, culture, and digital literacy causing remote participants to feel isolated and less able to participate.

It has further been suggested that the disruption that occurs due to asymmetries requires that the users do 'compensation work'. Hindmarsh et al. (1998) for example, found that participants in a virtual environment compensated for their fragmented views by verbally expressing their actions and difficulties. Karsenty (1999) looked at help dialogues of experts helping novices edit a text in conditions where participants interacted side-by-side, remotely but with shared screen and remotely without screen (audio-only). While the pairs were able to communicate in all conditions, it was found that the novices adapted their requests to include the necessary information and the experts adapted their interpretive strategies based on the available content.

Asymmetries and the corresponding compensation work have not yet been explored in studies of MRP. In the data presented in this thesis however, it quickly becomes evident that the capabilities of remote and local users are unequal and that there is a gap in how much of this is understood by the users. This is explored in chapters 5 and 8 and revisited in the discussion chapter (chapter 9).

Assistance

Given these asymmetries and aforementioned limitations of MRP, assistance is a very prominent part of the experience of use. Indeed, it was brought up by users and evidenced in the interaction data in all the studies presented in the following chapters of this thesis. The limited affordances of the MRP mean that the remote user is inherently at a disadvantage in terms of their capabilities and freedom of movement compared to the local people. As such they might not only rely on compensatory work from their local peers (such as checking if they can hear) but also require assistance for the

normal, natural troubles (Garfinkel and Bittner, 1967) of MRP-mediated existence. These can include navigating tight environments, opening doors or recovering from lost connection.

When I examine this in more detail in chapter 5, I draw on Kendrick and Drew's (2016) empirically-based conceptualisation of assistance recruitment. Kendrick and Drew examine the linguistic and embodied actions people used in face-to-face interactions which signaled trouble and led to the provision of assistance to resolve that trouble. They then present those as categories on a continuum, ranging from most explicit to most implicit. On the most explicit side are requests, where the Self verbally expresses what kind of assistance they need from the Other and directly asks them to provide it ("Could you give me X?"). Notably, the Self here does not have to describe the nature of their trouble, just what they need in order to resolve it. Next are reports of trouble, where the Self states what kind of trouble they are facing but does not specify a solution nor obliges the Other to provide one ("I can't do X"). Then there are trouble alerts, in which the Self expresses that they are having trouble but does not communicate what the trouble is. These mostly consist of cries, interjections and imprecations ("Uh oh"). After that, are embodied displays of trouble, where the body movements of the Self indicate to the Other that they are having trouble. For example, the act of hovering one's hands over an area might inform the Other that the Self is looking for something. Finally, at the most implicit end of the continuum, they position projectable troubles, which are situations where the Self does not do anything to express a need for assistance but the Other is able to anticipate it from the circumstances. They point out that only requests create an obligation to help and necessarily initiate an adjacency pair in which assistance is a relevant response. All other actions simply create an opportunity for the Other to help.

Beyond this work, other research on requests, looking at what strategies and level of directness are used when requests are made, finds more mitigating explanations and prefacing used when speakers feel less entitled to make the request (Heinemann, 2006; Curl and Drew, 2008). These explanations build on politeness theory (Brown et al., 1987), which argues that in the interest of maintaining the face of the Self and the Other, speakers want to avoid imposing an obligation to help onto the Other. As such they may employ strategies of indirectness or provide redress to justify the imposition. Therefore, the way in which someone solicits assistance may be indicative of how comfortable they are in interjecting this entitlement to assistance onto their peers. The study presented in chapter 5, specifically examines how this may be done through MRP.

2.2.4 Introducing technology in organisations

As noted earlier, MRP has not seen a level of mainstream success yet, despite the reported benefits. Some reports from applications in schools have pointed out at infrastructural factors hindering use, but these have not been explored in broader organisational settings. The present thesis explores these factors through a deployment of MRP in an office setting, presented in chapters 7 and 8, which draws parallels to work presented in this section.

Introducing a new technology in an organisation or workplace can take considerable planning and effort. Various works explore effective methods of implementing such change and training staff to use and incorporate new systems into their routines (e.g., Mirvis et al., 1991; Marler et al., 2006). When it comes to technology for mediated-communication, there is the added dimension of social dynamics. As Ellis et al. (1991) point out,

groupware, i.e., technologies for supporting communication and collaboration between small groups, need to consider not just the human-computer interaction, but also interaction between users.

The work of using technology

Grudin's (1994b) work, specifically discusses the reasons for the failure of groupware in organisations. One issue he raises is the *disparity between the work and benefit* for the different people involved in use. For a groupware system to work, it requires that more than one person uses it. In addition it may require that the different users have to invest different amounts of work into using it, which may not correspond with the benefits it gives them (e.g., keeping a calendar up-to date to allow the team administrator to schedule meetings). In the case of MRP, local users need to provide various forms of assistance to the remote user, with the remote users seemingly being the main receiver of the benefits. Grudin and Palen (1995) further pointed to the importance of social dynamics and organisational realities as important factors, as well as the ease of use and appropriate infrastructure.

Critical Mass

Another consideration is that of critical mass. For a groupware system to be worth using, it must be used by a certain amount of users (e.g., sending a meeting invite only makes sense if others also use their e-calendars) (Grudin, 1994b). Reaching critical mass relies on making the system easily accessible and desirable at the start, but may also rely on a group of early-adopters who are willing to accept the costs of use and demonstrate its benefits to others (Markus, 1987). Again with MRP, it may be appear that the technology only provides value to the remote users (it gives them

access to the local environment), and therefore as long as remote users are willing to use it, adoption should be successful. However, MRP is a medium for communication. Both the local and remote sides of the interaction are referred to as users because both are engaged in interacting with and through the robot. After all if a remote uses logs into the MRP but finds no-one on the other end willing to interact with and support them, nor any activities to do, they might understandably see no value in using it. As MRP requires engagement from both sides, introducing the technology must consider the broader social dynamics of prospective users.

An example to look at is the introduction of Instant Messaging (IM) in workplaces, which also initially encountered challenges in adoption (Herbsleb et al., 2001; Handel and Herbsleb, 2002; Hansen and Damm, 2002; Cameron and Webster, 2005; Nardi et al., 2000, e.g.,). For instance, Herbsleb et al.'s (2001) deployment case study saw improved adoption when taking group dynamics and critical mass into account. Their initial roll out of IM provided each user with one hour of training and support, only to find 10% sustained adoption after two months. One of the reasons, among software problems and privacy concerns, was that by training individuals rather than teams they did not show people how to collaborate meaningfully with the tool. Indeed, where it was adopted, it was a by all or substantial part of a team. People did not individually find each other and chat, but used it if it was a part of their team's way of communicating. In a second phase, they trained teams together (and fixed certain system issues), which then lead to more use (20-35%). Of course, the critical mass of users varies with each technology.

Workflows

The field of CSCW has sought to examine the implementation of technology within work through research on *workflows* (Luff et al., 2000). *Workflows* research usually aims to build models that showcase the different steps of work, the information and tools the workers are attending to at different steps and how they interact with one another (e.g., Ellis and Nutt, 1993; Georgakopoulos et al., 1995). However, as Nutt (1996) outlines, this approach has also been criticised by proponents of the *situated work* perspective (e.g., Suchman, 1987), which argue for letting people decide how to use tools as opposed to prescribing use to them. This has resulted in more flexible approaches also taking into account the situated nature of work (Luff et al., 2000). Bowers et al. (1995) noted that workflows research is done mostly in office contexts where the workflow technology was embedded in work software and the work itself. In response, they sought to examine the workflow of a print shop, where the work done did not in itself involve the use of software. They found that introducing a workflow system in a workplace, even if it is external to the tools of the work and does not directly constrain or impose on the work, can lead to disruption if it is not made to fit in with the existing conduct of the work. The implementation of MRP in organisations then, whether it is used as a tool for the work itself or as a peripheral supporting medium, needs to take into consideration how work is done at that setting and ensure it fits within those practices. This is explored in the final study of this thesis (chapter 8), which examines accounts for the non-use of the technology at a deployment site.

2.2.5 Non-use

Given that MRP is not a widely used technology, another angle for examining it is through the lens of non-use (rather than use). Research has reported on some unsuccessful deployments in offices and conferences (e.g., Rae and Neustaedter, 2017; Tsui et al., 2011) but lacks a deeper discussion on the broader reluctance to embrace this technology. HCI scholars such as Baumer et al. (2015a) point out that there is great value in studying technology non-use.

Literature on non-use highlights that there is more to how a person relates to technology beyond whether they use it or not; as Satchell and Dourish (2009) write, "experience may be intimately shaped by information technology outside or beyond specific circumstances of 'use' ".

In addition, use and non-use are not necessarily distinct categories, but may be more accurately described as a spectrum (Baumer et al., 2015a; Lenhart and Horrigan, 2003). Use may be selective (e.g., in Amish communities) or continually negotiated (e.g., adjusting privacy settings, limiting the use of recording devices in public (Baumer et al., 2015a). These examples also show that people's use/non-use, is often not an individual behavior but a response to others and society. In designing and deploying new technology we need to allow for use to take such forms, rather than expect total adoption. Moreover this points to the importance of seeing the broader picture of people's lives and how technology fits in them.

Researchers in the area point out that there are many different reasons and ways of using or not-using technology. Satchell and Dourish (2009) identify several different forms of non-use such as lagging adoption, active resistance, disenchantment, disenfranchisement and disinterest. Explorations

into Facebook non-use also find a variety of motivations for resisting, ending or just limiting use (e.g., privacy, productivity and addiction concerns), but also that people might relapse into use in order to stay socially connected (Baumer et al., 2013, 2015b). Looking at Internet of Things technology, Garg (2019) find that people limited use when they could not understand the devices' behaviours or did not feel in control, and that they abandoned use altogether if they felt overwhelmed with information or disappointed by the technology. Li et al. (2019) also find non-use commonly done as a protest against use of data for profit. Another case presented by Treem (2014) is the non-use of media in organisations as a way of avoiding accountability by not making actions visible.

Literature on systems failure within organisations also highlights the socially constructed nature of technology deployments; i.e. rather than the technology logically determining usage, views on its success and failure will vary among social groups (Bartis and Mitev, 2008). Selwyn (2003) also argues against the commonplace view that people don't use technology simply because they don't have access to it, but will use it if we make it accessible enough. This implies that using technology is assumed to be a logical choice (over not using it). As such, he warns against pathologising non-use and seeing the non-user as someone who needs to be helped into becoming a user. This approach takes for granted that technology adoption inherently brings improvements into people's lives, and falls into the trap of technological determinism (Drew, 2016). Instead we should acknowledge the individuals' agency in their non-use and consider whether the technology actually addresses their needs and make 'sense' in their lives (Chatman, 1996). Drawing on Orlikowski (1992), Selwyn (2003) proposes viewing technology as a 'medium of human action', i.e., something people appropriate through assigning shared meaning to it, in order to achieve

certain tasks.

Whilst non-use may appear to be the absence of use, the above studies also show that the phenomenon is certainly possible to study. The studies commonly employ self-report methods, such as surveys (e.g., Garg, 2019) and interviews (e.g., Baumer et al., 2013) to understand the behaviors and motivations of non-users. However, as Treem (2014) point out, non-use is also study-able through observational methods (e.g., through ethnomethodology), as the things people do instead of use or in order to do non-use —e.g., using other technology to facilitate non use, such as adblockers (Li et al., 2019).

Given this, we might also ask how to correctly measure the impact and the success or failure of technology (especially technology that is used infrequently, selectively or reluctantly). While some systems have clear quantitative criteria for what constitutes success, such as speed and accuracy, others do not. Gaver et al. (2009) argue that for a system aimed at supporting locally situated meaning making (and MRP may be considered one such system), more open ended and qualitative criteria are more apt. Taking this onboard, the final study of this thesis, chapter 8 examines the absence of MRP use through looking at the broader social environment of the non-users the aiming to identify the ways in which MRP fits or fails to support it.

2.3 Summary and relevance

Whilst a considerable body of research on MRP already exists, there is little in-depth examination into how MRP interactions are conducted, and the broader reality of successfully deploying the technology is overlooked.

The lack of detailed information about MRP interactions in the literature has motivated the first research question of this thesis: *How are MRP interactions conducted and experienced in practice?* While a few studies have begun to examine some of the details of interaction —e.g., looking at doing visibility checks (Jakonen and Jauni, 2021; Due, 2021), or proxemics (Lei et al., 2019)—, a complete image of what happens during use is still missing. What exactly occurs during an interaction breakdown at a conference that enables bullying behaviors towards the remote users? How do partners engender a sense of togetherness?

I begin unpacking this by first asking:*How is MRP-mediated telepresence experienced by users?* A lot of MRP studies talk about users feeling 'present' through the medium but avoid explaining what this means and why it matters. And while some studies explore it in some detail, they adopt a definition of presence that is more suitable to testing the audio-visual fidelity of the medium, rather than the quality of interpersonal interaction. To address this, I approach the question with a Phenomenological sensitivity, trying the understand what the mediated world is in the subjective, conscious experience of the user, and with an understanding of presence as it relates to the user's ability to engage with the world and those in it.

The existing literature is also lacking information on what exactly happens when remote and local users interact. *How are MRP-mediated interactions socially organised in terms of the interactional methods employed by users?* The literature outlined above gives some indication to things that might happen (awkward social encounters, exclusion). However, these are broad descriptions of events. The literature does not account for how such incidents unfold in the moment. In addition, the types of encounters that get reported tend to be negative experiences. Yet, most studies report that

users like the robots. Are there succesfull interactions, and if so what do they look like? Getting a close look at successful and unsuccessful encounters could reveal which aspects of the medium work and which do not, and how such technology might be better utilized.

The second research question is driven by the growing interest in technology for supporting hybrid work and hybrid events: *How suitable is MRP technology for supporting hybrid spaces in organisations?* As shown in this chapter, there is significant body of work in CSCW that critically examines the use of technology in organisations. However, research on MRP has omitted talking about how the technology fits within broader organisational factors, beyond some studies pointing out the need for appropriate infrastructure and support.

This has motivated the first part of the research question: *What are the practical considerations and challenges of deploying MRP technology in an organisational setting?* Drawing on Grudin's arguments about the work required to make groupware successful in an organisation, I report on the reality of making MRP devices part of a work place and identify factors the need to be taken into account during a deployment.

Beyond introducing the technology, a successful application is also about use post-adoption. For MRP, there is little work on the long term, day-to-day reality of use. Wende et al.(2017) report a successful long-term implementation, but do not reveal what this entails. Tsui et al. (2011) on the other hand report that teams abandoned the robots once they were too busy. This has motivated the second part of this, which asks about the fitness of MRP within the lives of prospective users: *How well do MRP systems align with the practices and needs of the organisations' members?* This is inspired by research on workflows, which shows that technology

must not disrupt the flow of work routines, as well as by the non-use literature, which advocates for examining technology from a holistic point of view, stepping back from the moment of use/non-use to understand the broader reality of people's lives and how technology becomes a part of it.

Chapter 3

Research approach and methodology

This chapter describes the research approach I adopted during this PhD work and the practical research methods I used. As noted in the introduction, this thesis is concerned with understanding how the medium of Mobile Robotic Telepresence (MRP) is used and experienced in interactions in practice, and whether it can present a viable solution for hybrid participation in organisational spaces. To that end I employ a combination of approaches and forms of data, so as to capture the realities of MRP at different levels of detail and engage with the subject from multiple perspectives.

The first section of this chapter gives an overview of how different research approaches were used in order to respond to the research questions. Then the subsequent sections explain how each approach was used in more detail. The second section explains the approach of phenomenology and describes how it was employed in the first study with the use of semi-structured interviews and thematic analysis. The third section explains EMCA and

how it informed the second and third studies in order to analyse video data of interactions. The fourth section explains the approach taken for the second part of the thesis, which looked at the practical application of MRP through a deployment study drawing on an Action Research approach. Finally, in the fifth section I provide a reflexive positionality statement, clarifying some contextual details of the research and my position as the researcher who has been conducting it.

3.1 Approaches for understanding MRP reality

3.1.1 The relationship between the two research questions

As stated in the previous chapters, this thesis engages with two research questions: 1) How are MRP interactions conducted and experienced in practice? and 2) How suitable is MRP technology for supporting hybrid spaces in organisations? The first question is concerned with understanding MRP as a medium for interaction, whilst the second is concerned with understanding what role MRP can have in organisations. That is, the first question asks for an in-depth understanding of the medium itself, whilst the second asks about its contextual application. In essence, both questions are concerned with the practical realities of MRP but at different levels. The first looks at the level of what is happening during an interaction; e.g., how is the user experiencing seeing, hearing and being seen in the mediated environment, what actions are they employing to communicate and how are those actions responded to? Then, the second question takes a

step back, to look at the organisational level; e.g., how is the provision of MRP in an organisation's building managed, what information needs to be communicated to people in that space and what activities taking place in that space can be done remotely through MRP? As such, both questions look at real-world use, and essentially ask about what is done in practice, in and around MRP use. Nonetheless, the different levels at which the questions engage place them in a sequential order; insights from exploring the first question will feed into engaging with second one. Understanding the realities of MRP at the interaction level will help make sense of how the technology is handled and used at the organisation. For example: the studies corresponding to the first question reveal the ways in which MRP incorporates movement in physical space in interaction as well as the interactional work involved in achieving participation through MPR. Then, the deployment studies reveal what kinds of spaces exist and how they are used in an organisation, as well as how members lives are structured and whether they can accommodate the necessary work of using MRP. Consolidating both approaches leads to a clearer understanding of why MPR might or might not be viable or appropriate for use in an organisation. As such, alongside the broader understanding of what the organisational space entails, drawing out the implications of using MRP in an organisation benefits from having a foundational understanding of how MPR is used in interaction — thereby understanding what hybrid needs it can fulfil as well as what demands it makes of users and others in that space.

3.1.2 Combining approaches for different levels of analysis

As stated above, both research questions of this thesis look at the practical realities of MRP use. This invites a common general approach to the research. As a whole, my work in answering these questions is broadly informed by Ethnomethodology (see section 3.3). That is, I approach the study of MRP with the aim of understanding the social organisation of practices around it. Whether this is during a lab study or a real-world deployment, I endeavour to reveal the ways in which the technology is embedded into ongoing social life, (or the ways in which it is avoided) whilst taking into account its situated nature.

At the same time, the aim of this thesis is to both examine MRP use in-depth and also to understand its big-picture, real-world implications. Responding to this necessitated some variation on the more specific approaches employed at each study. The research questions ask about the reality of MRP use at three different levels of detail: the personal experience, the interpersonal interaction, and the organisational considerations. To capture information relevant to understanding each level, I have used different data collection methods (interviews, video, autoethnography, deployment) and employed various analytical lenses (phenomenology, EMCA, action research).

The first research question is *How are MRP interactions conducted and experienced in practice?* It focuses on MRP during interaction. This involves understanding both sides of use (remote and local) as ultimately it is a medium for communication between people. As explained in the previous chapter, a lot of studies make claims about the experience of presence during use. Examining this in more detail requires tapping into the the

subjective, first-person way that being telepresent is experienced by users. Then, understanding interaction, of course, also requires looking at the details of how an inter-subjective reality emerges between the users. For a comprehensive understanding of MRP interaction I wanted to look at both task-driven, structured interactions as well as more unstructured moments, in order to the capture a wider range what activities that the medium can (or can not) support. Finally, to arrive at a complete understanding, I also wished to look at familiar use —use by people who have interacted via MRP enough to be competent users and unfazed by its novelty. Such data was limited in the previous literature. In order to realistically cover all these angles, I had to use various forms of data and employ slightly different approaches in analysing it.

To understand MRP use at the level of subjective experience, responding the first part of the research question, *How is MRP-mediated telepresence experienced by users?*, I drew on the phenomenological tradition. This approach is embedded into the phrasing of the question itself, as phenomenology in social sciences is concerned with the understanding subjective experience. To understand how users experience being telepresent, I collected first person narrative accounts through semi-structured interviews with long term users of MRP. Whilst I used MRP myself, recruiting other users allowed me to collect more perspectives and enrich my understanding. Using semi-structured interviews as the data collection method allowed participants to freely describe their experiences as they were available in their memories of use. With minimal prompting, I used the descriptive accounts of interactions that the users provided in order to understand how those interactions were experienced —what aspects of the interaction were salient, what stood out as particularly good or bad, how they describe moments of feeling 'present'. The participants' words provide an insight into their

experiences that would not be captured by simply observing use. On a practical side, given that the few long-term users of MRP that I could find mostly lived abroad, interviewing them was also easier than meeting them in-person for any other form of data collection. Of course, in an approach that involves making deductions the lived experience of others from their accounts, there is a high degree of interpretation. To that end, I am using Reflexive Thematic Analysis, as a procedure that allows me to remain visible as an active producer of the analysis. Using phenomenology as a lens for making sense of the data further allowed me to hone my focus by looking at just what exists in the conscious awareness of the users, without relying on pre-existing assumptions. As such, the findings I present towards answering this question are simply themes I identified from my position as someone with some personal experience with MPR, guided by the principles of phenomenology.

Moving from subjective experience, towards understanding the reality of interaction between users, required looking at what actually occurs during use and unpacking the things users do to achieve shared moments. To that end, I looked at video data of MRP use from two different sources. First, I looked at video data of local and remote user pairs engaged in a short, timed, collaborative task. This allowed me to look at goal-driven interactions, where the motivation for users to cooperate engendered communicative work towards reaching an inter-subjective understanding of the situation. Then, to look at interactions with familiar use, I captured video-data from a longitudinal, autobiographical study in which I used the robot myself. In the first case, I was able to look at use in a structured way — seeing multiple people doing the same task and seeing what methods they employ to resolve the communicative limitations of the medium and achieve their shared goal. These participants were first time users of MRP

(an unavoidable limitation given the lack of mainstream use). In the second case, I looked at use that was unrestricted by time limits or task demands — this allowed me to also see a different side of use, one between participants who are simply motivated so connect and spend time together. The use of autobiographical data —with myself as one of the participants— allowed me to a) get a first hand understanding of being a local user of MRP, but also b) to allow the participants to develop familiarity with the medium and embed it into their daily lives so as to see mundane, expert use without any novelty effects or behaviours resulting from not knowing how to use the device. As such the two types of video data allowed me to cover a greater breadth of forms of interaction. The focus here was to understand users' behaviours within the context of each setting in terms of what impact those behaviours had in the interaction and how they were responded to by the other person. The analysis of this data is informed by EMCA which, as explained later (see section 3.3), lends itself suitably to the study of interaction as it is a tradition primarily concerned with how people build shared, inter-subjective meaning by the methods they employ to communicate with one another.

The second research question then is concerned with taking this understanding of MRP exploring what implications this has in terms of using MRP in organisational spaces. Answering this question requires moving beyond the minute details of interaction to explore the reality of the broader context. Here I am not simply trying to identify use cases for MRP —this has been done in previous literature (e.g., Tsui et al., 2011)— but trying to understand what it means to have MRP technology in an organisation in terms of the day to day management of the technology and the ways it can become part of the tools of hybrid work. To that end, I turn towards deployment studies and Action Research; traditions which focus on hands-

on approaches that involve introducing the technology to the a real-world setting and learning through doing. That is, I examine the application of MRP in organisational settings by conducting a deployment in an office space, reflecting on the process, identifying the organisational matters that arise and seeing how the technology is responded based on the features and practices of that context.

The first part of this research question focuses on the practical considerations of making the technology available in the organisational setting. To address this question I draw on Action Research to understand those considerations based on the work conducted during the deployment (by me and other colleagues) and the challenges that spontaneously arose during it. I document what happens during the deployment, and reflect on the implications filtered through other CSCW literature (see section 2.1.2) and my own understanding of MRP. As such, in using this approach, I learn about the practices of deploying and using MRP in that space by embedding myself in this process. This was a suitable approach to answering this question, as certain issues could not have been anticipated or predicted by just looking at interaction; the realities of the deployment were only made known when naturally encountered during the process.

The second part of the this research question is then concerned with understanding the fitness of the technology within the organisational setting. Answering this benefited from a strong understanding of how MRP is used —what kinds of interactions is it conducive to? what kinds of limitations does it have? what work is required in using it? — but also requires an understanding of the reality of life in a given setting — how are activities at that organisation arranged? what do people do there? how do they communicate and what about? For this part I needed understand what peoples' daily realities consisted of at the deployment site. As I did not

have the time and resources to conduct an in-depth ethnography about what it is like being a worker at that office, my next best option was to ask the workers. As such, I conducted another interview study, this time with office employees, including both people who used the deployed robots and people who did not. Whilst the first interview study was concerned with understanding the first-person, subjective, lived experience of use, my focus in this case was to understand the characteristics and structure of office life and the ways those related to whether the participants were able or interested in using MRP as a medium for participating in that setting. Therefore, instead of using phenomenology as my analytical lens, the analysis of this data draws more on CSCW studies around the introduction of groupware technology at work, and on non-use literature around examining technology in the broader context of people's communities and social needs.

3.2 Phenomenology as a research approach

3.2.1 Phenomenology for understanding mediated presence and co-presence

Phenomenology, as used in social sciences, focuses on understanding the subjective lived experiences of individuals. Grounded in the philosophical tradition of Edmund Husserl, phenomenology aims to explore the essence and meaning of (usually mundane) human experiences through detailed examination of conscious phenomena (Zahavi, 2003). This involves examining information available to us based on our accountable or observable conscious experiences of the world. This approach encourages researchers to conduct in-depth interviews, observations, and other qualitative methods

to capture the rich and nuanced aspects of everyday, human experiences. Furthermore, analysis through the phenomenological lens requires suspending pre-existing, common sense assumptions about the subject matter (a practice also referred to as bracketing) and attempting to understand it from the bottom up based the observable phenomena or accounts of the participants (Winograd et al., 1986).

Within HCI, phenomenology has been used to gain a more in-depth and holistic understanding of human-computer interaction processes. Winograd et al. (1986) propose using Heidegger's phenomenology to make sense of people's interactions with technology. For example, Heidegger's concept of *Dasein* (Being-in-the-world) posits that our *Being* and the world we interact with can not be examined separately. It follows from that, that objects in the world do not inherently poses meaning or properties; those arise through social interactions. Therefore those interactions should the starting point of study. In line with this, Heidegger's concept of *readiness-to-hand* can be used to understand how the technology is experienced as it is used. Objects in the world (e.g., a hammer or a keyboard), whilst in use, are not always part of our conscious experience. They are in the background, *ready-to-hand* but practically invisible. They only enter conscious experience (become *present-at-hand*) when there is a *breakdown* that brings them into our awareness and makes their properties relevant to our consideration (Heidegger, 1967). Beyond phenomenology as a philosophical lens, post-phenomenology, as developed by Don Idhe, argues for basing analysis on empirical work, whilst maintaining the phenomenological view that technological artifacts should not be studied separately from the human experience (Ihde, 1986).

The influence of phenomenology runs throughout the work I present in this thesis. The importance of understanding the subjective experience of

being telepresent has informed most of my analyses to varying degrees. However, this approach is more prominently used in the first study (chapter 4), where I have asked users of MRP to provide detailed descriptions of their experiences, from their point of view (akin to personal stories of how they remember their interactions). I then analysed these accounts, drawing on Heidegger's phenomenological concept of *readiness-to-hand*, to examine how remote users experience the mediated environment through the medium of MRP, where and how the properties of the medium enter the users' foreground and how this becomes relevant in their capacity to interact with their local peers.

The phenomenological lens is less central but still present in the subsequent two studies (chapters 5 and 6). Whilst looking at interactions between two people (with the focus shifting from the subjective on to the inter-subjective), the individual users' perspectives into the experience are also considered. In my second study (chapter 5), where the data is captured from the remote users' screen, literally showing us their window into the interaction, the analysis unavoidably considers the users' access to the activity (their experience of perception), as it is made available through the affordances of the robot. This then influences how the user builds a common ground understanding with their partner and as such how the interaction unfolds. In the third study (chapter 6), where there is more emphasis on the local user and her environment, phenomenology informs the consideration of her experiences of co-presence and dwelling (relevant literature in section 2.2.1).

Beyond employing phenomenology to understand the subjective experience of robotic telepresence, the principles of phenomenology have directly influenced the ethnomethodologicaly-informed approach used in this thesis as well. When developing his ethnomethodological approach to sociological

research, Garfinkel drew on phenomenological ideas in response to Parson's use of "objective" principles for analysing the actors' subjective points of view (Vom Lehn, 2014). Following Schutz's phenomenology, Garfinkel instead argued that an observer ought to analyse the actor's behaviour by considering the actor's competencies and knowledge — and not through third-person evaluations about the rationality of that actor's decision. Further drawing on Schutz, he advocated for the idea that objects should be examined as they are perceived and constituted by given actors, in given situations, within the knowledge those actors have — allowing for a plurality of interpretations of the world (Vom Lehn, 2014). Following these ideas, social order is developed in-the-moment, in a dynamic manner, where actions in social situations are ways actors employ to build coherent experiences.

3.2.2 Phenomenology through semi-structured interviews

As noted above, phenomenology is most directly employed in the first study of this thesis (chapter 4), which uses semi-structured interviews to understand the users' experiences of telepresence. Semi-structured interviews are also used in the final study (chapter 8) following a similar process but without the phenomenological lens playing as strong a role in informing the analysis due to a different research focus.

Semi-structured interviews combine open-ended questions with a flexible interview format. Doing this entails having a script with some pre-planned questions and notes on how to probe the participant to talk about certain subjects, but also allowing them to influence the direction of the conversation to some degree. The participants could elaborate more or less on the questions that seem more relevant to them, as well as bring up their

own stories and concerns. The approach was suitable because it enabled me to elicit accounts that were relevant to my research interests, but also honour the unique perspectives of each participant and allow for more exploratory, inductive research, driven by what people wanted to talk about. This aligned with the principles of phenomenology which emphasizes the active role of individuals in constructing their own realities and meanings. Further, the flexible nature of the semi-structured interviews allowed for rich and nuanced data collection, enabling me to capture the complexity and variability of individuals' experiences.

Reflexive Thematic Analysis for Interview Data

To analyse the transcripts of data collected through the interviews I used the process of Reflexive Thematic Analysis (Braun and Clarke, 2006). Thematic Analysis (TA) is a research method employed to analyze qualitative data in a systematic and rigorous manner so as to identify patterns of meaning (themes). Doing this analysis involves close reading of the data, coding data items with meaningful labels and grouping those labels into themes that represent the data set, in an iterative process (Braun and Clarke, 2006).

Reflexive in TA refers to the importance of the researcher's subjectivity and reflexivity throughout the analytical process. As Braun and Clarke often point out, the themes do not passively emerge from the data, but rather, the researchers have an active role in interpreting the participants' words and selecting what is important (2006). In deciding what constitutes a theme, the researcher may decide, not only on what is more prevalent in the data but also on what is interesting and relevant to the research question.

This process can be applied within a variety of research approaches and frameworks. Braun and Clarke broadly divide the analytical approaches into inductive (data-driven) and deductive (theory-driven) 2006. Keeping with the exploratory motivation of my research and the aim to understand subjective experiences, I have conducted my analysis in a mostly inductive manner, but using phenomenology as the lens through which I make sense of the accounts. That is, the themes are not shaped by phenomenological concepts but by what the participants make relevant. However, the content of the themes is interpreted with that sensitivity, using phenomenology to examine what the accounts reveal about the experience of telepresence.

3.3 Ethnomethodology and Conversation Analysis for understanding mediated interaction

3.3.1 The EMCA approach to interaction

Ethnomethodology and Conversation Analysis (EMCA) is an approach to studying human everyday experiences and interactions by close examination of the things people do and how those are responded to. The aim of EMCA is to uncover how interaction is socially organised and shared meaning is produced (Boden, 1990). *Ethnomethodology* (EM) was developed as an analytic approach by Harold Garfinkel and refers to the study of the practical and mundane details of daily life in order to understand how people make sense of the world around them and learn to act in it (Garfinkel, 1967). As described above, this approach is closely linked to phenomenology, as it is also underpinned by the notion that reality is con-

structed through people's interactions with the world. *Conversation Analysis* (CA) more specifically refers to the examination of conversation (or talk-in-interaction) Sacks (1992). This includes looking at what people say but also how it is said, as well as other actions such as pauses, interruptions and embodied cues. Through this approach, social organisation can be understood as comprised of various interactional features, such as turn-taking, the sequential orders in which things are done, opening and closings, breakdowns and repairs etc. These phenomena are seen as routine parts of everyday life, but no less worthy of study.

While EM and CA are distinct approaches, they are often used together (e.g., Reeves et al., 2017). EMCA studies draw insights from both approaches to understand how the things people do in interaction (the members' methods) are operationalised in the moment, to accomplish different goals, to build a common ground understanding and an intersubjective, shared reality. As such, EMCA is an analytical approach inherently concerned with the details of interaction, which lends itself suitably to the study of MRP-mediated interactions.

EMCA research can take many different forms. I predominantly draw on EMCA when unpacking MRP-mediated interactions in the second and third studies presented in this thesis (chapters 5 and 6), by breaking down observable fragments of interaction into the members' methods used to accomplish those shared moments. My second study, presented in chapter 5, takes a more CA-oriented frame, as I select specific phenomena in interaction and unpack the turn-by-turn actions made by participants to determine how they are constructed. The third study, presented in chapter 6, is more EM-oriented as I draw heavily on the notion of 'being a member' of the phenomenon I study. I used the robot myself, and then used video data to show what that membership entailed.

Beyond that, I employ an EMCA-sensitivity throughout the work in making sense of what my data reveals about what users actually do on/with MRP. The work of EMCA scholars, such as Garfinkel and Sacks (Sacks, 1984; Garfinkel, 1967), is used to inform my understanding of how users of MRP enact their presence in hybrid environments. As discussed in section 2.2.1, presence is a common object of MRP research, but rarely looked it with a focus on interaction. EMCA is concerned with the ways in which a participant is "geared into" the unfolding "action" of interaction. In that sense, presence can be examined as the capacity to be part of the activity. Moreover, EMCA approaches peoples' being "ordinary" and "normal" as something they actively do, as *interactional, shared accomplishments* (Sacks, 1984). This lens is used in the analysis of users' accounts of presence in the study presented in chapter 4, as well as in the discussion, to further examine how an MRP user is able to participate in an interaction as just another, 'ordinary', present member. Taking these ideas on board, I aim to understand the things users do (or are able or unable to do) when using MRP so as to be *normal* (in the sense of being treated as present, participating people) within the mediated environment.

In the next two subsections I provide more details into how the studies in chapters 5 and 6 were conducted.

3.3.2 EMCA and lab observations

The second study of this thesis (5) is based on video recordings of MRP interactions (Heath et al., 2010). With the pandemic preventing me from collecting original data, I relied on existing data from a previous study. That data was recorded during an experimental design study testing a telepresence robot prototype with an overlaid augmented reality avatar system

(Jones et al., 2020b, 2021). The videos I used are derived from the control condition data of that study, in which the participants used the standard Beam telepresence system instead of the prototype for comparison. The procedure of that experiment, and the details of the activities performed by the participants in the videos are outlined in Chapter 5, section 5.1.2.

Despite the 'unnatural' circumstances of the lab study, the interactions that unfold in the videos constitute instances of social interaction through the medium of robotic telepresence and as such lend themselves to examination. That is, whilst the interactions happened within the context of an experiment, I study them not through an experimental lens (i.e., measuring the effects of controlled variables), but as field observations within a qualitative framework. In the spirit of EMCA, all actions are actions; the features of interaction are present and accountable in all life situations regardless of the reasons why an interaction occurred. As Rooksby (2013) highlights, laboratory observations need not be entirely discarded for lacking ecological validity; Suchman's (1987) ground-braking studies indeed were also lab studies, but often treated as studies *in-the-wild*.

As such, I analyse this data through the traditional EMCA approach of unpacking interaction fragments and identifying the members' methods. With a specific interest in how the participants in that study organise themselves so as to collaborate effectively, I look at where and how *breakdowns* occur in the interactions and how they are addressed.

3.3.3 EMCA and Auto-ethnography

For the third study (chapter 6), I brought an MRP into my home and studied my own use of it. The decision to pursue this method of research

was in part influenced by the lockdown conditions that were in place at the time. I had conducted interviews with long-term users of MRP, and studied short-term use interactions, but I still wanted to observe and examine real-world, long-term use. Coming into contact with other people was restricted and, for the foreseeable future, social interactions at the office had been rendered irrelevant as everyone worked from home. As such, using the robot myself fulfilled the real-world need of enabling me to have visitors in my home whilst respecting health regulations. At the same time, exploring MRP as a medium for connecting with family and my long-distance partner, presented an opportunity to study MRP from a different perspective. This use case lead to more prolonged use for intimate interactions, unhindered by technical limitations or other workplace-related interruptions. It provided a kind so of data that I might not have been able to observe in an organisational setting, giving me a richer data-set of how the medium can be used in interaction. Moreover, in conducting a longitudinal (six month) study, I was able to move beyond novelty and explore the production of habituated, mundane and familiar forms of MRP use. In addition, beyond these practical benefits, conducting a study with myself as the user provided me with valuable personal insight into the experience and a lived understanding of what MRP interactions can entail.

This form of research could be characterised as an autobiographical ethnography, auto-ethnography or (the less loaded term) self-study. Whilst infrequent and occasionally contested (Holt, 2003), such autobiographical methods have been effectively employed in various ways, including in MRP research (Yang and Neustaedter, 2020a; James et al., 2019). Yang and Neustaedter explored using a telepresence robot to allow the first author to maintain presence in the home she shared with her partner whilst living away for three months. James et al. looked at how the first author used a

telepresence robot to attend and present a keynote speech at an academic conference. From an HCI perspective, it could be argued that that having the researcher in the position of the subject can help uncover more detailed, subtle understandings of a system that user studies could not have yielded (Neustaedter and Sengers, 2012). Other examples of auto-ethnographic work, where the value of the personal insight is evident include Sudnow's explorations on learning to play the piano and Atari's Breakout (Sudnow, 1983; Sudnow and Dreyfus, 2001), Hayano's dive into the world of poker (Hayano, 1983) or Ellis' evocative examination of loss (Ellis, 1993).

Although there is not one agreed upon way of doing such research (Wall, 2006), they all explicitly acknowledge the researcher as active participator in the production of knowledge. Ethnomethodology-oriented researchers would point out that there is nothing special in doing that because a researcher is always taking part in the construction of the reality they study (Livingston, 1987). Such methods disrupt the taken-for-granted, positivist assumption that research can be separate from the researcher (Ellingson and Ellis, 2008). Whether in controlled experiments, or in the field observations, the researcher like any other person involved in research partakes in the social construction of meaning.

Whilst not following a prescribed methodology, Anderson's (2006) framework of analytic autoethnography can be used to explain the work I did. Analytic autoethnography, according to Anderson, as opposed to the more literary and evocative autoethnography such as Ellis's, is characterized by: (1) complete member researcher (CMR) status, (2) analytic reflexivity, (3) narrative visibility of the researcher's self, (4) dialogue with informants beyond the self, and (5) commitment to theoretical analysis. With regards to membership, my status as a user and person highly interested in MRP technology developed through my research (see 3.5). Analytic reflexivity,

engaging in reflection of my own impact in the research and of the research on me, is something I attempt to do throughout the work. Through doing this, and writing openly in the first-person I also remain visible and active as a researcher in this text. Dialogue with informants beyond myself is accomplished through the rest of this thesis, particularly in the interview studies (chapters 4 and 8). Finally, commitment to theoretical analysis refers to using "data-transcending practices that are directed toward theoretical development", which I do through an EMCA-oriented analysis of video data.

As in the previous study, I unpack the data using an EMCA approach. This serves to ensure a level of analytical rigour, differentiating the work from personal anecdotes, and to make the work open to critique and evaluation by other readers. Whilst my personal insights influence my interpretation of the data (as is the case in all research), the analysis relies on data captured on video, presented though images and transcripts, and analyzed through an established approach that allows other readers to evaluate my interpretations. Through the analysis, I take exemplary fragments of the interactions and examine the members methods (mine and my visitors') in collaboratively building a shared understandings our situation. Specifically, I highlight the members' embodied and verbal actions and how those are operationalized within the interaction to create a sense of being together.

3.4 Learning through deployment and Action Research

Following the first three exploratory studies, the second part of this thesis looks at the practical implementation of MRP in organisational settings.

Chapter 7 presents a case study of the practical process of deploying MRP in an office, and chapter 8 presents an interview study examining the non-use of MRP in that office after the deployment. The research method employed can be characterised as a hybrid of a field deployment study and an Action Research case study, as the focus and purpose of the project evolved during the process.

Deployments or field studies, in HCI, refer to the introduction of a new technological system or artifact in a real world setting, for the purpose of collecting empirical data on its use in a naturalistic way (Hayes, 2014, p. 119). This allows us to evaluate the impact of the technology on the prospective users and within the intended context of use. To understand the potential value and role of MRP in organisations, I co-operated with Microsoft Research, to conduct a deployment of telepresence robots in their offices in Cambridge, with the aim of collecting interviews and observational data of how their employees used the robots. During the process of the deployment, it became apparent that conducting the deployment, making the robots available for use in the office, so as to explore their use, was going require significant time and effort. This shifted the focus of the project to also include an exploration into the practical work of deploying the telepresence robots (chapter 7). In addition, use of the robots at that site was significantly lower than what was anticipated. Instead of collecting data on use, the deployment was concluded with a follow-up interview study aimed at understanding the reasons for the non-use of the robots (chapter 8).

The study into the practical work of deploying the MRP took on an approach that can be characterised as Action Research. Credited to psychologist Kurt Lewin, Action Research refers to research conducted by engaging in a community and doing real-world practical work to address a problem

(Lewin, 1946). In HCI, this can be done within the frame of deployment projects, working with the people whose problems the project is seeking to solve (Hayes, 2014). With an inherent focus on contextual factors, Action Research may not be highly generalisable, but can generate knowledge that can be extrapolated to inform future projects. The researcher in Action Research may be seen as a "friendly outsider", who works alongside the prospective users rather than maintaining an "objective distance". Moreover they may be a"facilitator" that enables other collaborators of the project to come together, and should prioritise addressing the needs of the users over the research (Hayes, 2014).

The approach used in this case is more akin to "practical" Action Research, as opposed to technical or emancipatory Action Research. Practical Action Research tends take a dynamic approach, evolving as the understanding of the research problem is explored, and aims to arrive at a mutual understanding and solution for all the stakeholders (Masters, 1995). Indeed, in managing the deployment of the robots I found myself in the position of having to coordinate several different stakeholders (such as the maintenance staff, IT and business administrators) as well as having to engage prospective users, advocate for the potential benefits of the technology and provide everyone with appropriate information on how to use and handle the robots in a safe and effective way. Given that there is little published information on conducting such work, it was also highly iterative. I used documents and notes created during the process as well as information I gathered informally by interacting with the stakeholders to write a case study that collated all these insights into what considerations are involved in making robots available for users in an organisational space.

As noted above, following the deployment, use of the robots was not sufficient to provide data on use of MRP in the office setting. Instead, a

follow-up study was held, to understand the reasons for the non-use of the technology. This was done through the use of semi-structured interviews, analysed through Reflexive Thematic Analysis, similar to the process described for the first study (see 3.2.2). The analysis in this case was still inductive (data-driven), as the aim to was give a voice to the participants and understand non-use from their perspective, and with consideration of their needs. However, instead of using the phenomenological lens to interpret the data I drew on concepts from literature on workflows (see 2.2.4) and non-use (see 2.2.5) as the study was concerned less with their subjective experience and more with the realities of their work lives.

3.5 Reflexivity and researcher positionality

The approach I take in this research acknowledges the importance of context and researcher subjectivity. Phenomena are understood as products of the circumstances in which they arise — where phenomena includes the content of the research and the production of the research. Knowing what those circumstances are is then vital to understanding the research. Therefore, *reflexivity* is an important element of the process; that is, reflecting on the researcher's role in the knowledge production. As Lynch (2000) highlights, the purpose and meaning of *reflexivity* varies across methodologies. Ethnomethodology, according to Lynch, sees reflexivity as an 'unavoidable feature of the way actions are performed, made sense of and incorporated into social'. Practices are by their very nature embodied and situated, and therefore inherently reflexive. Still, to make those practices (including the production of research) interpret-able, I clarify my context and positionality in as far is it relates to the research and my ability to do it.

As noted in the introduction, the studies were conducted during and in the aftermath of the Covid-19 pandemic. Whilst the current events brought remote working into broader relevance, MRP technology, paradoxically, became less useful as a medium for work. One would only want to be (tele)present in the office if their colleagues were there, and at the time everyone worked from home and offices were empty. This was the context in which I interviewed long-term users of MRP for the first study in this thesis (chapter 4). These people had been proponents of MRP prior to the pandemic, during times when remote working required effort, technological resources and advocacy. They now found all their colleagues brought to similar positions as them, in terms of access and motivation to use online media, and the need for MRP was essentially eliminated.

At the same time, the need for social connection was heightened as people spent more time in their homes and unable to meet with family and friends outside of their households. This is the context in which I conducted my self-study of MRP use in the home setting (chapter 6). Specifically, as a foreign student living alone in Nottingham (UK), I was physically cut-off from my family and friends. MRP then presented a natural solution to my situation as it allowed my mother and my partner, who lived in other cities, to 'visit' me and interact with me in my space. Still, I was fortunate to be able to borrow a device for the six-month period of the study. My home also allowed for its use, as it was all on a single level, without any floor obstacles, and with good internet coverage throughout.

Regarding my position in relation to researching MRP: as my research progressed, I became increasingly more familiar with the medium and my competency in interpreting the data also evolved. During the the first year, I studied the existing literature, and had a trial test of a Beam robot. By the second year of my PhD, I had been working on the first two studies

of this thesis, having observed videos of use and spoken to several long term users about their experiences. At that time, the university acquired a Double robot and I was able gain a first-hand experience. I tested it as a remote user by driving it around the university, and later brought it into my own home for a period of six months, where I experienced it as a local user (chapter 6). In my third year, I had the opportunity to co-lead the robot deployment project at Microsoft Research (chapter 7). This hands-on involvement gave me experience of the practical aspects of providing and maintaining robots in an office setting, and allowed me to gain an understanding of some organisational realities as well. Through these experiences, and through my evolving competence at conducting HCI research, I have developed a deep, multifaceted understanding of the intricacies of using the medium, which I draw on in my analyses and discussion of the research presented here. My understanding of MRP has evolved from a rather simplistic view of seeing the medium as an augmentation on static videoconferencing, towards a more critical stance on what a meaningful solution would entail. This work has helped me develop a deeper appreciation for the complexities and troubles of mediated interaction. I have thus filtered and made sense of my data through my own expanding understanding of MRP.

Chapter 4

The phenomenology of being robotically telepresent: an interview study

To begin building an understanding of Mobile Robotic Telepresence(MRP), this chapter presents an interview study with real-world, long term users of the technology, which provide detailed descriptions of their experiences. Thus, the exploration begins by laying a foundation of phenomena that occur during MPR use, as those are experienced by the users. By closely studying these detailed, first-person accounts, this study presents a close examination of what being telepresent looks and feels like. As outlined in the literature review (chapter 2), users in most studies respond positively to the technology and report feeling present (e.g., Björnfot et al., 2018; Schouten et al., 2022). Some studies, looking more specifically at presence on MRP further, suggest that the experience of presence through the medium relates to competence with driving the robot Kaptelinin et al.; Kaptelinin et al., and on users aligning on desirable orientations towards

the user and robot James et al. (2019). Still, there is limited in-depth understating into *how presence is experienced* and its role in those mediated interactions. Beyond this examination, this study also addresses a gap in the literature by looking into the day-to-day, competent, mundane use of MRP. As outlined in chapter 3, section 3.2, the data was gathered using semi-structured interviews and was analysed through the process of reflexive thematic analysis, drawing on a phenomenological understanding of subjective experience, in order to reveal insights on the experience of robotic telepresence. The study presents two themes which showcase the mundane experiences of being in the world as a robot; 1) The troubles of perceiving and doing as a robot, and 2) Being present and ordinary as a robot. As such this study contributes to the thesis by highlighting the key elements of the users' experiences of robotic telepresence, including being limited in one's capacities and standing out, as well as by examining how presence is achieved and what role it plays in the interactions.

4.1 Study Approach

This study focuses on primarily addressing the first research question: *How are MRP interactions conducted and experienced in practice?* More specifically the first part of that question: *How is robot-mediated telepresence experienced by users?* To that end, I spoke with familiar, expert users of the technology through semi-structured interviews. This data collection method allowed me to probe users into describing interactions in detail, with information available to them from their own lived experiences. The analysis followed a reflexive thematic analysis process, and drew on concepts from phenomenology to focus on understanding the subjective reality of being telepresent as a robot. This allowed me to go beyond findings from

the existing literature, set aside those insights for a moment, and reach an understanding of MRP experiences based on what the users were able to report.

4.1.1 Participants

For this study I spoke to seven users of MRP. They were all male, ages 44-61, from the UK, US and Canada. They had all used MRP in real world situations, as opposed to because they were taking part in a study, and had used it often enough to have gained a mundane familiarity with the medium. The details of the participants' experiences with MRP are shown in table 4.1.

Table 4.1: Context and length of use for each user

ID	Role	Reasons for Use	Length of Use
1	Researcher (HCI)	Research about MRP	4 months
2	Software developer	Work meetings	2 years
3	Researcher (HCI)	Work meetings & prototype demos	4 years
4	Program Manager	Work & connecting with family at home	4 years
5	Company director	Work, whilst immobilized due to injury	3 months
6	Professor (HCI)	Work events & home	2 years
7	Researcher (Psych.)	Connecting with family at home	3 years

4.1.2 Interview Procedure

The semi-structured interviews were held online via Microsoft Teams and each lasted between 45 minutes to 1 hour. To begin the interviews, the participants were asked questions to establish the context within which they used MRP. These questions included; what do you do for work?, what means do you use to communicate remotely for work or personal reasons?, what are the reasons why you used/use MRP?, and how frequently do you

use MRP? Then they were asked to give descriptions of different experiences they have had with MRP, going from broader to more specific types of experiences. First they were asked to describe, in as much detail as possible, one good and one bad experience they have had with MRP, as well as, if they could, one funny and one productive experience. Following that, depending on what had not yet been mentioned, and what could be relevant given their context of use, they were probed with more specific questions based on issues that were flagged as interesting during the literature review. This included questions about use in different social contexts (e.g., interacting with groups of local users, use in planned or spontaneous interactions, being introduced to someone new via the MRP), bystander interactions (e.g., what is it like to use the robot in a public space), mobility (e.g., did you find driving easy or difficult? in what situations did you find it useful to be able to move?), autonomy and help (e.g., were you able to do everything you wanted to do via the MRP? did people offer to help you? how did you overcome problems?) and problematic interactions (e.g., have there been other instances you felt uncomfortable or offended by how other people treated you?). After the aforementioned questions had been answered, the participants were asked if they would continue to use MRP in the future.

4.1.3 Analysis

The data consisted of 7 transcribed interviews containing users' descriptive accounts of their experiences. As outlined in chapter 3, the data was analysed using reflexive thematic analysis (section 3.2) and was interpreted through the lens of phenomenology and through my own understanding and experiences of MRP (see section 3.5). The structure and presentation

of the themes is geared towards demonstrating the subjective first-person and experiences of the users, revealing the taken-for-granted nature of seeing, being and doing in the world as a robot, and examining how those experiences impact the types of interactions the users can have.

4.2 Findings: being in the world as a robot

The themes I have identified are; 1) The troubles of perceiving and doing as a robot, and 2) Being present and ordinary as a robot.

4.2.1 Theme 1: Troubles of perceiving and doing as a robot

Throughout the interviews, the participants described from their point of view what it was like to be telepresent and the difficulties they had. These pertained to seeing, hearing, manipulating the environment, as well as relying on internet connection. These are issues that have to some degree been mentioned in the existing literature (subsection 2.1.3), however, this study highlights the ways in which those limitations are central to the user's subjective experiences, the fact that they persist even in long-term use, and that they have a significant impact on how their interactions are conducted.

Seeing

When describing interactions, the interviewees often referred to their ability to see the local environment, highlighting this as an important aspect of their experience when being remote. Whilst the wide view of the camera

was seen as a good thing, the users commented on the low quality of the video feed. This impacted their capacity to perceive the environment and the people in it, and consequently hindered their ability to participate in interactions.

Participant 3: *"The visual acuity is such that people can recognize me from much further away than I can recognize them. [...] that creates a socially awkward situation because someone who I can't recognize will say 'hello, hey [name], how's it going?' And I've got to kind of continue to move closer until I can recognize that person."*

Seeing, and being able to read text was frequently described as a challenge. Participants reported workarounds that they developed to deal with such challenges — a form of compensatory work. One user described going into a meeting via the MRP, but once there, muting the MRP's sound feed and watching the presentations via Teams, as the presentation display was difficult to see clearly via the MRP's camera. The remote user in this case was using the MRP mainly to create a presence of himself among the local users, but did not exclusively rely on it as a way of gaining access to information pertaining to that interaction.

In addition, the users' accounts show that the movement of the robot is interlinked with their capacity to see in the environment.

Participant 2: *"I'll turn the Beam side to side, but it wasn't very comfortable. Usually, I prefer to just back up so that I could see both [local users] at the same time. OK, then the Beam has a pretty wide-angle camera, so it's not that hard. It was only necessary to turn back and forth when we're standing in the hallway, trying to get out of the way."*

The speed and flexibility of the physical structure of the robot impacted

how easily the remote users could look around. Despite the wide view camera, sometimes turning to look at a different part of the room was essential to a task, but as the MRP moves relatively slowly, this cannot be achieved quickly and gracefully. For example, one user reported having trouble synchronising his speech with slides during a presentation as it was difficult to look at the slides and at the audience.

Participant 6: *"I had somebody in the room present the slides on a projected screen for me and I would just tell them when to advance, but it was extremely difficult to synchronize and know what was being shown in the projector versus what I was saying and to make sure they're aligning. It was also difficult for me to know for sure if everybody in the room could hear me fine."*

In line with this, one of the participants reported having a strategy for explaining to local people what their field of view is.

Participant 2: *"I have a standard spiel about that I work remotely. And then I'll make this gesture [draws an imaginary square around his face]. I do it to help people get some literacy about the fact that I know exactly how I'm coming across to you. And then I'm kind of limited in this box, but I'm very literate or aware of my presentation and to invite them to kind of treat it like...I can see them. I guess I want to try to convey how much I'm able to see and how much I'm aware of my presentation so that they would treat it normally. Because a lot of people tend to ask, you know how much can you see and what are the limits that you can see. I guess I want to try to communicate that that I'm very aware of what I can see and I can't see. Basically, you shouldn't worry about it because I know what I can and can't see in. I will take care of making sure I can see what I need to see."*

The remote user here is doing work to put others at ease as to what he is

able to see, as well as to the fact that he is capable of altering his view to access more things outside of his field of view. Notably, in trying to convey his perspective and capabilities, the user is striving to make others, as he says, "treat it normally". I return to this point later when talking about standing out and being normal as an MRP user.

Hearing

Participants also reported that hearing as an MRP was not always ideal. The clarity of their sound might depend on various factors such as internet connection, size of the environment and types of sounds. Through the MRP, a remote user can not discern where different sounds are coming from when in a room with many speakers and they are not able to find and focus on the conversation that is relevant to them. This affected how remote and local users interacted; the remote user would either have to miss out on elements of the conversation or local users would have to adjust by moving closer to the MRP. One user reported that local users would have to lean in and speak close to the MRP's microphone so that he could hear them, which he found "jarring" .

Participant 2: *"Hearing would definitely have lower fidelity than a video game, in a video game you probably hear everything you were meant to hear, but on the Beam you could hear things behind you and not necessarily know how far away they are."*

Doing

When asked if they felt autonomous as remote users, all participants mentioned not being able to manipulate objects in the local environment as

their main obstacle and source of frustration; this is where a lack of autonomy was most acutely felt.

Participant 1: *"I'm free to drive where I want but without a manipulator arm or two, or without any other sort of radio-based software control of other things in the environment I can't open doors, I can't go into the lift, I can't push the button in the lift, I can't go up and down stairs. I can't reach, grab, point."*

Not being able to manipulate objects meant that the remote users were not able to open doors or push elevator buttons. While these are minor tasks, they are tasks people face daily in the workplace and not being able to perform them poses a significant disruption. The remote users also had no means of taking action in their environment within work activities, such as drawing on a whiteboard or pointing. As such the remote user is slowed down and is less capable to participate in interactions.

Moreover, a remote user is always reliant on help from local users or bystanders in order to overcome barriers such as doors and elevators. This is an experience users would have to go though regularly, and as Participant 2 describes below, being put in a position of having to ask for help would make the remote users feel self-conscious.

Participant 2: *"Occasionally I'd have to ask a friend a favour to escort me to a meeting that they weren't a part of and they were usually happy to oblige. But I always felt a little bit self-conscious and after that, when I felt confident enough in myself I would just hang out in front of the elevators and luckily the Beam gets enough attention that when people walk by, even if I don't know them, they'll stop and look. And then at that point I would say hey, 'could you do me a favour and open the elevator and hit floor four for me?' "*

Of course, this was not the same experience for everyone. Other users were more comfortable and direct in asking for help. This may also have to do with contextual factors, such as one's position in the organisation and office culture. The interactional intricacies of soliciting help are explored more in the next chapter.

Reliance on internet connection

When asked to describe a bad experience, four participants brought up situations where Wi-Fi coverage was not sufficient and required them to seek the help of others nearby. The issue of signal loss also came up in several other instances throughout the interviews.

Participant 4: *"Signal almost invariably cut out in the elevator, requiring me to have someone's assistance"*

The remote user relies on the MRP having good internet connection in order to function. A weak connection—mostly invisible to any local users—might mean the remote users' ability to hear, see, and be heard are impacted. However, the participants mostly described situations were they lost internet connection completely. This commonly occurred in elevators but also in areas of an office where the Wi-Fi did not reach or between two Wi-Fi access points with non-overlapping coverage.

The experience of entering an area without Wi-Fi coverage and as a result being unable to communicate or control the MRP's movement can significantly impact the social interaction, or disrupt it completely.

Participant 3: *"What is difficult is when I lose connection, then I lose the ability to socially interact and then, in that state, it doesn't have any explanation about what to do. So I do wish it had a kind of a help screen in*

that state."

Essentially, the remote user's experience may be described as becoming incapacitated; their vision, their hearing and their access into the interaction taking place in the local environment are lost. They are completely removed from that environment while their 'body' remains there, inaccessible to them. While for other communication devices, such as smartphones, the user has the ability walk back to the Wi-fi area and reconnect, the MRP user is incapable of autonomously dealing with this trouble or even with communicating with local others to solicit help. They have to wait for someone locally to notice the issue and understand what needs to be done or switch to a different mode of communication.

4.2.2 Theme 2: Being present and ordinary as a robot

Presence in MRP

When asked if they felt present, the participants reported that they felt a sense of presence in the local environment but they did not describe it as a completely immersive experience of 'being there', as defined in some literature (subsection 2.2.1). Rather, they agreed to feeling present in a much *lighter* sense of the word; they felt able to be engaged in what was going on at the mediated environment whilst still remaining aware that it was mediated. The words of Participant 5 capture this well.

Participant 5: *"I did [feel present], yeah. Clearly, not literally. Yeah, but it certainly made me feel like I was in the community. Definitely".*

Disrupted sense of presence

Some of the physical and perceptual capabilities of the MRP, such as those discussed in the previous section, were mentioned when users described disruptions of their sense of presence. For Participant 6, the height of the MRP was brought up when accounting for why they didn't feel that they were there.

Participant 6: *"Well, I wouldn't say that I felt like I was really there there. I think the challenge was that even in the robot, I still have a lot of social deficiencies. It was a BeamPlus, and so it was pretty short. Shorter than I am in real life. And so I'm basically kind of looking up at my colleagues. The camera view is not particularly great in terms of fidelity and 'cause it was in a very big room and there's lots of people, the audio is hard sometimes to pick up certain people's conversations. They would have to lean in to my microphone and talk more closely. So that was a bit jarring as the remote person."*

The MRP did not match the user's real life height, or a height from which they could comfortably interact. It meant they had to be looking up to people and be looked down on by them. Their perceptual capabilities were also limited. As such the user was keenly aware of the features of the robot throughout the interaction. To draw on phenomenological language, the MRP as a tool of the interaction did not fade in the background but rather posed obstacles that the user had to actively and consciously work with. The participant in the above quote, moreover, describes this as an example of a social deficiency. It is not the looking up and being looked down on that are inherently disruptive, but the fact that such behaviours break away from normal social interaction. Participant 7, who uses an MRP at home to connect with family also suggested that what detracted from an

experience of presence was the inability to feel the warmth and touch of the other person.

These findings are aligned with literature presented in subsection 2.2.1, showing that competence with using the medium resulted in a greater sense of presence (Kaptelinin et al., 2021).

Being present by participating in the action

When describing what contributed to the sense of presence, participants brought up the ability to move in space and be autonomous. Though not under an illusion of really being there, they were nonetheless capable of tuning their attention to the action taking place in the local environment and actively participating in it by exercising their autonomy. Another part of this was being treated as present by the locals.

Participant 1: *"It's not like being literally physically present in my own body. But the autonomy that I have to drive around... definitely. I pay less attention to my immediate physical surroundings. So if I'm driving it from this room, I'm of course aware that I'm physically present in the room but I'm also very much aware that I can drive around over there anywhere I like."*

Participant 4 further elaborates on how other capabilities of the remote user as an MRP, specifically ones that surpass those available in traditional video conferencing, supported a sense of presence.

Participant 4: *"It's like the Google Street View checking out somewhere you're going to. And so it definitely gives the feeling of presence in the space more than just Skyping for all sorts of reasons. I mean, first of all, the camera is fish eye, so you get like a much wider view. And also you*

rotate so you get an even wider view, right? By rotating you'll see more of it. [...] That definitely helps. And then, you are aware that other people can see a physical thing which corresponds to you, which helps you feel like you have a physical presence as well, right? You're taking up room."

The participant describes being able to see more through the wider camera but also being able to actively pursue what to look at using the MRP's ability to move. In addition, Participant 4 refers to the literal, physical presence of the robot ("you're taking up room") in the local environment as evoking a sense of presence through an awareness that the local users are reacting to the telepresent user as an entity with a physical, embodied presence. As such, whether the remote user feels present is in part achieved through interactions with local users who orient themselves towards the remote user in such a way as to suggest that the remote user is perceived by them as present —in line with the results found byJames et al. (2019).

That experience of feeling present because the local people treated them as such, was particularly felt in instances where the remote user was the only remote attendee in a meeting. In those situations, when attending without an MRP the other local users had a propensity to ignore the videoconferencing attendee (especially prior to the pandemic, due to lack of familiarly with remote working). As such, the sense of presence was particularly felt when the capabilities of the remote user (to move and take up space) mattered due to contextual factors.

Participant 4: *"I think it did help, because otherwise I've often otherwise been in situations, where if you're the only remote attendee, people in the room can ignore you. [...] As soon as there's enough of a critical mass of people attending remotely, and nowadays everything is remote, then they don't need a physical presence, right? Everyone realizes that half the at-*

tendees or three quarters of the attendees are remote and you need to pay attention. So I think it's particularly valuable in situations where you're the only remote person."

Participant 2: *"Usually people worked in the office and I was one of the few that worked remotely and so I felt a need to have a physical presence so that people would include me in conversations. But now 'cause of Covid everybody's working remotely. But even before Covid for the last year people used [Microsoft] Teams anyway, so it was not important that I have to have physical presence."*

In the situations where the activity was taking place mainly in-person (as everyone else was physically present), the MRP helped the users to better command the local people's attention in a conversation where otherwise they might have been ignored. Having an autonomous body in that physical environment brought the remote participant more on par with the local people and this gave them a greater capacity to participate in the interaction. In that setting the physical aspect of the MRP was required to make up for the inability to engage via video. As such, we see that the embodied, mobile aspect of MRP does not inherently create a sense of presence; however, it does so when those features are relevant to the way in which the interaction is conducted.

Failing to be "ordinary"

According to interviewees' accounts, when embodied by the MRP the remote user tends to stand out, to be seen, noticed, pointed out and reacted to without tact when making a mistake. Whether attempting to or not, the remote user is not blending in with the locals. Instead they are treated as different. Standing out can be both a help or a hindrance, depending

on the situation.

Participant 6: *"The attention is kind of fun and nice, but if you really want to get something done, like if I really need to drive to a particular location to attend a meeting, I don't want to have all that kind of attention on me."*

Participant 6 refers to a kind of unwanted attention. Other accounts suggest that when in a "public" area of the office, the MRP attracted the attention of bystanders, who would not just look with curiosity but also initiate interactions. Whilst it can be nice and even useful to attract attention and be noticed in the office, participants also claimed that it prevented them from carrying on with their work.

The propensity of the MRP to stand out and be treated as different was a problem particularly in situations where the remote user did not have complete control over the MRP's behaviour and made mistakes due to that limited capacity. The conspicuous nature of the MRP means that remote users do not have an easy way to be discreet in public areas should they wish to. Rather, they are always prominent and their every movement tends to be noticeable by people in the local environment.

In situations where people are expected to remain quiet and not cause any interruptions, the remote users were at a disadvantage, as any small movement of the MRP could attract local attention owing to, for example, mechanical noises or the unusualness of large pieces of technology moving on their own. Participant 2 reported that he would make an effort to position his MRP out of the way and stay as still as possible during meetings for that reason.

Participant 2: *"I felt like it was distracting when I would move. Usually it would catch the eye of a lot of people and they would look over it, not*

necessarily apprehensively. But maybe a little bit of that. I mean 'cause it is a big device. It's moving on its own."

In the case that the remote user makes an error, the local users and bystanders will not only notice it, but make it known that they have noticed it, usually by laughing, breaking away from the conventional methods of politeness (Brown and Levinson, 1978). Participant 6, below, describes what happened after he made a driving error, whilst trying to quietly leave the room of a faculty event and hitting against a chair.

Participant 6: *"And I kind of start to hear people laughing and I sort of turn sideways to the audience. And then I didn't want to stay so I said, 'Sorry, I'm just trying to sneak out' and then the room just erupted in giant laughter, so it was kinda comical, but for me it was kind of really challenging because there was no way for me to gracefully leave that room."*

It was felt that local people in those situations are not necessarily as willing to tactfully overlook the disruption and pretend that they did not notice or that they did not mind so as to save the remote user from embarrassment, as might have been expected in an in-person interaction. Being present via an MRP does not allow the remote user to be perceived as present in an 'ordinary' way, it evokes a different treatment.

Again, the subjective experience of such situations — whether they are experienced as fun or unpleasant— may be highly dependant on context. For example, Participant 5 described standing out as a fun experience, and dealt with being made fun of in a lighthearted way.

Participant 5: *"It was fun. You know what I mean? I don't think anybody had ever seen anything like a kind of robotic version of me before. So everybody is really surprised and amused by the idea. And certainly if I*

had been walking around the office normally, nobody would have stopped and laughed and smiled. It would have been a respectful 'hello' or 'good morning' or whatever. But when I'm walking around the office in robot form then it is really funny. People thought it was the funniest thing. [...] I have humor and my personality lends itself to making light of situations and playing the fool. And I have quite a light atmosphere in the business. And I'm very comfortable being the butt of jokes and ridicule, so I didn't have a problem with that, but I imagine some people might."

As evidenced in the above quote, even when it not received as a problematic experience, being present via an MRP elicits a different treatment of the remote user than of the other, physically present people. This treatment involves drawing attention to the funny or unusual presentation of the person as a robot, and seems to enable some 'impolite' behaviours towards that person, such as pointing and making jokes at their expense.

4.3 Summary and Discussion

4.3.1 Summary

This chapter presents an exploratory study into the experience of being present via MRP. The study consisted of semi-structured interviews with 7 people who have used MRP in the real world, as part of their daily lives at work or at home, for extended periods if time. The interviews, which contained detailed first-person perspective accounts of experiences of being tele-present, were analysed using reflexive thematic analysis and the data was interpreted through a phenomenological lens. The study presents accounts that describe the practical actions of MRP use. Moreover, it

provides insights into the phenomenological, experiential reality of being in the (mediated) world as a robotically telepresent participant. The data is presented in two themes, 1) Troubles with perceiving and doing as a robot, 2) Being present and ordinary as a robot, which are summarised below.

The first theme shows that MRP puts several limitations on remote users, both on perceiving the environment (hearing and seeing) as well as on acting in it (manipulating objects, remaining connected). The limitations impact the experience in pervasive and important ways, they hinder doing mundane things and they persists even in familiar, long-term use. The participants reported that the visual and audio fidelity was low, that driving was burdensome, that they were not able to manipulate their environment, and that they relied on consistent internet connectivity. These reports reaffirm previous literature (2.1.3), but the present study shows that such issues persist even after extended use and that they disrupt the experience in important ways. The accounts also show that taking any form of action on the MRP, including actions to support perceiving the environment (e.g., looking around) is an active undertaking that requires a certain degree of intentionality. In line with that, interactions around assistance are also a core part of the experience (this is explored in more detail in the next chapter).

Within the second theme, the users reports show that presence via MRP is not immersive nor in any way akin to an illusion of non-mediation, but more of an experience of being geared into the action taking place in the mediated environment. As such, presence via MRP then may best be explored through the lens of interaction and participation. Further, the accounts suggest that whether MRP facilitates that sense of presence is context-dependent — depending on whether the affordances of the MRP are relevant to the activity at hand — and not due an inherent superiority

of robotic mobility over other media. The users' stories also highlight the experience of standing and being treated differently by local users. This further suggests, in line with James et al.(2019), that a sense of presence also relies on being treated as present.

4.3.2 Discussion

The present study addressed the first research question: *How are MRP interactions conducted and experienced in practice?*. Moreover, it focused on the first part of that question: *How is robot-mediated telepresence experienced by users?*. In particular, the aim of this study has been to understand the subjective experience of MRP from the perspective of the remote users, and to examine from that phenomenological lens what is means to be (tele)present. I doing so, the study finds that the experience of MRP is largely characterised by its practical limitations, that presence when described by the users relates more to effective participation rather than immersion and that being embodied as an MRP presents a challenge with regards to being treated as "ordinary".

As restated in the summary above, a large portion of the users descriptions referred to various limitations they faced in terms of perceiving and doing things as an MRP. Taking a phenomenological sensibility, we can see that these limitations are not mere hiccups in using a piece of technology, but a core part of the subjective experience of accessing the world as a someone embodied through a robot. To be (tele)present via MRP, in part, is to be limited. As mentioned in chapter 2 (subsection 2.2.2), comparisons can be drawn between MRP and the disabled body in that it is a distinct type of body which is oriented to in interaction in unique ways. MPR provides a distinct and limited kind of window into the mediated environment; it does

not provide a perfect or immersive access.

As the accounts in the second theme further show, the medium's limitations are also interlinked with the users' sense of presence. Disruptions caused by the technology are often points during which that sense of presence breaks and the users are brought to face the medium rather than the mediated environment and the activities unfolding in it. Moreover, when talking about limitations, this of course has to be in comparison to something else; in this case, to the local users. These limitations do no exist alone, they are made evident in-interaction, because the vision, speed, precision and autonomy of the remote user are more limited than those of the people they are interacting with. As will be further explored in the next chapter, these limitations therefore constitute communicative asymmetries in mobility, perception and intersubjectivity, which impact the social organisation of interactions between remote and local users.

Further, looking at telepresence through the first-person perspectives of users, we see that their experience of presence is indeed not one of immersion. That is, when people respond "yes" to having felt present this should not be taken to mean that they really felt as if they were "there". Based on the given accounts, it can mean that the users felt included and able to explore. This is especially the case in the situations where they otherwise would not have had the opportunity to participate to such a degree due to situational factors (such as task demands or expectations of local attendees). From these descriptions, feeling "presence" seems to fit more with definitions of presence that relate it to interaction with the world, rather than definitions that measure the degree of immersion into the mediated environment. This approach to presence, as related to users' capacity to interact and be interacted with, is also more aligned to an Ethnomethodological and Conversation Analytic (EMCA) approach to research, which

is concerned with understanding the ways in which people become "geared into" an interaction; i.e., the ways in which people make themselves understood by one another in practice, in moment by moment interaction. In that sense, presence is a kind of capacity to understand what is happening within an interaction and take part in it, to perceive what is relevant and interpret it appropriately and to be seen and understood. As will be further explored in the final discussion (chapter 9), future work on MRP should make a point of not trying to achieve a sense of immersion but rather focus on supporting this type of presence by focusing on participation.

The above two points both culminate into another issue raised by these interviews, that of achieving "being ordinary" as an MRP user. As shown through the participants descriptions, regardless of how present they might be, the users are failing to "blend in" as normal, ordinary people in the local environment. Instead they are treated differently. Their presence attracts the attention of local users very easily, and local users have little hesitation in reacting to the MRP as something odd or funny. The local users might treat the remote user with a certain lack of tact or politeness — having a propensity to play jokes on the MRP or point and laugh at the ways it behaves. This behaviour towards the MRP suggests that the remote user is unable to truly establish themselves as an ordinary, unremarkable presence, as just another person in the room. As shown in the participants' quotes, a remote user might do compensatory work, by explaining their perspective, in an effort to make themselves more normal in the eyes of local users. Or they might employ strategies to make themselves less conspicuous in order to attract less attention. To draw on the work of Sacks(1984), 'being ordinary' can be understood as something people actively do by behaving in ordinary ways. This will be examined in more depth in the final discussion (chapter 9), after gathering more insights from

the subsequent studies on the limitations of MRP and their impact on users' ability to achieve "being ordinary" in interactions.

The next chapter presents an EMCA study of MRP interactions through video data of local and remote participant pairs performing a collaborative task. Moving from self-reported data to recorded, observable interactions, that study will show some of the topics raised here as they are managed in practice. The study will showcase how assistance is recruited in MRP and demonstrate the impact of limitations as communicative asymmetries in interaction by providing a look into just how MRP interactions are socially organised.

Chapter 5

Recruiting Assistance in MRP: an observational study of remote-local collaboration

Having laid out a foundational understanding of users' experiences of Mobile Robotic Telepresence (MRP) through self-reported data, this chapter now proceeds to show the realities of use during interaction. The study presented in this chapter consists of an Ethnomethodological and Conversation Analytic (EMCA) examination of video-recorded interactions between remote and local user pairs. The user pairs in this data are engaged in a collaborative, physical task, which invites them to grapple with the affordances of MRP in order to communicate and cooperate. The data was collected within the context of a larger, experimental study, but as explained in 3.3.2, it is used here simply as recordings of situated instances of interaction. The participants in this data are tasked with searching for specific items in an office environment and have the option of helping one another in order to aid their outcome. The analysis focuses on unravel-

ling the social organisation of how their communication is achieved. In particular, this centres around how help is solicited by and given to the remote user. As showcased in the previous chapter, and the literature review, there are certain limitations faced by the remote user in terms of how well they can perceive and act in the environment, which naturally result in them relying on certain forms of help from people in the local environment. Further, collaboration with an MRP user may be impacted by the existence of communicative asymmetries and the "fractured" nature of the mediated environment (2.2.3). This study draws on the assistance recruitment framework developed by Kendrick and Drew (2016), outlined in the literature review, to examine how this is done through the medium of MRP.

5.1 Study Approach

This study primarily addresses the first research question: *How are MRP interactions conducted and experienced in practice?* Whilst the previous chapter looked at the remote users' subjective experiences, this chapter will focus more on the second part of that research question which broadens the scope to the interaction between local and remote users by asking: *How are MRP-mediated interactions socially organised in terms of the interactional methods employed by users?* The question itself is driven by, and invites, an EMCA approach (section 3.3). To understand MRP interactions, I look at just what users do and what effect it has. As such, the present study responds to the research question by presenting and unpacking instances of interaction between remote an local user pairs through a more Conversation-Analytic-driven EMCA approach which identifies the ways in which users communicate and interact.

5.1.1 Participants

The sample consists of ten pairs of participants, recruited from within the organisation that run the study, Microsoft Research. Their ages ranged from 25-54 (M = 35, SD = 7.3). Eight of the participants were female and twelve were male. None of the participants had previous experience with MRP.

5.1.2 Procedure

The present work utilises data that was collected as part of a larger, experiment-based study. The original study was conducted to test a prototype for an MRP system that utilises a VR headset to overlay an Augmented Reality avatar over a Beam telepresence robot (Jones et al., 2020b). For this study I used the video recordings of the participants going through the control condition of that study, in which they used the regular Beam robot.

The experiment run as follows. The participants were put into pairs, such that the paired participants did not know each other prior to the study. In each pair, one participant was assigned the role of the remote user and one of the local user. The remote participants were set up on the Beam interface using a computer in one room of the building, while the local participants interacted with their remote partner through the robot in another part of the same building. The pairs performed a searching task followed by a word-guessing game. This study only looks at data from the searching task. They did the tasks once using the Beam robot (control condition) and once using the enhanced prototype, with the order of the two conditions assigned randomly for each pair.

For the searching task, the pairs had three minutes to look for five items each, within a specified area of the office. The local participants had to find five ping-pong balls and the remote participants had to find five pieces of pink paper. The target items were selected so that both local and remote participants would encounter a similar level of difficulty given their capabilities (ping-pong balls were difficult to spot via the MRP, while papers were very easy to see in person). To prove that they had found them, the participants had to photograph their items. To do this, the local participants used a tablet whilst the remote participants took screenshots of their interface with the target item in view.

The participants were allowed to talk and help each other find their items. Whilst they were not explicitly told to collaborate, they were told that for every item they found they would gain an extra 30 seconds to the time they would have for the collaborative word-guessing game that followed. As such there was an incentive to collaborate.

5.1.3 Data

The data used for the present study comes from the control condition of the searching task. As such it consists of 10, 3-minute videos, captured via screen recordings of the remote participants' interface. Figure Figure 5.1 shows an example of the remote participants point-of-view of the Beam interface.

5.1.4 Analysis

Whilst this data does not come from ethnographic fieldwork, I have approached the analysis with an EMCA orientation (3.3) so as to closely

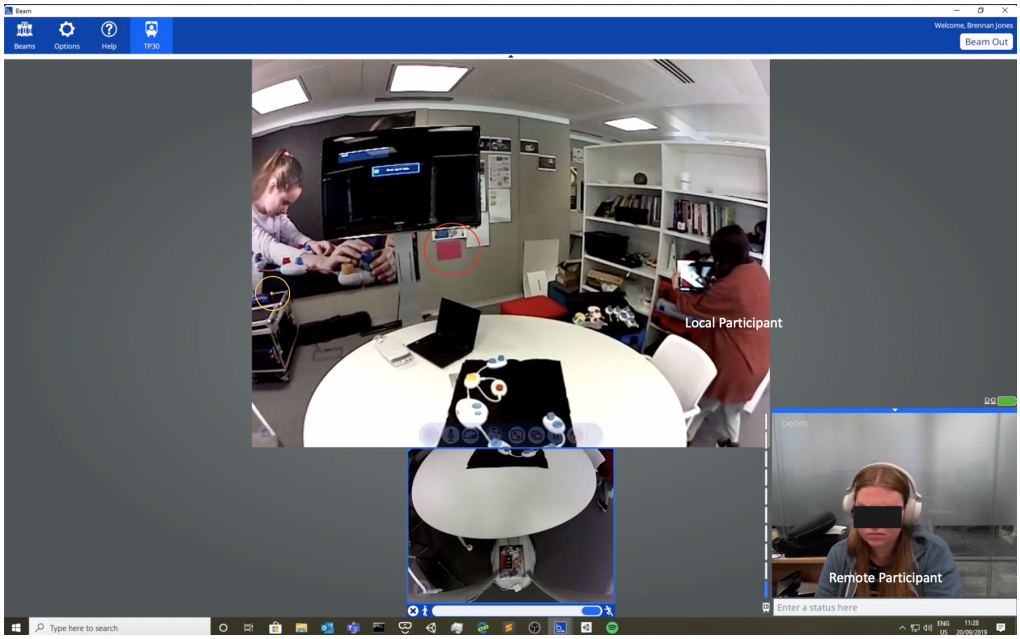

Figure 5.1: Experiment set up from the remote participants' point of view showing one of the target pink papers.

examine how the social order of interaction between local and remote users is produced through linguistic and embodied methods. The EMCA approach here is more CA-driven, in that the work focuses on examining the turn-by-turn actions of the participants and the work they do in-interaction in order to communicate with each other. Although the experimental setting of the users may add a layer of artificiality, it still allows us to look at emergent interactions of mediated collaboration. In examining these interactions, I specifically draw on Kendrick and Drew's (2016) conception of assistance recruitment and present the findings using the categories they identified.

5.2 Findings: collaborating and being helped as a robot

In this section I present five fragments that exemplify the types of assistance recruitment interactions that were prevalent in the data. The first two fragments show examples of successful assistance recruitment. Fragment 1 (Figure 5.2) is an example of explicit articulations of trouble whilst Fragment 2 (Figure 5.3) showcases how anticipations, or projections, of possible troubles were made by participants. The next two fragments are examples of failures, where due to communicative asymmetries, assistance was unsuccessful. Fragment 3, (Figure 5.4) is an example of a remote user failing to recruit the help they need, whilst Fragment 4 (Figure 5.5) shows a local user making an inaccurate projection and providing unsolicited help. Finally, the 5th Fragment (Figure 5.6) shows an example of 'status reporting', where remote participants reported troubles without any apparent expectation of help from the local participants. Names appearing in the fragments have been changed to preserve the participants' anonymity.

5.2.1 Reporting and projecting troubles; successful assistance recruitment

The two fragments in this section represent the most common methods of recruitment employed by the participants in this data-set, and also the most successful in their occasioning of subsequent assistance from a local participants.

Reporting troubles

Fragment 1 is transcribed in Figure 5.2 below. It shows a typical occurrence (three times in the data) of the remote MRP participant reporting trouble as a method of recruiting assistance from the local participant. In the following transcript, the remote participant (R5) and the local (L5) are pausing to check if they have captured all the pink papers or not. L5 spots one that R5 has not captured, and R5 then produces an account of what Kendrick and Drew describe as reporting a trouble; "I can't get round" (Kendrick and Drew, 2016).

Figure 5.2: Fragment 1: Remote (MRP) participant reporting a problem

The fragment takes place towards the end of their timed task. As seen in 2a, the remote participant is turning while saying "Erm. I thought there was one", and then starts to drive towards the table in front of the pink paper she needs to get to (indicated with a red circle) while saying "over here". As she is talking, the local participant starts counting the pink pieces of paper.

Notably, the local includes the target paper in her count. Earlier in the task, the local participant had pointed out that paper to her partner and, as can be inferred by her behavior in the present fragment, she assumed that the partner had managed to photograph it. With her beginning remark, "I

thought there was one over here", the remote participant is not really asking if there is a paper there (this is known by both participants). The remote participant had already been made aware of the paper and had made a failed attempt at getting to it (shown in Fragment 3). By remarking on it, she renders it remarkable, she draws attention to it and thus initiates the recruitment of assistance directed towards it.

It is also worth noting that up to the point shown in 2b, the remote participant is facing the direction of two papers. Yet the local participant is able to understand which of the two is the target paper without further explanation. Perhaps this is because, of the two possible papers, the one in the back is the only one that is difficult to reach. The situation, then, gives meaning to the participants' actions.

In 2b, the remark "Oh, you didn't get that" suggests that the remote's prior utterance paired with her movement towards the table suffices to convey to the local that her partner has not photographed the target paper yet. Then, after confirming the local's assertion, the remote participant offers an account of her physical imposition for not capturing the paper. Specifically, she reports the trouble encountered by saying, "I can't get round". She follows this statement by moving towards a chair and stopping in front of it (her movement indicated by the yellow arrow in 2a and 2b). After a short pause, the local participant responds by moving the chair out of the way, so that the remote can drive the MRP around the table and reach the paper. It is of note how the remote participant here combines verbal and embodied cues (such as driving towards the table paired with "over here" to convey the missing paper), succeeding in what might be called a relatively implicit way of communicating her need.

Moreover, this recruitment sequence is a clear use of reporting trouble,

which according to Kendrick and Drew is not as explicit as a direct request but still on the explicit side of the scale. Still, this report of trouble is offered after the problem has already been understood by the local, as an account that the image was not taken, "I can't get round". This account warrants no further explanation, such as why this is the case exactly, or what might be in her way. All that is expressed more implicitly by her movement towards the obstacle chair, thus incorporating an embodied cue into the recruitment sequence. What this fragment illustrates is the importance of orientation, movement and embodiment in MRP in sequence with talk. Instances of trouble reporting in other fragments included remarks such as, "I think I can not even get to the big screen", referring to not having the space to move so that the paper would be in the view of the main camera (as opposed to the small camera facing the floor) and "I cannot move".

Projectable troubles

Fragment 2, next, shows an instance in which assistance is provided by a local participant in anticipation — what Kendrick and Drew call a "projectable trouble"(Kendrick and Drew, 2016). This kind of assistance recruitment strategy was very common in the data (seven occurrences). In this case a different pair of participants are performing the task. The local participant has already informed his remote partner of another pink paper to capture ("there's one back there") and is asking her to follow him to its location. Just prior to this, L3 says "just turn" as the remote participant commences a turn leftwards, capturing one of the pink targets along the way ("so I got this one").

At first, the remote participant is turning. She is shifting her gaze from facing the paper she just captured that is visible in Figure 5.3, 3a (circled

3a

1 R3: So I got this one?

2 L3: ((raises hand, sidesteps away from R3))

3b

3 R3: [And there is another one?]

4 R3: [((turns to face L3))]

5 L3: ((raises right arm again))

3c

6 L3: =(If you follow me.) Yeah that you haven't seen

7 L3: ((turns towards R3, moves chair and moves aside))

3d

8 L3: [((raises arm and sidesteps away))]

9 R3: [((moves forward))]

Figure 5.3: Fragment 2: Local participant responding to projectable trouble

in red, to the local participant's left hand side), and is turning the MRP towards her partner as seen in both 3a and 3b. In the course of doing this turn, R3 reviews her activity, making her capturing activity accountable to L3 ("so I got this one"), and in doing so showing both verbally and non-verbally that she's literally turning her attention to her partner.

During this turn, between 3a and 3b, L3 is intermittently side-stepping away from R3 whilst maintaining his gaze on the MRP. The turn of the MRP and the sequential placement of this action by R3 amidst their conversation and L3's side-stepping opens up the possibility, clearly oriented

to by L3, that R3 will be following L3 as he leads R3 over to "another one". During this sequence, rather like a tour guide in a city, L3 also raises his hand, as if to further emphasise what they will be doing next, following him and moving "back there" in L3's direction.

R3 then begins moving forwards almost immediately after completing her question to L3: "and there is another one?". The local participant responds by asking R3 to "follow me". At this point, seeing the start of R3's movement towards him, L3 steps forward and pulls the chair to one side, as seen in 3c-3d. He then returns to holding his hand up and continues side-stepping towards the next target whilst looking back momentarily to the MRP. With the chair then out of the direct line of R3's initial movement forwards, she continues moving ahead with a minor amount of steering to still avoid the edge of the chair.

R3 did not explicitly formulate a request for assistance, and instead she merely started moving forwards in response to L3's request to "follow me". In doing so, L3 projected a trouble with the position of the chair and R3's trajectory of movement. The incident passes unremarked upon. Nevertheless, R3's response to L3's suggestion that there is another pink target to capture occasions L3 to deal with troubles before they explicitly arise. The remote participant indicated, through her gaze and speech, that she was willing to follow him and the chair was in the path that she would take if she did follow.

Whilst the main assistance I focus on in this fragment is the pulling of the chair, it is also worth noting how the local participant lifts one arm up, as seen in 3b and 3d, similar to a tour-guide ensuring that he can be seen. This might suggest that he is unsure of whether he can be sufficiently seen or heard by the remote user without doing this extra work. His 'unnec-

essary' work (in some sense) in becoming more visible thus reveals some suggestion of a lack of certainty about how visible he actually is to the MRP participant. This is one of the asymmetries in MRP use which play a significant role in the manner of recruitment and assistance.

5.2.2 Communicative asymmetries impact recruitment

Successfully recruiting assistance or being provided with anticipatory forms of assistance in response to projected troubles were not always present in the task as it unfolded between the remote and local participants. In many cases there were problems with either getting help in the first place, or in the manner of projecting trouble (such as troubles which are misjudged, or do not ultimately emerge). The following two fragments describe moments that were less successful and offer 'inverse' cases of the first two.

Failed assistance recruitment

Fragment 3 begins just after R5 has captured a pink paper. L5 has then asked R5 if she has seen the captured one, to which R5 responds positively. Still, there seems to be some confusion about whether what L5 is pointing towards is the target visible in Figure 5.4, 4a, circled in red — which is a different target paper to the one R5 had just captured. R5 then spots this particular target at the start of this fragment, just after L5 has moved to the next bay.

Here, the remote participant spots the target paper ("what's that?") but at the same time cannot move closer due to an obstacle being in the way. Her question in line 1 remarking on this moment of spotting the target leads to nothing in return from L5. R5's attempt to recruit L5's assistance thus

4a

1 R5: [Oh, what's <that>?]

2 R5: [((moves straight towards paper))]

4b

3 R5: (3.29)

4 R5: [Am I too far away from that? To take that?]

5 R5: [((moves slightly closer towards paper))]

Figure 5.4: Fragment 3: Example unsuccessful recruitment

doesn't seem to be successful at getting the local participant's attention. It is worth remembering that R5's ability to 'see' is limited by the resolution and field-of-view of the camera on the MRP. R5's pause of 3.29s leads to her reformulating the question, this time questioning whether she should be closer to take the photo of the target ("am I too far away from that?"), the sense of which is built by the obstacle preventing her from getting any closer. After R5 produces this apparent question once again, there is no response. After this point the remote participant reverses backwards, and turns to join L5 in the adjacent bay, ceasing the attempt to recruit L5 for help. Later on, in Fragment 1 which occurs a few minutes after this one, this same pair then return to this problem of whether R5 has captured all the pink targets, and discover that this particular one had been missed, due in part, as we see here, to a lack of assistance from L5.

We note that as R5 approaches the obstacles, her exclamation (line 1) is designed in a more implicit linguistic form of recruitment. It does not articulate a trouble, and works more as a way of soliciting L5's attention back to R5's current activities. In that sense, it is less explicit than a

direct request for help, and is not communicating the actual trouble into her utterance at this time (i.e., that there's a box in the way), or suggesting a desired solution. Thus, R5 begins by rather ambiguously stating what might be made sense of as trouble, but could equally be heard as a broader curiosity.

After waiting in front of the obstacles and not getting a response, R5 makes another attempt with her reformulation of her recruitment of L5. This time her question, which is whether getting a photo of the paper from that distance would 'count', is more specific and has a potential double duty. While it is available to L5, it is also available to the experimenter sitting in the room with her to her left, whom she has already asked a prior question regarding the MRP controls. Her utterance is also slightly quieter than the surrounding ones, however she does not glance at the experimenter this time, so it retains an ambiguous character regarding who it is designed for. In any case, this is an instance where the question seems to act as an attempt at recruitment of either party, although it is not responded to.

Finally, she reverses straight backwards and then turns to the right to look for her partner, abandoning her attempt to capture this paper, and returns to it later in the interaction as seen in Fragment 1.

This fragment showcases how the limited capabilities of a remote user of MRP restrict them in effectively perceiving their environment and consequently (and more importantly, with regards to interaction) restrict them in knowing whether and how their presence and actions are perceived by others in the local environment. For example, given that L5 has left R5's field of view in this fragment and is no longer talking, the remote participant has no way of knowing whether she has been heard or whether her partner is paying attention to her. Attempts to deal with this lack of awareness

are underlined by changes in how loudly she is speaking; there are some mild variations in volume of her utterances that suggest some distinction between talking to L5 and talking to the experimenter (although as noted, line 3 is ambiguous). Furthermore, R5 can only see straight in front and in order to look for her partner she has to move the entire robot out of that position and then turn around (which she eventually does). This example then showcases how restricted movement flexibility and limited access to information about what is happening in the local environment (including whether local persons are in ear-shot and displaying attention) can sometimes prevent the remote user from effectively asking for help, and from employing effective methods of communication more broadly.

Unsolicited assistance

Fragment 4 presents a different type of 'unsuccessful' recruitment. As shown earlier (in Fragment 2), the local participants often projected troubles as they emerged, leading to them providing assistance without the remote having to do anything. Here, we see the local participant projecting one such trouble— regarding what the MRP participant can and can't see —and then beginning to offer help where it may be unwarranted. This shows just how difficult it can be for the local participant to judge what kinds of assistance might be needed. At the start of this fragment (5a), R8 has spotted a pink piece of paper and is driving towards it (Figure 5.5.

R8 stops in front of this target in order to capture it (5b). The local participant at this point informs him about the paper ("on the left hand side there's a pink bit of paper"). That paper has been visible in R8's video stream for some time, and R8 has been quite clearly piloting his MRP towards it ('clearly' from the perspective of viewing R8's video, that

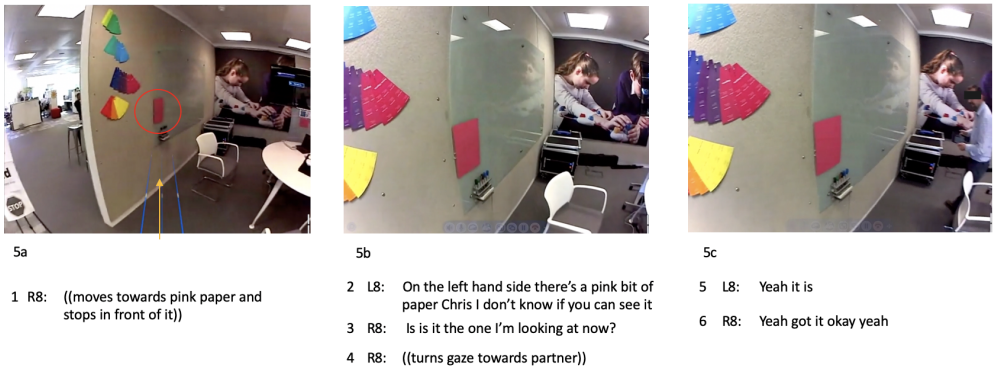

Figure 5.5: Fragment 4: Unsolicited projectable trouble

is). In line 2, R8 checks that the pink target he is in front of is indeed the same as the one referred to by L8, which also acts as a way of acknowledging L8's assistance even if unnecessary. Still, L8 does seem oriented towards the possibility of this assistance to R8 being unneeded by downgrading his observation with "I don't know if you can see it".

In this scenario, the local participant was not able to make an accurate assessment of the situation. He did not accurately judge what R8 was driving towards or what was within his vision. It is worth noting that in the recording, R8's final movement towards the wall maintains the pink paper almost entirely in the centre of the screen, although perhaps the directionality of this is not available to L8. It is possible that L8 did not see the Beam move towards the paper (5a) but only saw the Beam standing next to it (5b). Even then, by his utterances, L8 does not seem able to tell how well his partner could see through the Beam from this stationary point, and whether he could make out the paper in front of him. Once again, this is supported by his disclaimer "I don't know if you can see it".

This is not necessarily a problematic interaction. Indeed, the remote participant smiles and moves on without taking offense and instead builds a response (line 2) that simply confirms matters. Given the circumstances of a short-term collaboration for a timed task, it is probably a good strategy

for the local participant to offer assistance even where there is uncertainty about its necessity. Rather than spend time figuring out the MRP's exact capabilities, they prioritise capturing all the target items. Still, it is possible that sustained incidents of unsolicited help such as this, in long-term collaborations, may be heard as patronising and place the remote user in an unfairly subordinate role. Further, this scenario highlights how lack of knowledge about MRPs on the part of local users can also be an obstacle to smooth interactions.

5.2.3 Trouble reporting as status reporting

Throughout the task, both remote and local participants would verbally report on what they were doing. This could serve as a way of updating each other on the status of the search task when they were working separately (the office space in which the task took place was not large and overhearing was a distinct possibility). In a similar manner, the remote participants also developed a practice of reporting trouble out loud as they encountered it without an apparent expectation of the local then providing assistance (given differences in participants' exhibited orientations to such utterances). Often these utterances concerned the limitations of the Beam as the remote participant came across them during the task. Sometimes troubles were formulated as apologies: for instance, some examples from the data include "I feel very conscious of hitting stuff" and "It's kinda slow backwards", as well as more humorous remarks about the Beam's slow speed, "Is there a run key?" and "I'm racing against time!".

Fragment 5 shows an instance of what might be described as a 'status reporting' practice that articulated trouble but not with the aim of recruiting assistance. In this fragment, the remote participant is moving around a

table and stools in order to reach one of the pink targets having identified it with L4 and pre-empted their subsequent action with "I'll go to that one".

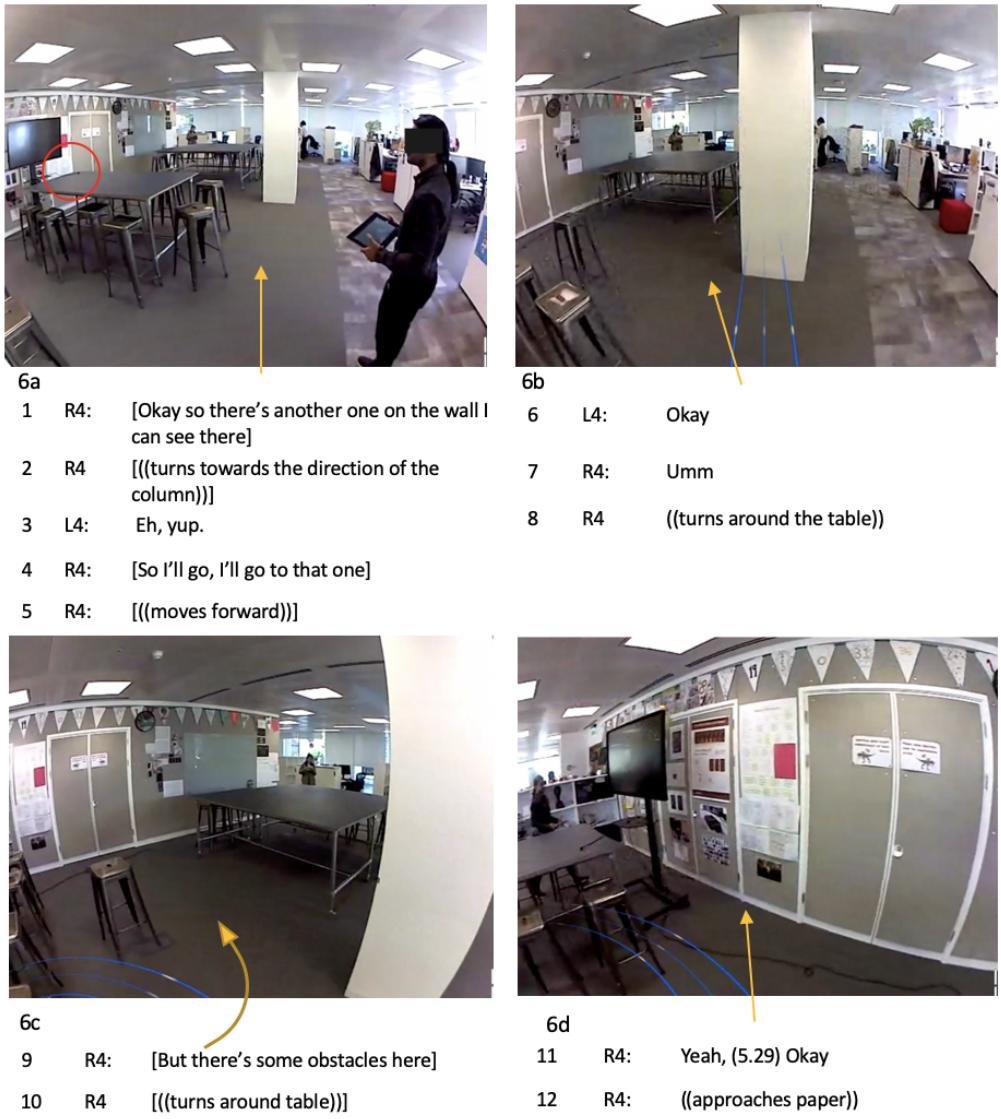

Figure 5.6: Fragment 5: Trouble reporting as status reporting

As R4 turns around the table, in Figure 5.6, 6c, he sees a stool in his path and reports this with a developing level of specificity, beginning with "umm" and then "but there's some obstacles here". As shown in Fragment 1, this kind of apparent reporting trouble is a strategy participants often used to get their partner to provide the help they needed. In this case, however, the Beam pilot seems to be doing something different regarding

how both he and L4 are treating this trouble report. Firstly, R4 carries on with his movement around the stool, L4 does not respond to R4, and R4 does not then do any remedial work. For example, R4 does not wait for his partner to respond, or repeat the report of trouble, reformulate it, or upgrade it in any way (all of which suggest expectation of response), or produce some other account of trouble. In short there seems to be less expectation of the trouble's resolution. Instead, R4 simply continues to move around the stool, following his apparent trouble report with "yeah".

One possibility for this less demanding treatment of the trouble is that as R4's trajectory continues, and perhaps as the video stream reveals more of the physical space the Beam is in, the obstacle becomes less projectably problematic for R4 and therefore R4 does not pursue the trouble's resolution through soliciting assistance. Maybe —although this is not possible to say from the video data— L4 himself also judges the route to be within the capabilities of the Beam and therefore does not intervene (although he also does not indicate that 'it's all fine' either).

This behavior may be comparable to participants in virtual meetings verbally reporting on their actions in order to overcome the barrier to symmetry caused by their fragmented environment (Hindmarsh et al., 1998). As such, this may be an example of compensatory work, performed by the remote participants to mitigate their asymmetry, suggesting that they and local participants are aware of a fracture in the assumed reciprocity of perspectives. Or this can be seen as a form of configuring awareness, (Heath et al., 2002), drawing attention and making visible this specific aspect of their experience and the difficulty they are encountering in order to foster more sensitivity and understanding. In either case, such actions suggest that users are attuned to the fact that their robotic appearance does not fully project their intended actions in a visible, accountable way.

5.3 Summary and Discussion

5.3.1 Summary

This chapter presented a close examination of the social organisation of dyadic interactions through the medium of MPR in a defined, task-based context. The analysis presented selected, exemplary fragments, from 10 videos of local and remote participant pairs engaged in a collaborative searching task, examined through an EMCA approach. Along with two other recent studies (Jakonen and Jauni, 2021; Due, 2021), it consists of the few detailed examinations into the realities of interactions through MRP. This type of analysis brings to light the overlooked nuances and complexities of interaction, which are nonetheless necessary to fully understand the medium.

The present study focused on interactions related to the report of troubles and recruitment of assistance, showing the various ways in which recruitment and assistance emerged around troubles and were practically dealt with by local and remote participants. Specifically the study presented instances of trouble reporting and projectable trouble, both successful and unsuccessful. In addition the data included instances of 'trouble reporting as status reporting', actions akin to 'noticings' but specifically about the remote users own limitations and troubles as they encounter them during action — potentially acting as compensatory work, serving to make known their users' perspectives and predispositions.

Whilst indicative of the prominence of assistance in MRP and the intricacies of soliciting it effectively, these fragments also serve as examples of interactions through which to observe and unpack the broader communicative elements present in MRP interactions. The findings demonstrate

the embodied and multimodal ways through which users build a common ground understanding of their situation and the strategies they employ to solicit or anticipate the need for assistance. Moreover, these fragments provide insight into how the limitations of MRP result in communicative asymmetries which impact the interactions.

5.3.2 Discussion

The study addressed the first research question: *How are MRP interactions conducted and experienced in practice?* It specifically focused on the second part of that question: *How are MRP-mediated interactions socially organised in terms of the interactional methods employed by users?* This was done through closely unpacking what users did and how it was responded to in interaction. The contributions of this study, as discussed in more detail in the final discussion chapter pertain to understanding MRP as its own distinct international category, characterised by the embodiment it affords, but also the asymmetries it introduces and the prominence of assistance-related behaviours within the interactions.

The fragments show that the remote users utilised their mobility as communicative cues. In line with previous literature presented in subsection 2.2.2, suggesting that people tend to move their MRP in ways drawn from in-person interactions, participants in the present study also embedded movement naturally within their behaviours. In fragment 1, the remote user is shown to move towards the chair that is in her way, as part of her strategy of recruiting assistance, instead of verbally stating the problem. As discussed later, the movement allows then for more implicit and non-imposing ways of asking for help. In fragment 2, we also see the remote user turning the robot to face her partner, essentially redirecting her gaze to the part of the

activity and the environment that is relevant to her. In doing so, she is communicating to her partner that she is paying attention to him and is ready to follow him. These two examples show embodied movement woven into the interaction alongside other elements, such as verbal language and use of the environment. Indeed, the mobility naturally allowed for the physical environment and broader situatedness to have relevance within the interaction as well. In fragment 1, again, the remote user's movement does not make sense in isolation, it makes sense because of the presence of the chair and the paper, the position of the chair between the paper and the user, and because of an existing understanding of the task demands and potentially, of the robot's movement limitations. As will be shown in the next study, and further examined in the final discussion, all these elements come together to support effective MRP interactions.

Of course, as already stated, the MRP's movement and overall capabilities are limited in comparison to those of local users, which give rise to communicative asymmetries. Building on user reports from the previous study, with the data presented in this chapter, we can identify three key types of asymmetries; asymmetries in mobility, perception and intersubjectivity. It has been shown in the previous chapter, that moving, perceiving the environment and doing things as a robot can be quite difficult for the remote users; they move more slowly, have lower fidelity, are subject to lagging and can not manipulate the environment. In this study we see that such limitations can get in the way of users communicating effectively. For example, in fragment 3, the remote user is making remarks about her situation, in an effort to solicit some help, but she is not being heard or responded to. We see that she remains facing the same direction throughout and does not do much to alter her strategy, until eventually giving up. An able-bodied, local individual could quickly look around and see where their partner is

and if they are paying attention, or simply move closer to their partner to get their attention, whereas a remote user of MRP is unable to do any of this. They are asymmetrically limited in their capacity for participation, based on the their material capabilities for movement and perception.

Beyond this, there is an asymmetry in intersubjecitvity. That is, the capability of remote and local users to understand each other's perspective and capabilities. As the aforementioned fragment demonstrated, it was difficult for the remote user to know what her partner could hear and see. Still, remote users, when they are able to see and hear a local user may be more successful in understanding their perspective because they know from experience what it is like to perceive the world as a person. On the other side, local users seem to have more trouble understanding what the capabilities of an MRP are. As we have seen in the presented fragments, the local users are likely to underestimate the remote users' vision. They do things such as point out clearly visible objects or raise their hand to make themselves more visible. We also see remote users engaging in ways of making their perspective more clear, such as accompanying their actions with verbal remarks of what they are doing and reporting on the troubles they are facing, even when they are capable of solving them without assistance. This was also brought up in the interview study presented in the previous chapter — remote users described trying to make their perspectives accessible to locals, so as to achieve a certain 'normal' way of interacting. Achieving a normal, 'ordinary' presence in MRP involves ongoing work by both parties to compensate for this asymmetry, so that the remote user can be understood by the locals and thus gain membership in the interaction.

Finally, this study serves to highlight a prominent element of MRP interactions: that of assistance. The issue of assistance was touched upon in the previous chapter, and it will be raised again in users' reports in chapter

chapter 8. I did not obtain this data in order to study assistance via MRP, I simply wanted to see how pairs interacted. The choice to centre the analysis of this study on interactions around assistance recruitment was made because a large number of the observed interactions involved helping. Also as mentioned, this helping was one-sided; the data did not contain instances of remote users helping the locals. This perhaps should not be so surprising given the multitude of evidence that MRP are limited in what they can do. Still this amount of reliance on help should not go unacknowledged. As the fragments show, the participants in this study tended to opt for more implicit ways of soliciting help and of communicating more broadly. This might be due a shyness given to the unnatural context of the task, but also an attempt at maintaining 'face' for one another and a reluctance to impose (see section 2.2.3). Whereas some people might be more comfortable asking for help than others, as seen in the previous chapter, it is still not an entirely neutral act, but, one that can impact the balance of the interaction and reduce willingness to use the technology.

The next chapter will continue building this understanding of MRP as an interactional category, through more EMCA analyses of MRP interactions. This time, I will be bringing an MPR into my home, and using it as a way to receive remote visits. While the present study observed use at an "organisational" setting, with office colleagues doing a specific task, it only gave us a glimpse into short-term use and by people using the MRP for the first time. The formality of the setting and task design may also have prevented users from fully exploring the capabilities of the MRP, in an effort to behave professionally among their colleagues and complete the task on time. The next study complements this by looking at long-term use, by users who eventually become very familiar with having the robot as part of their daily life, and who, knowing one another well, explore the

capabilities of the robot more playfully in the relaxed setting of a home.

Chapter 6

Robot-mediated visits: an autobiographical study of MRP use in the home

The last two chapters have begun building an understanding of the realities of Mobile Robotic Telepresence (MRP) as it is experienced and managed in interaction. This chapter adds to this understanding, through another exploration of interactions in a different setting. Complementing the self-reported accounts of long-term users and the video data of task-driven, short-term use interactions, this chapter will look at interactions by long-term users, in a home setting, obtained within a self-study context. Whilst the studies already presented provide a view into MRP use in organisational settings, they still do not paint a complete picture of the technology — the interview data only shows one side of use, and the collaborative task data only captured short snippets of MRP interactions.

In this chapter I present a longitudinal, autobiographical study of MRP use in the home setting, which examines the social organisation of inter-

actions within a context of familiar, mundane use. Given the obstacles to conducting an office deployment during the lockdown period in 2021, and the real need to interact with friends and family, I used an MRP in my home as a way to receive mediated 'visitors' who I could not meet in person. In addition, as explained in chapter 2 under section 2.1.2, MRP use in the home setting, by long distance couples, has been found be to more conducive to playful use, with users being more forgiving to the limitations of the medium. As such this setting presents an opportunity to see a different side of MRP use and explore the broader potential of the medium. Exploring MRP in the home, and through a self-study set up offered me the freedom to experience and observe MRP in a more extensively, capturing real-world instances of mundane use from start to finish, unhindered by limitations a workplace study or an experiment set up.

This study again takes on an Ethnomethodology and Conversation Analysis (EMCA) approach (see 3.3.3) to examine video recorded data of MRP interactions. In a similar manner to chapter 5, I present exemplary fragments and break them down to identify the members' methods used in communication, and show the observable realities of use. I unpack the more 'procedural' elements of the 'visits' —arriving and departing— and showcase how the qualities of mobility, situatedness and autonomy are employed in the interaction to allow for spontaneity and togetherness.

6.1 Study Approach

This study complements the studies presented in the two previous chapters in addressing the first research question (section 1.2): *How are MRP interactions conducted and experienced in practice?* It relates to the first part

of that research question: *How is robot-mediated telepresence experienced by users?*, as I use an ethnomethodological self-study approach, to draw on my own experience of having an MRP in my daily life and examine the experiencing of togetherness with the other users through the medium. However, the study responds more directly to the second part of the research question, *How are MRP-mediated interactions socially organised in terms of the interactional methods employed by users?*, as it unpacks interaction fragments to reveal the users' actions through an EMCA frame. Whereas the previous chapter examined data from the perspective of the remote users, and looked at task-driven, one-off interactions, the present study looks at long-term, mundane use for the purpose of social connection, with data captured from the perspective of the local user.

6.1.1 Procedure

This was an autobiographical study; I recorded and analysed my own interactions as a local user of the MRP. I kept a Double 3 telepresence robot (Figure 2.1) in my apartment and used it to connect with friends and family over a period of six months, from 27 January to 28 July, 2021.

The main remote users visiting me through the MRP were my mother (M) and my partner (J). Each used the MRP once a week, for visits that lasted between 40 minutes to an hour. These interactions mostly took place in the evenings and were planned in advance. J also made a few shorter visits (of about 15 minutes each) during lunchtime and in the earlier months of the study dropped in spontaneously just to say "hello" a few times. During that time period I also interacted with these two visitors regularly though messaging and video calls.

I was also visited twice by a friend and once by my brother, but these visitors did not show interest in continuing to use the MRP. Specifically, my friend reported finding being able to see me in this way a bit "creepy".

6.1.2 The data

I collected recordings of my interactions through the MRP in audio and video format using cameras placed in my living room and kitchen. This captured a third-person perspective of the interactions and, as such, the point of view of the remote user is not available in the data for analysis. I placed those cameras in appropriate locations in advance of planned interactions and when moving to other rooms I moved the cameras accordingly. I also took notes to help contextualise the experiences in my memory and preserve any additional relevant information.

The corpus of recordings is comprised of 22 video recordings MRP visits. Of these, 11 were with my mother, 8 with my partner, 2 with my friend and 1 with my brother. Several more visits took place with my mother and partner but were not recorded due to lack of planning or because the participants did not want these particular visits to be part of the corpus.

6.1.3 Analysis

I examined my experiences with the robot through the lens of EMCA section 3.3. Unavoidably, my analysis is informed by my own understanding and experience of MRP. The recordings provide rich resources to repeatedly examine moments of the study. They act as 'aids' or 'reminders' for my own understanding of the medium and the ways in which the routine experiences with MRP use produced 'visits', but also provide a way to

share the observable phenomena with the reader and demonstrate how the interactions are socially organised.

I describe the experiences as 'visits', which is also the term participants used to name this kind of MRP use. As such I present the beginnings and endings of the visit, and some routine features of the interactions in between, that demonstrate how togetherness is achieved as an interactional accomplishment. The fragments chosen show incidents typical of our experiences during the MRP visits. I present these using the conventions of conversation analysis (Hepburn and Bolden, 2013) and use *#fig* according to Mondada's rules for multimodal transcription to indicate the time within the transcript when the image was taken (Mondada, 2021). I have used yellow arrows to indicate the movement of the local user and red arrows to indicate the movement of the remote user. The conversations with my mother were conducted in mixed Greek and English (Greek being our native language), but for simplicity they are presented here translated into English.

6.2 Findings: establishing presence and influencing the interaction as a robot

This section presents four vignettes that exhibit typical scenes of everyday life with MRP-enabled visits. The first two address the more 'procedural' elements of visits: arriving and then departing. The next two vignettes then show aspects of everyday 'dwelling' for which MRP seem to provide interesting capabilities. But first, I briefly discuss how pre-visit preparations featured as routine elements of having MRP-mediated 'visits'.

6.2.1 Pre-visit: Preparations

Knowing that people would essentially be present in my home, I often made certain preparations before the visits. The MRP did not require the local user (me) to answer a call, and in that way actively agree to enter an interaction, as is the case with phone or video calls. Instead, the system allows the remote user to start the call when they want. As long as the robot is charged and turned on, they can appear on it.

My visitors, once logged in on the robot could move with relative ease around my flat, and with their wide field-of-view could look at potentially anything in my flat as well as myself from any angle. And they could do this largely independently - without any prompting or permission from me. This felt starkly different to having video calls, where the other person could just see my head and shoulders or things I intentionally bring into the camera's view. As such I became more conscious of what was visible in the flat and its general appearance and state when visitors were to arrive, as well as towards my own appearance, dependent upon who is visiting and the situation when they were to visit.

In that sense, the setting of the social interaction with the remote MRP user and the framing and control thereof has expanded from the domain of the video calling screen (which is largely in control of the local user) to the entire flat (or as much of it as can be reached by the MRP). This is far more difficult to meticulously manage than the static, immobile view provided during video calling. As noted earlier, my flat consisted of one floor, and all of it was accessible by the MRP if I left the doors to the different rooms open. As such, in the first few months of use, I would always tidy up the space before a visit (pick up dishes, fold blankets) in an attempt to control the presentation of the flat and by extension, myself. I

found that doors were also a way to maintain a 'backstage', in Goffman's performative sense (Goffman et al., 1978), as remote visitors could not open doors themselves. Unfolded laundry could be kept in the bedroom, behind a shut door. This changed how the whole flat was viewed, it was no longer my backstage but an extension of my performed self (although over time, I stopped controlling this as much).

6.2.2 Arrivals

Visits start with arrivals: a period of establishing that a visit has started to happen. Unlike telephone or video calls where the transition to the reason for the call follows relatively rapidly after a short greeting sequence (Drew and Chilton, 2000), in the MRP visit greetings would be followed by or mixed with an acknowledgement that the other person has arrived. Then the remote user would drive the MRP out of the dock, occasionally encountering and solving minor troubles and commentating on their actions, followed by a negotiation with me of where to proceed next.

In the earlier visits, those periods were characterised by a lot of awkward laughing, pauses, uncertainty on how to proceed, but also excitement. After 2-3 visits, these interactions became a normal part of our routine, and correspondingly the period of 'arrival' became shorter and more straightforward.

To demonstrate what the social organisation of these arrivals tended to look like I have selected the following fragment (see figure 6.1). In this fragment, J (my partner) is visiting me. The visit had been arranged only loosely; me suggesting to him previously to this moment that he visit some time in the afternoon. This particular fragment took place on the sixth

month of use, and we were well used to the routine of arrivals by then.

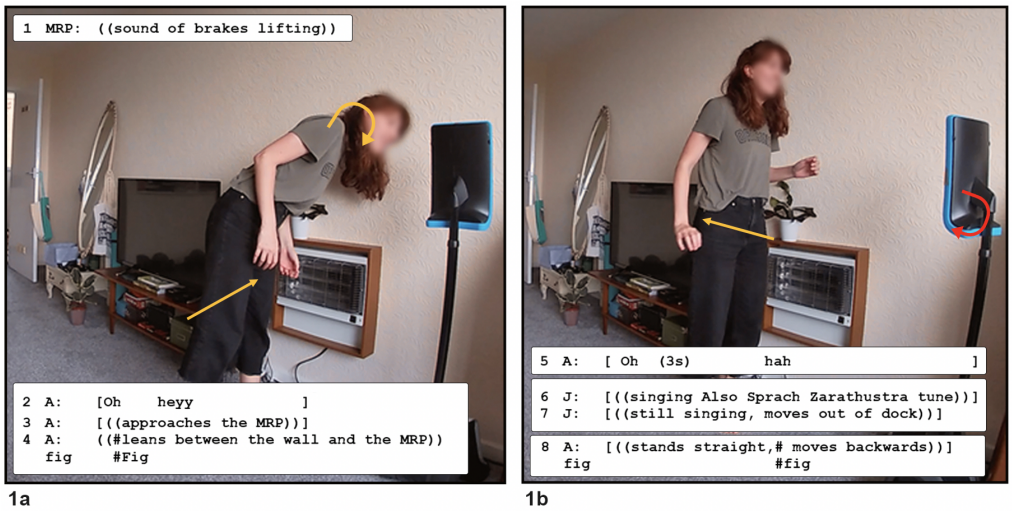

Figure 6.1: Fragment 1.1: The local user welcomes the remote user who has just arrived

The sound of the MRP's brakes mechanism releasing is distinctive (line 1), and indicates that a visitor has logged in. There is an element of surprise owing to the broad specification of "afternoon", but certainly the visit is not unexpected. The sound occasions me to look towards the MRP and produce a greeting (line 2). In Figure 6.1, 1a, you can see me approach the MRP (which is facing the wall), say "hey" and lean between it and the wall to look at the screen. Having logged in, J announces his presence by singing a tune—Also Sprach Zarathustra made famous by the movie 2001: A Space Odyssey—forming a little joke. At other times he would make robot noises, playing into his robotic form. In a way, these nods to science fiction acknowledge the weirdness of appearing as a robot, and make evident the fact that something different from normal (in-person) interaction is about to take place. Still singing, he moves out of the docking station and starts driving towards me. I stand up and take a step back.

In 1c, J is still singing and playfully driving towards me. I continue moving backwards to avoid him. In line 11, after I've once again said hello, J stops singing and acknowledges me using a personal nickname. Within our close

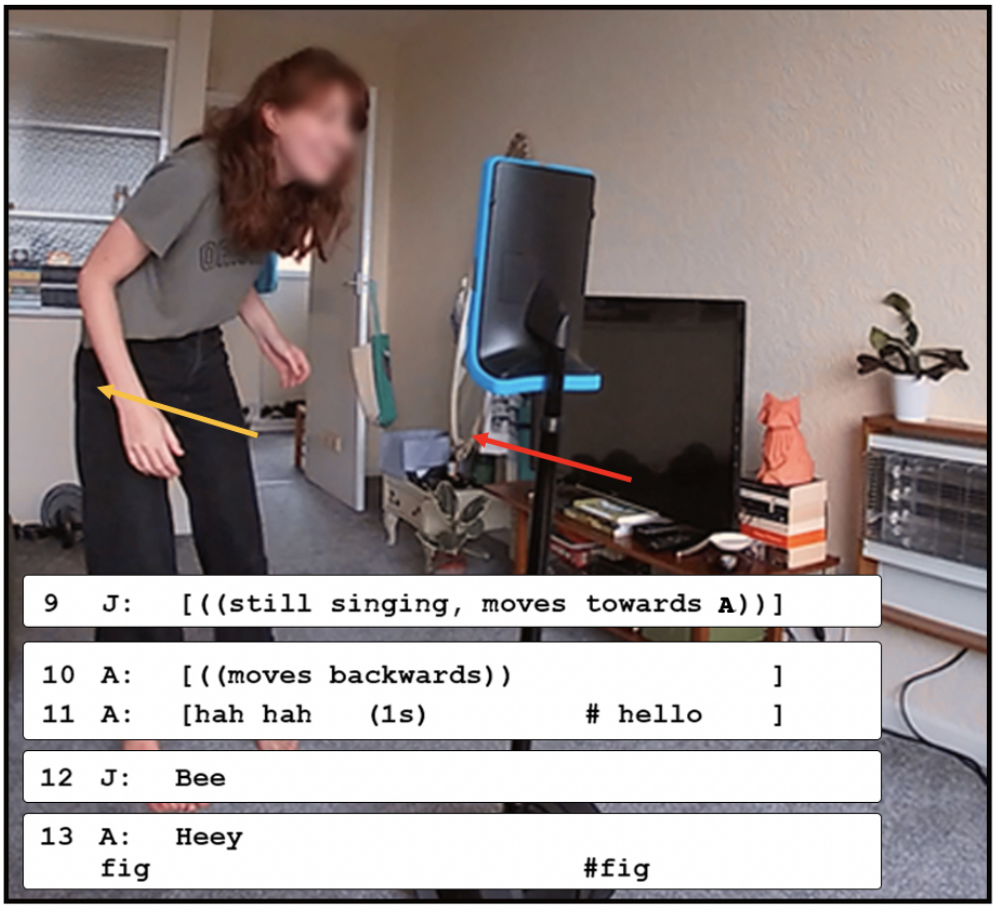

Figure 6.2: Fragment 1.2: The local user welcomes the remote user who has just arrived

relationship, this acts as a greeting. I say hello again, and then we proceed to talk about how our days have been.

What we see happen is that at the beginning of the visit, the remote user establishes their presence and capabilities, and the tone of the visit is set. A significant element of this is connected with the remote user's autonomy and ability to express that autonomy in various ways via the MRP's technical capabilities.

Another part of this has to do with the way MRP visits start. I do not answer a call; rather, the visitor, J, arrives on his own. As soon as he logs in, he is within my space. The sound of the MRP's brake lifting can be

said to act as a summons—hearing it informs me that J is here and that I should join the interaction (Schegloff, 2018). In that sense, it is akin to the ringing of a doorbell or phone. However, unlike in those cases, I do not have the option not to answer, or to wait —to take a moment to prepare—before answering.

Still we see that, in this case, the visitors take the time to announce their arrival, and in doing so perhaps they mitigate the intrusion.

The visitor is also technically free to arrive at any time they choose, albeit, in our case, within the parameters of the prior visit 'frame' that has been established between us ("come visit me in the afternoon" as opposed to "come visit at 3pm"). As noted earlier, I, as the local user, do not need to answer the 'call'. The remote user can be spontaneous, in line with the possibilities created by this prior framing of the situation.

J also makes a show of his ability to move as part of the start of the visit. This is not strictly 'necessary' since it is possible to hear an MRP user by voice alone, however J integrates the initiation of movement with his arrival. In other words, the movement, the singing by J, the appearance of J on screen, all constitute what it means to 'arrive' at my home. Of course, these ways are intimately bound up in our particular relationship in determining what is relevant, appropriate ways of using the MRP to reflect this relationship. In this sense, the arrival is not just anyone's arrival, it is J's arrival at my home.

There is also close coordinated action from myself with respect to this. I am not in control of the remote's position and actions (of course, a local user can forcibly power down the MRP). As such, I need to adjust my own actions to those made by the MRP user. In this fragment, I come up to the MRP when I hear the distinctive sound of it 'coming alive', and orienting

to this as an 'arrival', arrange myself so that I can correspondingly receive that arrival appropriately: I place my face between the wall and the MRP by leaning, so that I can be visible to J, reciprocating acknowledgement of this arrival. When J is out of the dock, I ensure that I am visible by standing directly in front of him. When J moves towards me, I need to move backwards to avoid the MRP but also to 'play along' in the game of movement he initiated. In 1c, whilst moving backwards to avoid him, I also lean forwards, so that I can see his face better and so that he can see mine—as he has chosen to keep the MRP at the low height. So in being a local user I must move along with the MRP and position myself sensitively to the way J acts in the MRP.

The arrival of the remote visitor thus entails a whole range of *coordinative actions*—bodily, verbal, mechanical, etc.—which present quite different phenomena (and interactional possibilities) to standard video calling systems. These actions are put to use in effectively welcoming the MRP user to the home space, and they are attentive to structuring the start of that visit.

6.2.3 Departures

In principle, a remote user can depart from the interaction at any time by shutting down their software client. However, this leaves the MRP away from its docking station, and source of charging. It would also result in the MRP being left in a potentially inappropriate place within the local space, acting as an obstacle or annoyance, and so on. So, departing is not just about 'saying goodbye' but also about 'parking' the MRP—departing 'considerately'. Having used MRP previously, and having read the literature, I was well aware of this. When it came to my visitors, I suggested to them

on their first visits that it would be nice of them to park the MRP before logging off, but I did not pressure them about it. Nonetheless they understood that it made sense for them to do it, and on most visits they took it upon themselves to do so—even though this usually meant remembering to do it last minute during the "goodbyes".

In most departure sequences the guest announced their intention to park and I accompanied them to the docking station. It is pointed out in literature that side sequences or insertion sequences might prolong or interrupt a leaving process several times (Jefferson, 1972). Button has also shown that the sequential organisation of closings allows for mutually achieved movements out of the closing (Button, 1987). So, on the MRP, an announcement that it is time to go is not the departure itself but the *occasioning* of a coordinated sequence of actions that then lead to the actual end of the visit. This announcement was usually followed by the remote user remembering, and often saying out loud, that they need to park, followed by them moving towards the dock, me accompanying them to it and more goodbyes on the way, somewhat similar to escorting an in-person guest to the door.

Like arrivals, departures come to be mutually organised in particular ways, the features of which I unpack in this section. I have chosen the following fragment for brevity as it contains less talk than many other instances of departures, with their often prolonged sequences. As with the arrivals, departures became shorter and more routinised over time, as the remote users got more adept at driving the MRP. That said, closings would still contain conversation sequences that would often prolong the remote users' completion of their departure (i.e., exiting the MRP client software). The following fragment is from the third month of use, where my mother, M, is completing a visit.

Figure 6.3: Fragment 2.1: The local user sees the remote user off at the end of a visit

In 2a, we have already said goodbyes—the terminal components of a closing sequence, according to Button (1987)— when M remembers she needs to park. Button's analysis reveals that movement out of closings occurs either before the terminal components or at the first terminal component. But here we see that the MRP's "necessity" for parking can lead to this more unusual pattern. As such, instead of ending the call, M exclaims, "A wait I have to go park". Her use of this turn also deviates from an expected movement out of closing, where someone would signal that they are open to continuing the conversation but let the other speaker "lock" that movement by responding. M establishes that we are interrupting the closing altogether in one turn. This is, in part, due to the MRP simply requiring parking; it can't be helped and it isn't something we need to mutually agree on. I do tell her that I can park it myself but the prolonged sequence is already in motion; she proceeds to drive to the dock herself ("wait I'll turn around", line 8). In that sense, as will be discussed later, she has a degree of control over the interaction.

The closing sequence is thus prolonged with several more turns. At this

point we haven't entirely moved out of closing, we are still working towards it. Despite our intentions to say goodbye however, the duration of this sequence is dependent on however long it will take for M to park. It should be noted also, that the additional turns create more space during which further sequence types that can more drastically disrupt the closing can occur (Button, 1987).

In addition, as the sequence takes place along with movement around my flat, the environment—our seeing it whilst moving through it—provides more opportunities for interactions too. Indeed, in 2b, as she turns around, my mother notices that the electric fireplace is on and comments on it. We can see in this, the basic mobility of the MRP and the ability of the user to do casual 'looking' (explored in the next fragment); this is crucial as a resource brought to bear during moments like this, in this case prolonging the 'goodbye'. This happened often in our interactions. For this particular case, we were both quite tired, and although the fireplace is brought into play, I do not take it up as a possible opening for further talk (instead: "Mhm").

As frequently occurred, docking is not a trivial activity and requires some measure of skill (and practice). So, some trouble is encountered on the journey to the dock. In 2b, the angle at which the MRP arrived after the turn is not appropriate; M finds herself driving towards the dining table, then accounts for the trouble with a "no no no no"—almost as if she is talking to the MRP (which she named "Yonas"), asking it to stop, whilst alerting me to the emergence of a problem. This time M fixes the problem herself by stopping and adjusting her angle to face the right direction. She then proceeds to move forwards in a straight line and, as we see a second later, in 2c, she arrives close enough to the docking station so that she can park.

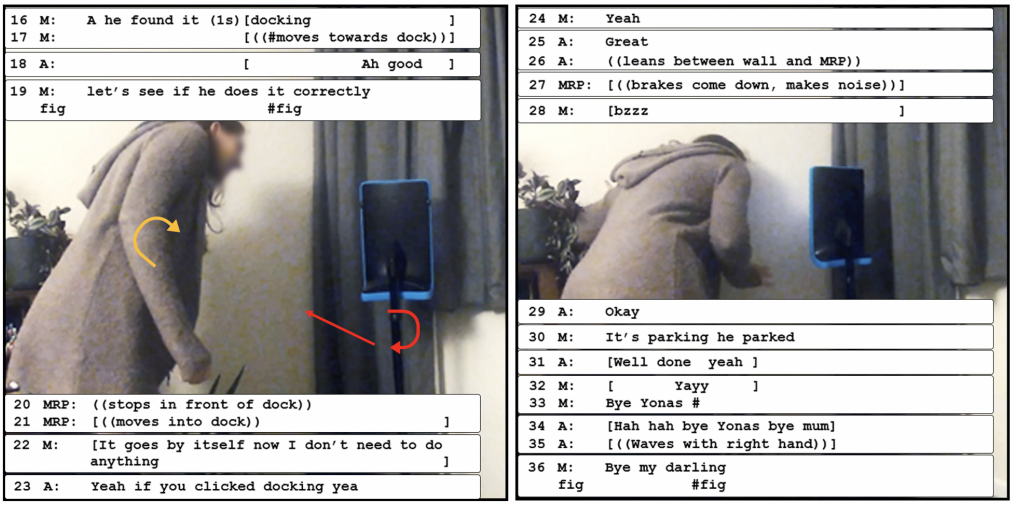

Figure 6.4: Fragment 2.2: The local user sees the remote user off at the end of a visit

In 2c, M finds the docking button and announces it. I lean in closer to look at her. As we saw in the previous fragment, as a local user of the MRP, I became sensitive towards how visible I was to the remote user. Similarly here, part of doing 'departure' and escorting involves maintaining my own visibility to M (i.e. working to support some measure of reciprocity of perspectives). On her side, M displays her involvement in or engagement with docking by narrating the process: "let's see if he does it correctly", "it goes by itself now". This mutual show of engagement between local and remote in what the MRP is doing and being made to do is vital to what makes the visit. This way of verbally explaining what the robot is doing or should be doing can be comparable to the status reportings made by users in the previous study, as it serves to let me better understand what struggles she is facing in operating the robot and how much of the robot's behaviour is her doing.

In 2d, the MRP has been docked, M playfully imitates the buzzing sound of its brakes. She then announces that it has parked and I jokingly congratulate her for managing to do it all without help. Often at this stage in

a departure, further topics of conversation might emerge, temporarily moving us out of closing. There have been visits where I have been standing in that position—leaning between the wall and the MRP—for extended periods of time chatting with my mother. This is perhaps akin to a 'doorway conversation'.

In this instance I simply congratulate M at the successful parking and say goodbye. M then says goodbye to the MRP, which she often refers to and treats as a separate person ("Yonas"). This separation between the equipment and the user routinely plays a strategic role in coordination with remote users. This can be taken as 'strategic', not to imply intentionality, but to suggest that its use enables remote users to momentarily call attention to, to foreground, the MRP itself and distance themselves from its behaviours. In other words, it is another method to account for possible troubles in interaction between local and remote user.

This fragment shows how an MRP visit closes, and like the arrival, demonstrates how the particularities of the MRP play a role in social interaction. For instance, having to drive to the dock gives someone various opportunities to expand on their goodbyes, to notice and spot things which open up further topics for discussion (e.g., the fireplace). When this happens, we don't entirely move out of closing, as parking is a necessary part of closing, but the closing sequence, from its initial components to the terminal components (goodbye) is likely to contain many more turns. Indeed as shown here, (although not necessarily always the case) upon successful parking, the closing sequence is not re-initiated—it is mutually acknowledged that a closing is taking place. It is simply completed.

Because the MRP is quite slow, these possibilities arise at a certain temporal pace. Of course, this is not a necessary condition for mediated intimacy,

and the slowness of the medium is not by design. It is simply another interactional possibility furnished by the MRP that may be used as a resource by local or remote interactants.

Finally, like arrivals, there is a significant role of the capabilities of the MRP both enabling the remote user to engage in courses of action (like moving away from the dock, or moving to the dock), but also for the local user to accommodate and attend to the remote user. In this sense, whilst arrivals and departures have their technical considerations (e.g., is the MRP functioning in a desired way?), they also integrate demonstrations of how the MRP creates a dynamic where the local user bears some responsibility for the remote user and needs to cater to their actions. In the context of intimate relations, this can manifest as a way of caring, but in other contexts it could be perceived as awkward or burdensome,

6.2.4 Looking around

Quite naturally visits contained many instances of 'looking around' and also more pointedly 'looking at things'. The basic mobility of the MRP enabled both of these—i.e. unfocussed and more focused 'looking'. Whilst this may seem trivial, it forms a key part of much of what is entailed in a visit, how a space is treated both by occupant and visitor, in and as the situation of their particular relationship. For instance, a remote user might comment on objects visible in the environment as they moved about—perhaps brought about as a result of a change of perspective as seen in the previous fragment with M commenting on the fireplace. The remote user might notice new items in the flat—new furniture, kitchen appliances, plants— or changes in the view out of the window. 'Looking around' in the course of doing other things with the MRP user would lead to conversations about matters

of personal significance to myself and the given visitor (e.g., relating to a shared interest, or items with family history). The long-term use of the MRP, repeated and habitual visits and the access to my personal space over time allowed something like the features of 'dwelling' to arise, where changes (plants growing, changes in the view from the window with the seasons, a new object, etc.) became available for topicalisation in talk, and in doing this, myself and a visitor (such as my mother or partner) could better maintain a sense of growing together even in a period where we were essentially forced to be apart.

Here I show a fragment from the first time M visited the flat. Whilst early in the study, this interaction is a clearer example of a phenomenon that persisted.

Figure 6.5: Fragment 3.1: The local user prepares coffee whilst the remote user explores the kitchen

In this fragment, M and I are in the kitchen. I am making coffee whilst she is looking around. We have taken up stances in the space that anticipate the thing being done. So, M is positioned in the middle of the kitchen—a straight line from the door through which we came into the room—towards which she will subsequently move backwards. Meanwhile, I will be moving back and forth to the two sides of counters, in a perpendicular path.

M sees the microwave in front of her (3a, not visible in pictures) and exclaims "ah and here is the microwave". She then starts moving backwards in reverse, and at the same time I move to the other side of the kitchen, coordinating our positions in the kitchen.

Whilst still moving, in 3b, she says "come back a bit to see the kitchen". The imperative "come back", here, is not directed at me but at the robot. We can infer this because she then starts moving backwards, as well as from the fact that she regularly addresses the MRP in this way (as shown in the previous fragment too). With such remarks, she is building a distinction between the MRP and herself. This can also be heard as an account of what she is trying to do and perhaps indicate that she finds the MRP a little challenging (like the trouble reporting remarks presented in chapter 5). While she is still moving in reverse, I switch back to the side of the sink. We nearly bump into each other but I manage to avoid the robot. It's worth restating here that the robot is moving rather slowly in comparison to a local user and that the local user often needs to take into account the capabilities of the MRP; in this case the inability to glance behind. Whilst we are both able to move independently and 'multi-task' to some degree, there is still a significant asymmetry in capabilities between us—I can move faster as well as interact with objects in the environment. This is another example of a "fractured ecology", as my mother and I have different access to the environment and what is happening in it, as well as differing capabilities to monitor each other's gaze and intentions, thus affecting the understanding of our mutual perspectives (Luff et al., 2003).

As M is going backwards, she accounts for her noticing the little chair with "and the little chair". I have translated this from Greek, in which little chair is a single word in diminutive form. The chair is indeed little in size, but the phrase also carries an endearing meaning as it is a chair

I have had since childhood. Without having to look, I understand what she is referring to because I know what exists in my space, and have some familiarity with what my mother will be able to see from her position. As we see later, my mother clearly names the things she notices, as the first step towards topicalising them, which also contributes towards us mutually orienting to the objects. Because mutual looking is somewhat difficult with the MRP—one can cannot estimate gaze easily, although gross direction is available—we can see that users develop methods of aligning practices of looking, particularly at objects —an example of compensatory work (Hindmarsh et al., 1998). Here, the naming of objects verbally provides for this between M and myself.

I proceed to explain to my mother that I now use it to reach the window handles, briefly looking up and pointing at the windows before moving back to the right side of the kitchen and continuing to prepare the coffee. Earlier work on video-mediated conversations has looked at how showing things is accomplished from an EMCA perspective (Licoppe, 2017). Whilst a local user might still bring an object into view of the remote user, similar to video conferencing, we see here that conversation around objects can be initiated (or sustained) through the remote user's autonomous looking around in the environment (coupled with the aforementioned methods of coordinated looking).

In 3c, no longer moving backwards, M points out the carpet. Again using a diminutive form to refer to it, more as a form of endearment than a comment on the size. We had previously spoken about how I wanted a carpet for the kitchen. "Yeah do you like it?" I ask her, without shifting my attention from the coffee. "I like it!" she replies with some emphasis. M mentions a problem with "Yonas" the MRP not "going further back": M is unable to see the door of course, which I remind her of. As I finish

Figure 6.6: Fragment 3.2: The local user prepares coffee whilst the remote user explores the kitchen

making the coffee, we continue talking about the kitchen.

One of the possibilities opened up by the MRP is the autonomy of looking (as an interaction activity). This is enabled both by its mobility and some measure of legible 'intentionality'—that I can roughly see what M is likely looking at by inspecting the MRP's orientation. This fragment shows just some of the ways in which M is able to locate parts of the kitchen on her own ("here is the microwave"). She is also able to topicalise things which are meaningful to our relationship ("and the little chair"). In and through this she can demonstrate a parental interest in where I am living and what my flat is like. The importance of this has been noted in previous studies of mediated intimacy (e.g., Vetere et al., 2005).

The MRP, then, allows the remote user to do that and, importantly, to demonstrate that they are doing it on their own accord, rather than relying on the local user to show them things. It is not a one-sided interaction, but one in which the remote user can also take initiative and influence the definition of the situation, unlike, for example, when a home is being shown in video-calling, where the home's host can control what the other person is seeing (Licoppe and Morel, 2014). Here, the remote user themselves is instead able to select what areas of the environment to look at and topicalise (and need not request it as they would need to do in the video-calling example).

At the same timem the local user loses some resources to act as a guide, and as shown in previous examples, has to respond to the remote user instead. The current fragment also reveals some of the ways the local user—myself—must further accommodate the remote user's autonomy of looking, by stepping out of the way, so as to to avoid obstructing their view. The fractured ecology may limit the host's control of the situation, as they are not entirely able to monitor the remote user's gaze (Luff et al., 2003). The remote user can 'hide' in a sense behind the flatness of robot's screen and lower fidelity of the camera—they can even zoom to parts of their view without the local user knowing they are doing this. So whilst limited in their mobility and perceptual abilities, the remote user has a certain freedom in leading the activity.

6.2.5 Being together

Some aspects of the visits were what might otherwise seem to be non-moments: gaps in more obvious moments of interaction that nevertheless are replete with possibilities for sharing intimacy. These are difficult to

describe, in that I found many points where I was simply with the visitor and seemingly doing little more than sharing the space. The physicality of the MRP enables a visitor to do this readily: to be 'present' with the local user, without much conversation, little obvious 'interaction' in a conventional sense, but nonetheless a strong sense of togetherness, 'dwelling' as described by Ingold (2011) i.e. the intransitive act of being together as life is lived (O'Hara et al., 2014). Such moments were common throughout in our interactions via the MRP.

In the following fragment I am making coffee in the kitchen whilst my partner, J, is observing me (and he is himself eating his lunch). Making coffee often happened in the beginning of a visit. I would then take my coffee to the living room and continue a conversation with the visitor there.

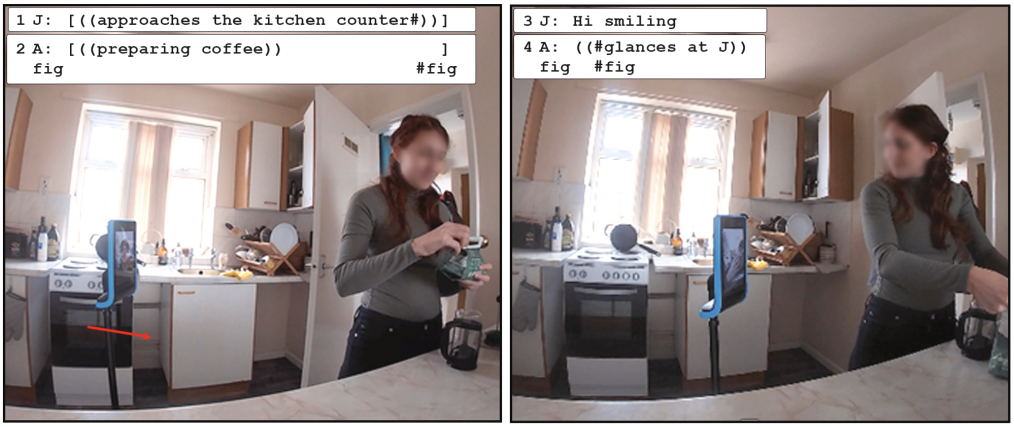

Figure 6.7: Fragment 4.1: The local user makes coffee while the remote user is observing her

In this fragment, I had told J to follow me into the kitchen where I would make a coffee. In 4a, after arriving in the kitchen and looking around, J sees me by the counter and approaches. In 4b, J has positioned himself next to me, to watch me making coffee as he is eating his lunch. He comments, "hi smiling" presumably having seen that I was smiling and I briefly look sideways at him.

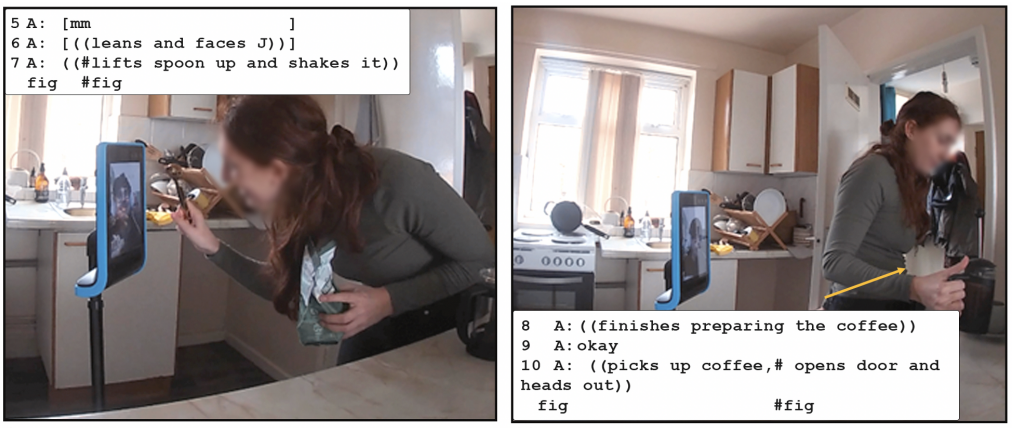

Figure 6.8: Fragment 4.2: The local user makes coffee while the remote user is observing her

In 4c, a second later, I respond with an "mm?". As I do this I turn and lean towards him so that my face can be in his frame of view. I also lift the spoon I was using, making it visible to him, and wave it playfully. To me, the spoon is significant because we bought it together; so J's intentional presence by my side watching me, and the relevance of the spoon as not just any spoon but *this particular spoon* then leads to that moment in 4c. In 4d, I finish making the coffee, "okay". I pick up the coffee, open the door behind and exit the kitchen, while J follows me.

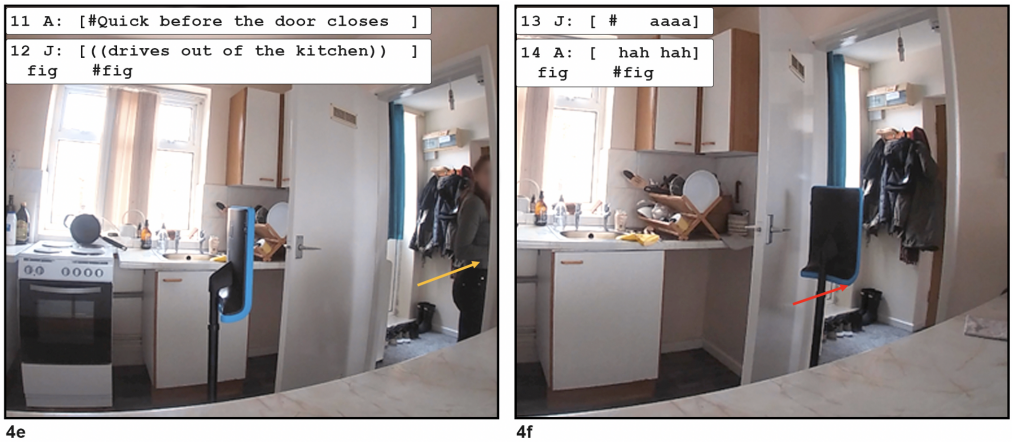

Figure 6.9: Fragment 4.3: The local user makes coffee while the remote user is observing her

In 4e, J turns towards the door to exit the kitchen too. Given the slower speed of the MRP, it takes him a while to follow me. The door begins

to close by itself while he is still moving through it. Seeing this unfold, I say "quick before the door closes". As he is moving, J screams "aaa" but manages to exit on time. It is a spontaneous moment of fun amidst our routine of coffee making, which comes about in part because of the physical capabilities of the MRP, coupled with a lapse of sorts from myself in ensuring J could exit the kitchen so as to move along with me.

There are many technical aspects that can be drawn out of this fragment. The resolution of the camera and the see-ability of the spoon as 'this' particular spoon, or the difficulties in moving swiftly around with the MRP. Yet at the same time, the distinctive formation of 4a points to the ability of the visitor and myself to very recognisably 'be together' in some sense. As such this fragment attempts to capture some of the subtleties of intimate 'non-moments' that would happen regularly across our use of the MRP. Being in the presence of the other person, even if they are not doing much can be enough. Speculatively, if J were to watch me make the coffee via a phone or laptop using video call, this sense of 'being together' would be different because the added dimension of mobile autonomy would be absent. Thus, it is perhaps the fact that he is observing me on his own more autonomous terms that makes a difference. As such, the possibilities of this physical autonomy of the remote user helped make such presence feel intimate. He chose to move to the position in 4a and sit and wait for me. This formation enables the smile, commented on in 4b, as a fleeting and routine smile done and readily shared with the other in the course of a familiar activity of making coffee.

We also see an example of playfulness in this fragment. Instead of holding the door open for J, I let the door close on its own and leave J to race to get out in time. Both of us laugh about it. Simply, this arises from the fact that visits like this with the MRP mean two independently moving people

in this space and not one controlling the position and view of the other. At the same time the (opportunistic) joke which unfolds acknowledges the limitations of the remote user. In having him "race" against the speed of the closing door, the slow speed of the MRP is funny. In the context of intimate interactions, in a domestic situation, the limitations of the MRP may well be approached in a very different way or attitude to other contexts. In our case, they had potential to become sources of play and conversation rather than frustration, something which has also been noted in the case of network distortions in couples' video calls (Rintel, 2013).

6.3 Summary and discussion

6.3.1 Summary

This chapter presented an ethnographic self-study of MRP use in the home setting, applying an EMCA approach to examining video-recorded incidents of interaction between the local and remote users. Notably, this was a longitudinal study, looking at mundane and familiar use. Continuing the work of the previous two chapters, the present study sheds light into the experiences and interactional details of communication via MRP, in a setting that enabled unrestricted exploration of the medium's potential.

The analysis presents fragments of use where calls were conducted as "visits"—showing the procedures of arrivals and departures as well as typical activities performed during the visits driven by the capabilities of the MRP medium. In taking the study to the home environment, and exploring more extended calls —as opposed to the 3 minute structured tasks of the previous study— it was also possible to examine the sequential elements of

MRP interactions, that is, to see what is entailed in an entire call. Given that the medium takes the form of a 'body' and is situated in a real space, the remote user must arrive and leave that space. We see then interactions resembling arrivals, with users announcing and establishing their presence, and departures —which are extended over time and physical space— as the two users walk to and from the docking station.

The study also shows examples of how the MRP can be used within visits to look around the local environment and share moments of togetherness. These interactions demonstrate different ways of leveraging the affordances of the MRP, to those presented in the previous study. Namely, the fragments show how movement in this case opens up the interaction stage to all the accessible areas of the local environment and allows for organically topicalising anything visible in it. In addition the study shows how the movement, through enhancing the remote user's autonomy, changes the dynamic between the interactants, with the local user having to follow, respond and cater to the remote, but also allowing for moments mutually achieved playfulness and togetherness to emerge.

6.3.2 Discussion

This study addressed the first research question —*How are MRP interactions conducted and experienced in practice?*— though an autoethnographic mode of study capturing both my own experience as a local user, and the interaction between myself and my remote visitors. As such it addresses both parts of the research question —*How is MRP-mediated telepresence experienced by users?* and *How are MRP-mediated interactions socially organised in terms of the interactional methods employed by users?* — although with a stronger emphasis on the second part. This study

contributes towards building an understanding of MRP by showcasing the procedural elements an entire visit (or call) — arrivals and departures — which help users orient towards the robot as a visitor. With the movement of the MRP, the local environment becomes the stage of the interaction, and is open to topicalisation. The movement further, enables of a degree of autonomy for the remote user, allowing them to influence the direction of the interaction and take part in achieving moments of togetherness.

As in the previous two studies, in the fragments presented in this study we see a considerable amount of work done by users to establish themselves in the space in ways that make sense and allow for communication and connection, and thus allow the remote user to be incorporated into interaction.

In the first fragment in particular, showing the remote user's arrival into the environment, we see the remote user make quite a show of their appearance. This could be because, on its own, the start of an MRP call is interactionally unusual. First of all, the MRP call starts abruptly with the remote user simply deciding to log in — it does not require a mutual agreement (unlike, for e.g., picking up a phone or opening the door). Then, when the MPR logs in and the call starts, very little happens to showcase that and necessitate a response. While the screen changes to showing the face of the remote user and the lifting of the brakes makes some noise, it is possible for the local user to not notice this if they are not near the MRP. As a result, the users enact an arrival procedure, announcing their appearance and establishing their presence. Building on from points raised in the previous chapters, this can be seen as an attempt by the users, on both sides, to do 'being ordinary', to lend a form of normality to the weirdness of having someone embodied in this way. Indeed, part of the work done by the remote users also serves towards showing to the local user their perspective — distancing

themselves from the robot by referring to it as another person and verbally reporting on its processes. Similarly, a departure procedure takes place at the end, to achieve a natural end to the call.

Another insight drawn from the observed interactions is how the autonomous movement of MRP shapes the behaviours of both local and remote users. It enables the users to interact on a more equal level—with both participants being able to show initiative, express interests and exert influence over the situation. In placing cameras in the local environment and through an attention on the local user, given the autobiographical nature if the study, we are able to see the embodied movement of both users and examine how the features of the MRP enable this. Indeed, as the data shows, the local user is moving as much as, if not more than the robot. And more interestingly, the local user is moving largely in ways that are responsive to the MRP. In the first fragment I move backwards, for example, to play along with J's playful arrival, and at the same time, I bend down, positioning myself in such a way so that he can view my face. In the second fragment, I follow behind M as she tries to return the robot to its dock, focused on whether I can provide any assistance, and again making myself visible to her at the end even though she is facing the wall. There is a rather distinct distribution of control and responsibility then in MRP, where whilst the remote user is often in need of assistance and limited in what they can do, their autonomous movement also allows them to direct the interaction.

The study also shows that through movement, the remote user is able to access the environment; the home, the objects in it and the actions happening in it. The space shapes how people move and becomes part of the activity. For example, the route between a current location and the docking station dictates the length of the departure sequence. Obstacles in the environment also present more opportunities for interaction. This

can involve recruiting help to overcome the obstacle, commenting on it as a way of making the users' perspective known, or even leveraging it as a chance for conversation and play (e.g., racing with the door). The environment is also more broadly topicalisable — it can become part of the conversation in natural and spontaneous ways. This further influences the local users' behaviour as she then views the environment through that lens. The environment is a stage to be prepared for interactions. During visits the local user also interacts with the environment as a response to the remote users; noticing the things the remote users draw attention too, moving so as to avoid colliding with the robot, holding doors open (or not). The design of the environment then plays a vital role in how MRP experiences unfold.

Finally, through seeing the data from this point of view, the analysis also highlights how the users' autonomous movement in the local environment can contribute towards building a sense of togetherness and shared presence in the space. The dynamic of the interaction afforded to both users allows for more mutually achieved movements, moments in which both users arrive at together, rather than one side instigating things. This can lead to a subtle sense of togetherness, such as when the remote user 'simply' moves towards the local user to show interest. What gave meaning to that moment was that J arrived there on his own. This can also allow for more overtly intimate moments, such as the playful arrival procedure or the spontaneous challenge to race against the door. Those moments were possible not simply because the remote user could move, but because the movement allowed for a more equal dynamic between the two sides. As such, this feature sets MRP apart from traditional video calling, not because it simulates 'being there' more accurately than other media, but because of its own set of interactional possibilities that are drawn upon to achieve a sense of co-

presence. What is evident from this analysis is that mobility in this use case works because it provides autonomy. As will be further explained in the discussion chapter, such movement does not inherently enable participation in remote and hybrid spaces, it does so only in as far as it give the user autonomy to act in ways that are relevant to the activity.

This chapter concludes the first part of the this thesis, which was concerned with building an understanding of MRP interactions. The following two chapters will present the second part, which is concerned with the suitability of MRP for organisational settings. Taking insights from these first three studies onboard, the next two studies look at an office deployment project to examine the application of MRP in such a space. The next chapter will present a case study into the practical realities of carrying out the deployment and making the robots available in that space.

Chapter 7

MRP at the office: a deployment case study

Entering the second part of this thesis, which is concerned with the practical application of Mobile Robotic Telepresence (MRP) in organisations, this chapter presents a case study into the work and practical considerations of deploying MRP in an office setting. Whilst there are studies that report on the use cases of MRP in offices (e.g., Tsui et al., 2011; Lee and Takayama, 2011) and the marketing of commercial telepresence robots presents them in that setting (Figure 1.2), there is little to no publicly available information and discussion on how this is to be accomplished (i.e., what is the process for implementing an MRP into an organisation? what is to be done once an organisation has purchased one?). In this study I contribute towards filling in that gap by reporting on the work undertaken during a deployment project that I was a part of. In this chapter, I present the matters that were raised during this project and how we resolved them. This work constitutes a discovery process into how to carry out a robot deployment in an organisational setting and what is entailed in introducing MRP into

a workplace. Given the lack of information and discussion on the practical matters of deploying and using MRP in the literature, this case study offers insights into the process and serves initiates a conversation into these considerations.

The deployment project took place at the offices of Microsoft Research in Cambridge. The company purchased telepresence robots with the intention of making them freely available at the office for employees to log into and use when working remotely as a way of fostering a flexible work environment that supports hybrid work. However, in deploying this initiative, we realised that there were a few steps that had to be carefully completed before it could be possible or sensible for employees to have access to the robots. In holding a Health and Safety risk assessment, it became evident that certain measures had to be put in place to ensure the safe and inclusive use the robots. In addition, drawing on the insights from the studies presented in the previous three chapters and the literature review, we understood that the suitability of MRP use in the office could depend on various factors, such as the set up of the space and the characteristics of the hybrid interactions (types of tasks, team configuration). We were also weary of the communicative asymmetries that the medium could introduce and the potential for unpleasant interactions (for example, previous literature has reported on bullying and disagreements on etiquette, see subsection 2.1.3). There ought then to be some support in onboarding the prospective users of MRP in order to safeguard against some of the shortfalls of the technology and encourage effective use practices. As such, this deployment involved the creation of procedures and informational material, in response to those matters of safety, security and use practices. As already stated, there was no information available on how to carry out such work, resulting in this project being a highly iterative learning pro-

cess. This highlighted new insights on the practical matters of deploying MRP. As explained in chapter 3, section 3.4, this case study takes on an Action Research approach. That is, knowledge is gained through doing the work of this real-world practical project, to improve our understanding of the medium. In describing the deployment in this chapter, I outline the occupational Health and Safety assessment process and the work done addressing the accessibility, safety, security and spatial placement of the robots as well as the design of boarding information. Finally, I describe how MRP was introduced into the prospective users and their response to the project.

7.1 Study Approach

This work addressed the second research question: *How suitable is MRP technology for supporting hybrid spaces in organisations?* Specifically the first part of this question: *What are the practical considerations and challenges of deploying MRP technology in an organisational setting?* This is answered in the present study through through an Action Research approach, reporting on the actual process of deploying MRP in an office.

7.1.1 The deployment

The deployment took place at the office building of Microsoft Research in Cambridge, UK. The company purchased 5 telepresence robots, of the model Double 3 by Double robotics (section 2.1.1); one for each floor of the 5 floor building. The project was lead by the HCI team of the company, of which I was a member as an intern. However, as explained further, the work involved collaboration with several other stakeholders and experts.

Whilst the robots were purchased in 2020, the project did not begin until May of 2021, when enough people had returned to working from the office to merit using the robots. As participants suggested in chapter 4, there is more value in having the MRP when the remote user is a minority among people who are on-site, rather than when the majority are working remotely. Moreover, it was valuable to have people in the office to assist with the deployment, given that it involved large physical devices moving in the space. The table below provides an overview of the different elements of the deployment, the time required for each one and the stakeholders involved in the process. The next section describes each one in more detail.

Table 7.1: Tasks required for the roll-out

Task	Time frame	Other teams involved	Section
Risk Assessment	5 weeks	OH&S, IT, Facilities	7.2.1
Accessibility	2 weeks	Users	7.2.2
Safety	2 weeks	IT, Facilities	7.2.3
Security	3 week	IT	7.2.4
Robot Placement	Iterative	Users, Facilities	7.2.5
User Guidelines	4 weeks	Office Outreach	7.2.6
User recruitment	5 weeks	Of. Outreach, Facil., Business Admins	7.3

7.2 Practical work of the deployment

This section begins with describing the Occupational Health and Safety risk assessment process and then proceeds to explain each of the areas of consideration in more detail. These include: accessibility, safety and robot maintenance, security, robot placement and information on use.

7.2.1 Occupational Health and Safety

The team decided to hold an Occupational Health and Safety (OH&S) assessment after it was suggested by several people at the company that one should be held before deploying the robots. That is to highlight that there was no prescribed, default process for introducing robots into the office. Rather, holding the assessment was something we actively opted in for in order to ensure that everything was done appropriately. Indeed, whilst MRP have been used in office settings before, including at the same company by specific employees or for studies and events, there is not information on procedures for OH&S assessments. Concerns over OH&S-related issues have not really been flagged within the existing academic literature or discussions, nor within the company. A key difference however, which prompted our caution in this case, was that our aim was to make the robots "freely available" at the office. That is, the robots would not be assigned to a specific employee or provided for specific use cases (as has been the case in previously). In addition, the MRPs were not to be monitored by us throughout their use. Instead, they would be placed in the office such that any employee could log in and use them at any time. For this kind of deployment it was thought best to proactively safeguard against any potential issues.

First, we had a video call with the external OH&S consultants, during which we described to them the MRPs and the scope of our project. Unsurprisingly, they had not dealt with such robots or anything similar before. Naturally, they asked for any information or reports we could share from similar past cases. After searching online, as well as contacting Double Robotics, we discovered that there was no information available on OH&S for MRP in offices —even Double Robotics did not have any previous risk

assessment cases to share with us. To aid the consultants with their initial work we sent them photos and videos of the Double 3 robots, and information about the product's specifications.

They then followed standard practice and proposed an on-site assessment; they had to see the robots in action, in person to understand what potential risks they can pose. However, since the first opportunity for a site visit was not possible for several weeks, we invited them in the meantime to experience the robots as remote users. During their remote "visit", we showed them how to drive and operate the robots. The two consultants drove the MRPs around the office and tested how they moved and how they dealt with avoiding various types of collisions (such as avoiding hitting furniture or a person abruptly walking into their path). In this way, the consultants were able to see each other as robots in the office, so they saw both the perspective of a remote user and how the robot might appear to on-site employees. As a result of this remote visit, they decided that a site visit was not needed. Apart from some follow-up clarification questions (e.g., what is the speed of the robots, what happens if they run out of battery), they had all the necessary information to draft the assessment report.

In their assessment, OH&S rated all potential hazards as low risk — meaning that they were deemed to have very low likelihood of occurring and/or posed slight or negligible risk of injury. The specific issues that were brought up during the process were about accessibility, safety, equitable use, and security. I outline below how each issue was addressed.

7.2.2 Accessibility

One of the first questions brought up during the OH&S assessment process was how accessible and inclusive the robots are — if they are to be made available for everyone, it is important to ensure that certain groups are not excluded from using them. In assessing this, we realised that the Double 3 robots are almost completely silent when the remote user is driving without speaking, and therefore a blind or low-vision person may not know that such a robot is in their vicinity. The robot then would need to indicate its presence using sound. We asked Double Robotics if they provided such accessibility applications, but they did not. Instead, we came up with the simple solution of equipping the robots with cat bells (Figure 7.1). We taped the bells on the robots' wheels, so that they moved and chimed with every wheel rotation. The sound was sufficiently noticeable without being distracting. A blind employee at the office reported that, once we explained to her the significance of the sound, she was able to hear it and know when a robot was in use near her. Moreover, sighted, on-site employees also found it useful to be able to hear when a robot is approaching. They had previously found the stealthy movement of the robot unsettling. Still, while the bell made the robot accessible to blind local users, we found that it was still not accessible to them from the remote user side. To achieve that would require significant development improvements on the interface. It would need to be made screen reader friendly and implement sounds which indicate position and provide feedback on the users' movement (e.g., footsteps sounds that increase with speed). We also did not have the opportunity to assess accessibility for other needs — such as whether the robot is noticeable to people with hearing impairments. For a technology that is aimed at use in offices and spaces within organisations, it is important that accessibility considerations are taken more seriously.

Figure 7.1: Cat bells attached to the robots' wheels

7.2.3 Safety and robot maintenance

Deploying robots in an office, it is also vital to ensure that they do not pose any safety risk to staff. For example, the robots may be capable of injuring someone if they fall over or collide with them in some way. To combat that, the Double robots are equipped with sensors that scan their 3D environment and avoid obstacles. When an obstacle is in their way they automatically adjust their path around it. Their speed is also restricted to 1.8mph: slower than the average walking speed. This makes it unlikely

to have collisions. However it can happen if someone runs into a robot without looking, or someone causes a robot to trip over by grabbing and and letting it go before it has time to stabilise again. It is important then that on-site employees are aware of the robots and informed on how to handle them correctly.

Beyond that, it was important to ensure that the robots were not left unattended around the office, but were instead returned to their docking stations between uses. This serves two purposes: 1) it minimises the possibility of the robots blocking the hallways (thus limiting people's space and potentially blocking emergency evacuation pathways) and 2) it ensures that the robots are charged and in a usable state for the next user. When the robots run out of battery whilst outside of their docks, their brakes automatically activate and they park in place before shutting down.

Although we asked remote users to always drive the robots back to their docking stations between uses (see 7.2.6), it is always possible that one may forget or not manage to do it due to other factors. Asking on-site employees to correct this could unfairly burden them —logging into the interface to remotely drive the robots back could take up a lot of their time, whilst picking up the robots and manually transferring them to the dock could be difficult for some. It could also result in them accidentally mishandling the robots. To address this, we posted instructions on the back of each robot informing on-site employees on what to do. They were asked to simply move un-piloted robots out of the way of pathways and then contact Facilities. The Facilities staff could then move the robots all the way back to their docks. The instructions also included information on how to pick up and move the robots without damaging them or causing them to fall (Figure 7.2). In addition, we asked the on-site Facilities team to check on the robots as part of their regular office rounds and move any

found or reported robots back into their docking stations.

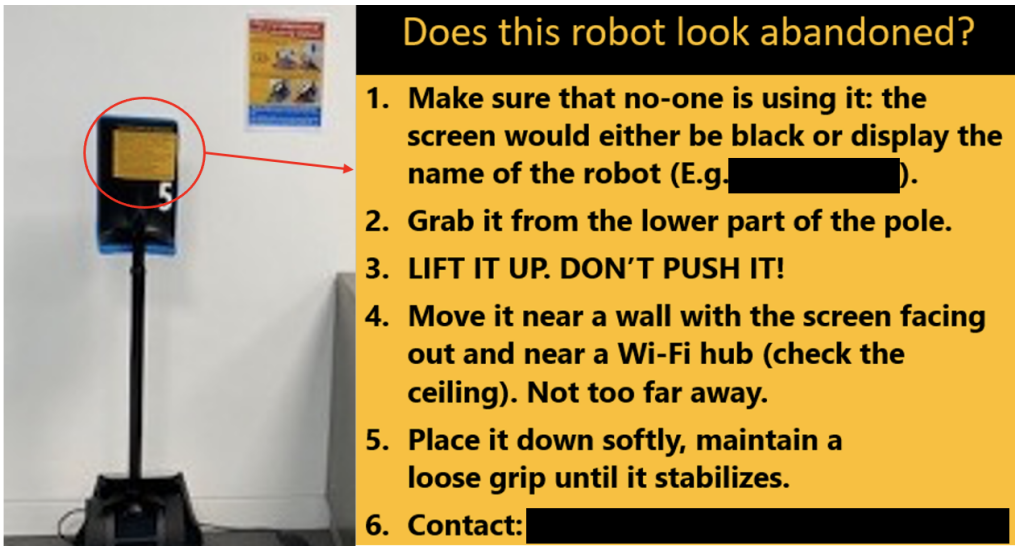

Figure 7.2: Instructions posted on the back of the robots, for on-site employees encountering abandoned robots in the office

7.2.4 Security

Given the organisation being a large technology company, the security of data, assets and patents was a very important matter. The telepresence robots essentially allow anyone with the log in details to access the building, roam around, and view potentially confidential information (e.g., on whiteboards or documents left on desks) without having to go through the entrance gates which require company cards or registration at the reception desk. As such it was important to ensure that only company employees were able to use the robots.

To ensure that only company employees had access to the robots, we used an internal security group. To gain access to the robots, new users were instructed to join this group through a link. The group automatically filtered requests and only granted membership to users who were registered as company employees. It also automatically removed members who lost

that status. When a new member was added to the group we received a notification of it, and we then sent them an invitation to sign up to the Double portal. When a member was deleted from the group, we were again notified and removed their access. This was an only partially automated system, which still required someone to continuously monitor it, and invite and delete users.

Even with encryption and the additional security group process, all such robots still pose some security risk for organisations that have strict security protocols. Although this can be assessed as reasonable or minimal risk in a review processes, using external web services (such as the Double interface) still represents a risk. In addition, it is always possible that access credentials are misplaced, stolen, or compromised. Moreover, there is no direct way to control who is at the remote endpoint of the robot in real time. Unless someone was watching the robots at all times, it was not possible to catch unauthorised use in action. Even if the risk of such a security breach is low, the repercussions could be very serious for certain organisations. In this case, and in conjunction with low use of the robots that was observed in the months following the deployment (which will be explored in the next chapter), it was decided that the project should be paused until more robust security measures could be developed.

7.2.5 Robot placement

The physical placement of the robots and their docks in the building was an ongoing challenge. For safety reasons, any devices or furniture (including robots) must not reduce or block access to fire exit pathways, pose a potential tripping hazard, or have cables that run through a pathway.

However, to make the introduction of the robots as smooth as possible we also took into account how the location of the docks might encourage or discourage use. We tried to place the docks near locations where people intended to use them so as to reduce time spent driving to and from the dock. Although we initially intended to place one robot on each floor (in central areas in order to give everyone equal access), we later moved the robots' docking station based on the teams and people who were interested in using them and the locations they most frequented. Moreover, it made sense to place them in areas with good Wi-Fi connection to ensure that remote users did not encounter connectivity problems as soon as they log in. We also needed the area to have enough free space for the robot to be easily driven in and out of its dock (its collision avoidance system prevents it from getting near things in the environment). Finally, we tried to avoid placing them near areas with open plan desks to avoid distracting the people who were working there.

It turned out that there were not many places in the lab's building to satisfy all these requirements. Most areas that were away from desks were fire exit pathways which could not be blocked. In common areas that were not pathways, such as collaboration spaces and kitchens, there were not always sockets behind walls and using a nearby floor socket would lead in exposed cables causing a tripping hazard. There also were not many empty walls against which a robot could stand without being awkwardly placed between furniture and other equipment. In some cases, we had to make compromises with regards to placement, prioritizing safety over convenience.

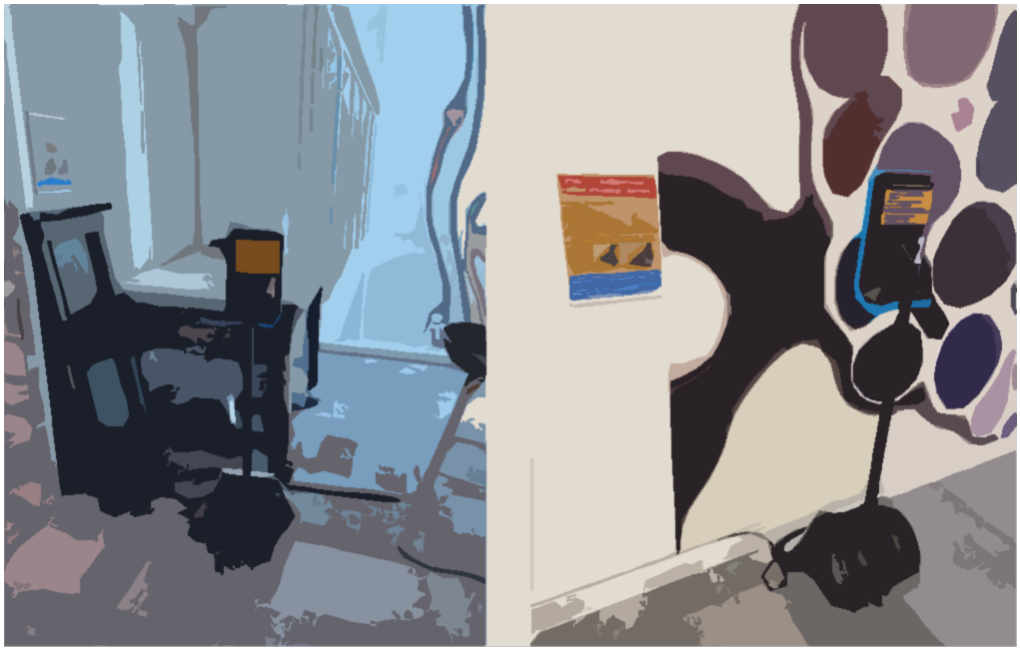

Figure 7.3: Robot docking locations in different areas of the building

7.2.6 Information on use

Introducing MRP into the office also involved providing the prospective users, and anyone else at the site who might encounter the robots, with appropriate information on how to handle the technology. In line with requests from the OH&S consultants, who asked us to inform people on how to use the robots safely and fairly, this educational material did not only cover information on how to operate the robots but also served in ensuring that everyone knew how to handle the robots in such a way that they remained in good condition, and therefore usable and available to people (e.g., charged, used an a ways that doesn't disrupt others).

In addition to the instructions on the backs of the robots (subsection 7.2.3), we used a SharePoint site to provide more information — instructions, bookings calendar, maps of the building with locations of the robots, and contact details. We created written instructions on how to operate the robots, accompanied by images of the interface. These covered how to log

in to the robot, exit the dock, drive the robot, adjust the robot's height and volume, zoom, park in place and how to dock the robot. We also made posters that were placed near the docking stations, asking on-site employees not to block the docking stations, repeating information on how to handle the robots manually and who to contact for help. This was also communicated to prospective users verbally wherever possible.

Furthermore, as the literature explored in chapter 2 (section 2.1.3), and the previous studies presented in this thesis point out, there are certain shortcomings to using MRP. Namely, the limitations of the medium with regards to movement and quality of sound and vision which can give rise to some social imbalances within the interaction, and the "abnormal", robotic embodiment of the remote user whih can result in somewhat insensitive or tactless behavior towards them. Whilst some of these may be solved with technological improvements (e.g., neck turning, binaural audio), some may be simply inherent to the medium (robotic appearance) and in any case, before improved models are created we ought to still make the most of the current models (if only to be able to inform future design). As such, part of my deployment effort (and as an advocate for the technology, in the spirit of Action Research) was aimed at minimising the social, interactional drawbacks of using MRP, by informaing prospective users of these limitations and promoting effective use practices.

To that end, I created a short video (around 5 minutes) which highlighted these issues in a humorous way and provided some instructions on effective use (e.g., adjusting a meeting room to make it more accessible to an MRP, asking permission from the remote user before grabbing the robot). A longer, in-person, workshop-style seminar had been previously piloted at the University of Nottingham, which guided prospective users through roleplaying activities that would enable them to understand the capabilities

and limitations of the medium for themselves and arrive at ideas for effective use through experience. However, this format was deemed too time consuming to be appealing to the busy office employees, and furthermore would require the presence of an 'expert' each time. The video could be shared quickly and give users the same information without imposing on their time. In addition to the video and online resources, I also repeated this information to new users in person when showing them the robots.

7.3 MRP use at the office

7.3.1 Promoting Use

Use of the robots at the Microsoft Research office was of course completely optional, there was no requirement to use the MRP. The employees had other alternatives, and the MRP interface was not embedded into their Teams platform. It was just there as an extra option.

That said, the company had invested in the robots, (and I had a personal academic interest in observing people use them). Whilst not enforcing use, we advertised the project internally as much as possible, in order to ensure people knew about the robots and considered using them as an additional hybrid work solution. We advertised the launch of the robots via email, word of mouth, posters and short presentations during team meetings. The advertising emphasised the benefits of the robots (autonomy, mobility, physical presence). This was done with the help of the Business Administrators of the office as whole and those of specific teams within the company. The administrators gave me information on how the teams are structured and who might be most interested in using them, and booked

time for me during their teams' meetings where I could present the robots.

7.3.2 Response to the deployment

Despite all this, interest in the robots was low. In the first week of recruitment three individuals and one team of four responded to the advertising and asked to try the robots. Another person reached out the following week on behalf of his colleagues who were based in other offices. Four more employees joined in the weeks that followed (15 new users in total). Of those, five did not actually use the robots, two used them once, and four used them a few times each but eventually stopped. The team of four used them for their regular weekly meetings, but their persistent use was also motivated by an interest in using the robots as a tool for their research (which was unrelated to robotic telepresence). In addition to those employees, there was some use by one-off visitors, as well as by the team I was a part of, who had been using them occasionally to remotely attend social events, workshops and meetings.

To better understand the reasons for the low interest, I first surveyed people around the office informally. Mostly, people simply said that they did not have a reason to use the robots. One on-site employee explained that the users' status on Microsoft Teams could let them know if their colleagues were at their desks and available to be interrupted. If they were not online it meant they would be at a part of the office where the robot couldn't go anyway (the technical labs). As such they did not see a reason to roam around the office remotely searching for their colleagues. Some reported that they thought that the sign-up process was too complicated. As one said, "If I was on Teams remotely and there was a button that said 'would you like to join on a robot?' I'd be more likely to click that and have a

go, rather than needing to dig out that e-mail that tells me how I can log into it." Two people also said that they would feel embarrassed to be seen using the robot incorrectly. Of course, these responses come from people who were at the office. They would naturally have less need to use the robot compared to people who work remotely or from other offices but who might collaborate with the people based in that office.

I also spoke to the people who had signed up but stopped using the MRP. The fully remote employees, who wanted to use the robots in order to maintain social presence in the office, reported that they found problems with audio and video quality the first time they used the robots, which discouraged them from using them further. One of them said, "I've not used the telepresence robots more after those few initial attempts. The audio filtering issues basically made them unusable for me, I'm afraid to say. I frequently had to ask people to repeat themselves. It just wasn't worth it." Both fully remote and partly remote employees who had signed up also claimed they did not have many opportunities to use the robots, such as social gatherings or meetings that required movement. Further some partly remote employees said that they did not have the time to drive the robot between meetings, and did not want to spend more time online than was necessary during the days when they worked from home. In addition, Double robots use their own videoconferencing platform that does not connect to Microsoft Teams meetings, which was the videoconferencing meeting technology in use by the office's employees. As such, for many of their MRP calls, the remote users had to also run a parallel Teams meeting to see shared screens and other resources (parallel chat, rosters, notes, transcription etc.). This was deemed to be inefficient and awkward.

In the next chapter, I present a formally conducted interview study of users and non-users, which explores the reasons behind the low use of MRP at

that deployment site in more depth.

7.4 Summary and discussion

7.4.1 Summary

This chapter presented a case study of the process of introducing MRP technology in an office setting, showcasing the different types of practical considerations that must be addressed when deploying these robots in an organisational setting. The project took place at the offices of Microsoft Research, in Cambridge UK, in the summer of 2021. Taking on an Action Research approach, I documented the work undertaken within this deployment project that I was a part of, so as to identify the practical considerations of having MRP in organisational spaces and highlight this side of MRP reality which is rarely, if at all, discussed in the literature.

Beginning with an Occupational Health and Safety risk assessment, the deployment had to account for issues relating to the accessibility of robots, as well as safety towards on-site users and the security of the building. In addition, drawing on insights from the previous chapters, and earlier work on MRP, as well as from issues raised during the risk assessment, the process of the deployment had to ensure not only that people knew how to operate the robots, but also that they knew how use them in effective ways as well as in ways that are safe and fair to other users and employees. During the process we also encountered issues with regards to the placement of the robots within the space.

Addressing these considerations involved work in the form of setting up systems and procedures, to ensure the safe presence of the robots in the

space and secure access to them. It also involved the creation of various types of informative material to ensure that people using them did so effectively, but also that anyone who might come across the robots incidentally would be equipped to interact with them appropriately. This work required the collaboration of several different teams and relied on different areas of expertise, such as IT and Facilities. It also required certain work to be ongoing for as long as the robots were available in the office.

In the end, despite all the measures taken, security could not be guaranteed to a satisfactory degree for this organisation. Coinciding with low interest in users, which will be explored in more detail in the next chapter, the project was eventually paused. As such, this work demonstrates that the application of MRP technology within an organisational setting is not a matter of purchasing the robot and simply turning it on, but requires considerable planning, infrastructure, accurate information and ongoing maintenance.

7.4.2 Discussion

This case study addressed the second research question of this thesis: *How suitable is MRP technology for supporting hybrid spaces in organisations?* The focus, furthermore, was on the first part of that question: *What are the practical considerations and challenges of deploying MRP technology in an organisational setting?* For the study I employed an approach drawn from Action Research, which allowed me to discover what is entailed in an MRP deployment from a real-world project by taking active part in it. This work contributes towards understanding the role MRP can have in hybrid organisations through identifying the practical considerations raised by their design. These include matters Health and Safety and the need for

resources and infrastructure to support the technology within the organisational space.

The deployment revealed that making MRP devices freely available in the office space was accompanied by certain concerns which stemmed from having large, remotely controlled devices moving around in that space. First, the mobility of the devices raises a challenge with regards to safety in terms of emergency pathways and tripping hazards. The robots are meant to move, so their position around the office may constantly change; it is not enough to just place their docking stations in appropriate places. The way in which their movement is done may not guarantee that they are always positioned appropriately. As has been previously mentioned, it can be difficult for a remote user to perceive their own robotic presence within the local environment — i.e. they can not accurately know how much space they are occupying or if they are in someone's way. It is not possible to constantly monitor exactly where the robots are, so vigilance and awareness is required by users and on-site staff to ensure that whilst in use and between uses the robots are not positioned in unsafe places. Then, the mobility of the robots, and the access to the space they allow through this mobility, also raises concerns over security. Essentially, the robots allow someone to move around the space without having to enter through the front door, without having to scan their company card or register at the reception. And whereas a remote user being brought into a local meeting through traditional video calling only has access to what the on-site employees allow to be shown on the stationary camera, an MRP user can move independently and see a lot more of the local environment. They can view things in that space, such as information written on whiteboards, posters, screens or documents left on desks. That is, these specific affordances of the technology, despite perhaps having the potential to aid in hybrid commu-

nication and presence, can also have other material repercussions relating to the space within which they are deployed. This is not to say that those repercussions prohibit use altogether, but rather, that certain work needs to be done to address them.

Indeed, this work has highlighted the necessity of certain resources in order to fully support a deployment of that scale. As identified in this project, these resources include specific knowledge, staff capable of carrying the continuous maintenance work and appropriate space. In terms of knowledge, we found that the project specifically relied on expertise by the Occupational Health and Safety consultants to outline all the areas that needed to be addressed and assess the degree to which various features of the technology posed a risk, as well as to assess the adequacy of our solutions to address these concerns. We also relied heavily on the expertise of the buildings' Facilities staff to approve the suitability of robots' placements with regards to compliance with building safety regulations, and on the company's IT staff to assess and mitigate security risks. Finally, as a part of the deployment project, I employed my existing knowledge of MRP to mediate a lot of this work —such as assisting with the OH&S assessment — and to create the on-boarding material, which informed prospective users on effective use practices for the robots. Beyond access to these types of specific knowledge, the continuation of the project would also require a certain amount of ongoing work, in order to maintain the safety and security standards set at the start. Vigilance over the locations of the robots around the space would need to be added to the Facilities staff's regular work responsibilities and on the side of IT someone would need to continue monitoring of the security group to ensure access is restricted to employees only. Finally, space is another important infrastructural consideration. Naturally, the medium of MRP is meant to provide access and presence to

a space, there is little point in a remote user logging in to the MRP but not making it move, as in that case they might as well just use traditional videoconferencing. The space of the MRP then needs to allow for it to move easily and freely. Moreover, as we discovered during the deployment there need to be appropriate places for its docking stations, that respect safety regulations whilst at the same time accounting for the users' needs. All these resources entail a significant cost to organisations and institutions wishing employ MRP. Whilst Microsoft Research, as a large company invested in technological innovations, was able to carry out this project, this might not be so feasible for others.

All these considerations raised here come into play due to the particular nature of organisational spaces. In such spaces, the technology is used by different people to those owning it and deploying it. There is a one-sided direction of responsibility by the organisation to look after people using its space who might use or come into contact with the robots. This raises the standards of what might be expected from a deployment. The organisation needs to ensure that the technology is safe but also has a social responsibility to ensure that access to it is allocated fairly and inclusively. Matters of accessibility in this case then are harder to overlook. In addition, such spaces host multiple potential users and other types of incidental bystanders. It is not just the core company employees who use the space, but also maintenance and cleaning staff, workers from other agencies, and external visitors (including sometimes the family members of workers). As such it is not enough to simply onboard every newly hired employee to the technology. Sufficient information on how to effectively and safely interact with MRP needs to be made available as soon as anyone encounters a robot. Organisations then need to engage in some preparatory work before employing MRP in their spaces.

As mentioned in this chapter, this deployment was discontinued due to security concerns by the company, but also in part due to encountering very limited interest by the employees to use the MRPs. The next chapter, continuing to report on this deployment project, will delve into the reasons for the low use of the technology in this setting through an interview study of employees at the site.

Chapter 8

MRP at the office: understanding non-use

As noted in the previous chapter, which looked at the work of deploying Mobile Robotic Telepresence (MRP) at the offices of Microsoft Research, use of the robots at the deployment site was low. In looking at the suitability of MRP in organisational settings, beyond accounting for considerations related to providing the robots, we must also consider what role the technology can play within the realities — the workflows, routines and needs — of the members of those spaces. As highlighted in the literature review chapter (chapter 2), exploring the relationship people have with technology even when they opt not to use can provide a deeper understanding of the ways in which it fits (or fails to fit) into their lives (see subsection 2.2.5). To that end, this chapter follows up on the deployment case study presented in the previous chapter with an interview study that explores the reasons behind the low use of MRP at the offices of Microsoft Research. The present study is part of the deployment presented in the previous chapter, but moves beyond the Action Research approach, to a more structured investi-

gation into the use or non-use of MRP, utilising semi-structured interviews and thematic analysis (as explained in chapter 3). For the interviews, I speak to both users and non-users (people who did not use the MRP at all, or who used it a little). I ask them about their experiences with hybrid work more broadly, and about their experiences and thoughts regarding MRP more specifically. Through the analysis, I show that in this case: 1) the knowledge workers were equipped to manage hybrid work, 2) the robots offered limited perceived value, and 3) the robots were a poor fit for the knowledge workers' physically distributed workflows. I examine the findings by drawing on previous work on workflows and non-use to explore how features of the technology failed to align with the office's work practices and needs, and discuss the implications for evaluating the low use of robotic telepresence.

8.1 Study Approach

This study responds to the second research question: *How suitable is MRP technology for supporting hybrid spaces in organisations?* Specifically, here I address the second part of that research question: *How well do MRP systems align with the practices and needs of the organisations' members?*, by interviewing employees at the deployment site about their routine work practices and fitness of MRP technology within those. As outlined in chapter 2 (in 2.2.5) non-use literature warns against pathologising the reluctance to use technology and defining people solely based on their identity as users or non-users of it. The literature on the subject demonstrates that people can have varied and complex relationships with technology, and argues for viewing technology as just another potential mode of meaning-making within peoples' lives rather than an inherent improvement to their lives.

Taking this onboard, this study sought first to understand the broader context of those employees' hybrid work routines and structures and then explore their relationship with MRP.

8.1.1 Participants

Participants for this study were recruited via an email that was sent to all the office employees. The email specifically stated that people who did not use the robots were also invited to participate. The sample consists of seven participants who were interviewed individually, and one team of five (ID no. 8) who were interviewed together as a group (see Table 8.1). Overall, there were 12 participants (7 male, 5 female, ages 30-45). Participant 6 used the robots during the lock-down periods, before the pilot deployment, as a way to check on equipment in the office without coming into contact with other people.

Table 8.1: Interview Participants

ID	Work style	Use
1	on-site/flexible	Used a few times as local user, used once as remote user
2	on-site/flexible	Used a few times as local user
3	on-site/flexible	Used twice as a local user
4	on-site/flexible	Used once as remote user
5	remote	Used a few times as remote user
6	on-site/flexible	Used a few times as remote user during lock-down
7	remote	Never used the robots
8	Group; on-site/flexible	2 team members used the robots as remote users

8.1.2 Procedure

Except for Participants 6 and 8, who were interviewed in person during the pilot deployment, the rest of the interviews were conducted online via Microsoft Teams within two months after the end of the deployment. The

interviews lasted 30 minutes, to facilitate participants fitting them into to their busy schedules. The interviews were recorded and transcribed for analysis.

To establish context, participants were asked to describe what their work days look like and how they manage online communication and collaboration with their colleagues. They were also asked how they feel about hybrid work and whether it poses any challenges for them. Then, the participants were asked what they knew about the robots in order to see how they perceived the robots and whether they had an accurate understanding of them. Participants who had used the robots were then asked about how they used them and what they thought of them. Then, participants were more specifically asked why they did not opt to use or why they stopped using the robots. After giving their initial answers, they were asked whether they would use the robots provided that the issues they brought up were solved, as well as whether they would use them in other contexts (for e.g., at a conference or social event). Finally, they were probed to discuss whether the physical presence and the mobility that the robots provided were relevant in how they conducted their hybrid interactions.

8.1.3 Analysis

As explained in chapter 3, I analysed the transcribed interviews using Thematic Analysis (Braun and Clarke, 2006). My aim in this study was to understand why people did not opt to use the robots more, and how the robots failed to meet their needs around hybrid work. I asked participants those questions directly and, as such, the analysis is mostly data-driven (inductive) rather than theory driven (deductive) and directly reports on the participants' direct answers.

8.2 Findings: unsatisfied by MRP

I identified three themes: 1) These knowledge workers are equipped to manage hybrid work, 2) the robots offer limited perceived value, and 3) the robots are a poor fit to the knowledge workers' physically distributed workflows. The first theme pertains to the broader context within which the participants operate. The second and third themes focus on the participants' accounts for their low use or non-use of the robots.

8.2.1 Theme 1: These knowledge workers were equipped to manage hybrid work

Participants of this study (knowledge workers) were already well equipped to handle hybrid and remote work in terms of resources and strategies. This seems obvious in retrospect but contradicted our anticipations of potential use.

Knowledge workers are capable of managing hybrid work

I initially asked the participants to describe how they conduct their work. All of them tend to work within physically distributed teams or with colleagues who work in a flexible way (some days on-site/ some days working from home). Some had already been working in this way even before the Covid-19 pandemic. As such, they were very familiar with this way of working. This meant that they were aware that it can pose challenges for communication and productivity, and they actively structured their work with that in mind. As participant 3's words show below, there is a self-awareness of their own needs and capabilities within this mode of working

as well as an understanding that other's might respond do remote work differently, and that accommodating for this takes some pro-active effort.

Participant 3: *"So I'm very used to working with people who are not anywhere near me, and so I'm productive in that environment. But that's not the case for everyone. So I try and make sure that that everyone I work with has the option to do what works for them."*

They have already established routines and thought-out strategies around communicating and collaborating remotely. Most participants will have certain regularly occurring meetings for catching up with their colleagues, which happen over video conferencing. They will also have other remote interactions during their day, through a variety of media; video, chat, email or other tools (e.g., digital whiteboards).

Participant 3: *"So we have a bunch of teams, channels, and also a few group chats which are a bit better for building communities around because it's a smallish group of people that are willing to share personal things that they wouldn't in an official project channel sort of setting."*

Other participants also described using different channels for different types of interactions. For example, Participant 7 also reported that they leave Microsoft Teams meeting calls running after the end of meetings to allow space for follow-up ad-hoc discussions. The participants are aware that different media are better suited for different types of interaction, and that different people and teams have different preferences. As such they proactively create channels to accommodate various needs (such as chat for less formal topics and open-ended meetings for ad-hoc discussions). Beyond that, Participants 1 and 2, who work in a physical lab have adjusted their experiments to be accessible remotely, so that their fully remote colleague can also participate in the work without significant limitations.

Participant 1: *"But the thing is that because we are working in the mixed environment, we made all our experiments remotely accessible. And so basically, we can do all these remotely. Everyone can do that. So, most of the debugging you can do mostly as well. So, we designed around the remote presence."*

The participants' reports indicate not only that they have solutions in place to manage hybrid work, but also that they themselves put considerate thought and effort into those solutions.

Preferences depend on activity

When asked how they felt about their hybrid work situation, many expressed a preference for in-person interaction. However, this was not a strongly felt sentiment. The following quote by Participant 2 reflects most participants' positions.

Participant 2: *"Well, it's definitely not the same as the physical presence. I think it's much easier when everyone's physically present, because it's easier to see also other things like body movement. But it's not like it has been a huge obstacle in that we could not work remotely. It's just feels better if you can meet physically, I guess that's how I would put it."*

This slight ambivalence about preferred ways of working may in part have to do with the fact that they are quite competent at managing remote communication. As Participant 4 says in the quote bellow, talking about videoconferencing, they also have workarounds for dealing with its limitations and an established communication etiquette.

Participant 4: *"I don't really mind because there's always someone at least who's looking at the chat or doing something, so I tend to just use the chat*

to get [attention]"

Moreover, some participants followed their answers with caveats, saying that sometimes there are occasions when remote work also makes sense over meeting in-person. Their preference depended on the type of activity or reason for the interaction, and for certain activities remote communication was even preferred. As the quote below suggests, keeping a meeting fully remote even when some attendees could have met in-person allows each of the workers to have access to their own equipment; this can be beneficial for some types of work.

Participant 1: *"When we have meetings, if the people are in the office, I prefer at least to do it in person since they're already there. Not to do it over [Microsoft] Teams. But if you have one person which is on Teams, then we would do it. [...] Sometimes a couple of us come to the same office and a person on Teams, and sometimes we are all in Teams and I think it depends on the topic. If it's debugging and we share a screen, everyone looks at the screen. It might be easier to have your own screen because you have better visibility otherwise we are all crowding in front of a screen. But if we are brainstorming something, then, it may be better to sit and just see each other."*

Participant 4 also claimed that when at least one person is remote, they prefer to move the whole meeting to online, rather than have part of the team meet in person. This allows for more equal participation as everyone then has the same access to the meeting.

Participant 4: *"'But when it's just the core team of four people, which is the team that most often meets with the US people, then it's just two of us here in the office, so we might as well meet online."*

At other times, remote and asynchronous methods might be preferred to avoid disrupting others' work, as Participant 7 reports.

Participant 7: *"For quick question to someone you know [...] I'd be hesitant to kind of physically go and if I was in the office, if their door was closed, I probably wouldn't knock on the door, interrupt them. I'd be conscious. That's something that strikes me a great deal if I'm in the middle of something, so I probably tend to do some initial question via Teams, chat or email that could be handled asynchronously or ignored."*

8.2.2 Theme 2: The robots offered limited perceived value

When asked what they thought about the robots and why they stopped using them, the participants gave a wide list of reasons, ranging from technical limitations to issues relating more to interpersonal interaction and participation.

Technical quality limitations

Poor audio quality was a common concern. Participants often compared it with the quality they got on their standard videoconferencing application, Microsoft Teams, and reported using Teams alongside the robot for that reason.

Participant 8: *"...whereas in the conference room, the audio I think made it challenging for a robot to be feasible in that like big conference room. So in the end I ended up just joining the room audio with no video. So I could listen to everything and see everyone, but they just couldn't see me on the*

giant screen."

Participant 8: *"Maybe the ultimate combination then is to listen on [Microsoft] Teams, but to talk through the robot."*

The participants described these limitations within the context of interactions, and in doing so revealed how something like not being able to hear very well essentially renders an interaction impossible without resorting to other media.

Participant 4: *"Uh, two people in person and then me on the robot. And they had a very fluid conversation with each other. But then, you know, every time I maybe wanted to say something. Then, if they didn't stop talking to give me time and so on, then it would immediately cut out one of us, and it was just very awkward."*

Other technical quality complaints included the speed of the robot, difficulty driving, difficulty reading from screens through the robot, limited spatial awareness and the fact that the robot did not work on certain surfaces.

Participant 1: *"[...] one of the main issues was the speed of the robot. You know, you basically have to wait for[...] by the time the robot comes to the call, we are already there and we started discussing. [...] The robot was not able to follow us, it was more like we have a little toddler and you kind of walk with the toddler. 'OK is it gonna fall, is it gonna get stuck?' and then you spend like 5 minutes getting it over there and five minutes getting the robot back. And it's a lot of worries."*

This scene is comparable to the arrival and departure sequences described chapter 6. The local users here are also having to walk alongside the robot and adjust their own behaviour to match its speed and capabilities, or

even assist it. However, in this organisational setting, such interactions are described in a negative light. The local users are not happy to have to accommodate the robot in these ways; they are busy with work, and do not have any kinds of familiar, intimate relationship with the remote user so as to motivate them to push through the technological limitations.

Use requires effort

The limitations mentioned above introduced the need to put in considerable effort to use the technology, often on the part of the local users. As discussed in the literature review in chapter 2 (2.2.4) in the case of groupware an important factor is balancing the amount work required to make a system work by the different members of the organisations with the degree to which they benefit from it. In this case, with MRP, local users' might have felt that other media, which did not require as much effort from them might have been sufficient for them to do their work.

Participant 2: *"We had multiple locations where I had to follow whoever was using the robot or others had to follow me to make sure that this will dock properly. Otherwise, I would get a message later saying I'm stuck. [...] Small things like that. But I think they make a big difference [...] For us at least we would be a lot more happy with using the robots if those were not there."*

Indeed, using the robot involved a lot of reliance on help, confirming the findings of the second study (chapter 5). This was described as an awkward experience that people would prefer to avoid, echoing similar reports made by users in the first study (chapter 4), especially given that in this case they had other options that worked well enough.

Participant 4: *"But first of all, it was hard to get to the table because there were chairs in the way. And again I couldn't move them. So again, having to ask for help would be kind of an awkward thing to do and. [...] I'm sort of afraid of being a bother."*

As the words of Participant 4 above suggest, the matter of relying on help is not an issue simply because it requires the remote and local users' time and extra effort. More than that, there is a socially awkward dimension in the act of asking for the help, and perhaps in receiving it. As Participant 2, (below) also explains, it may be seen as inappropriate to take someone out of their work, when this could have been avoided by using other means to participate.

Participant 2: *"It's not the time so much, it is also a bit annoying having to call someone. You take them out of their work to, you know, 'I'm stuck. Come and help me.' [...] Ideally, I should be able to do it myself, otherwise I can find other ways of joining. Like, it would actually be easier to say, 'Call me on Teams' if I want to be there, unless I can do it myself."*

As the previous theme explored, these participants were aware that hybrid communication requires some effort, and in other occasions they were willing to do that for the benefit of their colleagues. In the case of the robots however, they expressed more discontent. Perhaps the effort of using MRP is significantly greater than that required of other technology. However, this could also be taken to suggest that effort alone is not an obstacle to using the technology. Rather, there is a weirdness in the nature of that effort (e.g., walking next to a slow and clumsy robot as if accompanying a toddler) and to the MRP overall, that acted as a barrier to use.

Participation

To inquire into the value of mobile telepresence, beyond the material features of the existing devices, I asked participants if they could imagine themselves using such robots if the technical issues they had mentioned were to be fixed (for example, if audio and video quality improved, driving was easier, lagging was not an issue and smart technology was used to assist with opening doors). The participants found it difficult to answer this question, and some had to pause and think or admit that they were not sure. Through more discussion into the value of being able to move in the office, it became evident that there were more substantial reasons into why people did not use the robots as much as expected.

First of all, the robots did not allow for equal participation in local, physical activities over and above what other media already provided. As already seen above, when accounting for issues with the robots, the participants often brought up the fact that they needed to use Teams alongside. This was not only because the robots' audio was not good enough, but also in order to make use of other affordances provided by Teams, such as sharing files and collaborating on documents. That is, they used the digital environment on Teams in order to be able to take part in the work. The robot did not provide a significant added value to that experience.

Many meetings involve looking or even working on documents. The visual acuity of the robot was not sufficient to allow looking at a screen through the robot's camera. Moreover, the documents would in any case be shared digitally. Participant 8, below, explains that it has been nice having the robot in a meeting where she is simply addressing her team-members in a dialogue, but when the meeting involves documents having the robot becomes futile.

Participant 8: *"I think in the meetings, when I was needing to lead those meetings, then it was really useful. But I think that's changed now because we now have something on screen during our meetings. [...] I think once you're there [on the robot] and there's stuff on screen, you can't really see it and it's a real pain. [...] We can share docs and things like that. But then why are you on the robot, right? Because you're just looking at a doc anyways."*

Participants also brought up not being able to do things in the environment as a reason why the robot was of limited value. For physical activities, such as drawing on a whiteboard or working in a laboratory, the robot did not actually allow the remote user to do much. When attending a physical activity via the MRP, the remote users were stuck in the role of an observer and at a disadvantage compared to the local users. Participant 1 explains below that being on the MRP during a whiteboard activity meant that the remote user was much slower at participating. As they could not draw on the board, they would have to describe their idea or share their drawing through another channel. In the time required to do all that, the rest of the in-person members may have moved on to other ideas.

Participant 1: *"Certainly, he couldn't draw. That's another thing, right? He couldn't contribute so he was basically an observer. So he couldn't say 'oh, why don't we do this?' and then by the time he explains what he wants, he was sort of disadvantaged on that."*

Participant 3, shares a similar view and then goes on to explain that if such an activity can be done entirely online, then the experience is better because then everyone has the same ability to participate.

Participant 3: *"Right, the kind of times when I want to be able to be in the same room to work with someone usually there's some physical thing that*

I want us to both interact with, like a whiteboard. And there if anything, the robot is less helpful because if we have a Surface Hub and we're both on laptops or one of us is on the laptop with a touch screen remotely and the other one's got the Surface Hub, we can share a whiteboard. We can both draw on things. But if one of us has hands and the other one doesn't, but we're both in the same room... yeah, doesn't work nearly as well."

Beyond particularly hand-on activities, such as drawing, having an embodied presence through the robot also resulted in limited capacity to participate compared to the in-person attendees. As Participant 4 describes, there are still certain embodied actions, such as raising a hand, which are expected in person, and which the robot is not able to do. Again in that example, the user had to resort to the Teams platform, which provided digital version of these affordances.

Participant 4: *"There were a couple of times when it wasn't nice, like at one point they said 'So when you're done doing this, like brainstorming whatever, please raise your hand.' And I was like, how am I gonna raise my hand? I have no hand. And then I think I ended up actually being in Teams on my computer and then being in the robot as well. So I was there twice in a way. "*

In addition, in most meetings there would be more than one remote participant. In those cases, it made little sense to have some people join through videoconferencing while others join via a robot. As Participant 6 puts it, using the robot resulted in them being the odd-one out. Even though they were in the room, it felt less inclusive than being on the video call.

Participant 6: *"But then when I joined a meeting which was much more hybrid with several people on teams and several people in. [...] The robot I don't think added a lot of value to that. In fact it would have been better if*

I'd been in Teams and felt more inclusive actually within that hybrid environment, because there at least I'm on the same platform as a percentage of the rest of the attendees."

Graceful presence

The second important issue the users expressed beside limited participation was that the robots did not allow for more subtle forms of interaction, nor did they allow them to a have graceful presence.

Some participants compared the use of the robot to actions made when physically present. This may be because the physicality of the medium invites such comparisons, as well as because the situations where participants would have liked to use the robots are those not yet supported by their other channels. Specifically, these were the more social and spontaneous interactions, where the subtlety of non-verbal, in-person cues plays a big role. Communicative actions in physical presence are quick and done without much thinking. On the robot, these are done a lot more slowly, often more intentionally, and less effectively. As Participant 1 explains, even scanning a room within an interaction to see who is doing and saying what, is important in order to be part of a casual office interaction. This became evident to them when they saw that their remote colleague was struggling to do that whilst on the MRP.

Participant 1: *"You know, if you're [in] the office, you see the whole thing. You quickly move left and right with your eye glance, and so it's not a mechanical move that takes time. You wanna look there and then you look there. It's an instantaneous thing. Whereas he wasn't... I mean, I think he didn't have a great experience."*

The issue of having to be much more intentional with actions was also brought up. While the participants wanted to be able to express embodied cues in their interactions, the robot did not quite provide for that. The remote users felt that they had to consciously manipulate the robot to make it move, which resulted in their intended communicative cues being unnatural and ineffective.

Participant 4: *"Even if you have peripheral vision, you still can't express cues because even if you could... I mean maybe it will get to the point where it would detect your facial cues and kind of communicate them around. But if I have to press a button to show curiosity, then it acts weird again."*

Lacking these subtle cues, the behavior of the remote users and the robot ended up appearing abrupt and awkward.

Participant 4: *"Normally you can clearly breathe in, or you can do something so people see you're trying to say something to them, and I felt it was very hard to not abruptly interrupt and ask."*

Indeed, the mechanical actions of the robot made it difficult for participants to gracefully enter and exit social situations. That fact that this is an issue has been raised in previous literature (see 2.1.2). Having now seen the MRP's interactional realities in action, and through the reports of these participants, it is made evident how the lack of subtle and graceful actions contributes to this.

As Participant 5 describes, not being able to gradually peak into a space and subtly look at what is going on makes it difficult to negotiate whether it is an appropriate moment to interrupt and have a "serendipitous" conversation.

Participant 5: *"When I walk around here, it's very easy to casually see*

who's in their office or not. [...] with the robot, you have to stare, otherwise you can't, you know, see properly [...] there is a bit of grace missing to act more like a human and where you can make out if someone is there and then maybe if you think you want to chat then OK."

To provide some context, when a remote user begins a call on the MRP, their face instantly appears on the screen of the robot. If there are people in the local environment, it is as if the remote user has instantly joined them. If that room is empty, the remote user will have to navigate to the next room, and there, again the robot will appear into the space quite abruptly as the remote user will not be able to slowly "poke their head". In chapter 6, we saw how in the home setting, this gave rise to "arrival" sequences that establish the remote user's presence in the space. These however, took considerable time and work from both parties. It is not so surprising that in the context of a busy office, where the necessary work can not always be allocated towards doing a proper arrival, the remote users' entrance in the space is sudden and awkward.

Confirming the reports from the participants in the first study (chapter 4), these participants also felt very visible and noticeable on the robots.

Participant 8: *"Wasn't private. Once you're moving on a robot, everybody's looking at you."*

Participant 5 also reported avoiding using the MRP at time when he knew the office would be busy so as not be cause a disturbance.

Participant 5: *"It's a bit awkward? And you have to be quite comfortable doing that. And so I don't know, I think sometimes I just used it at times where I knew it was a bit quieter, late afternoon or so. Because I felt like otherwise it was too much of a disruption or disturbance. I mean, even*

though it was supposed to model a normal human, you know, occupying the same space roughly and emitting the same noises. I don't know. It still felt too foreign."

Overall, the robots had technical quality limitations in comparison to other resources available to the participants. Their use also seemed to require more effort than participants were willing to put in (again in relation to other resources). However, the limitations of the robots that truly seemed to matter were those hindering equal participation in activities, and the lack of graceful and intuitive interaction.

8.2.3 Theme 3: The robots were a poor fit for the knowledge workers' physically distributed workflows

As mentioned in the previous theme, the MRPs did not provide solutions for participation. Beyond this, adopting the lens of workflows research (see 2.2.4), the interviews also suggest that the affordances and ways of using MRP did not fit within the employees' workflows and routines.

Time

As noted above, several participants brought up the speed of the robot. It takes time to drive it between different locations as well as park it back to its dock at the end of use. The study participants often simply did not have time to spend on something like this. As the participant below further explains, the ease or strictness of schedules can also depend on the situation. Specifically, someone working remotely may not plan time be-

tween their meetings, because they have them all from the same location. Using the MRP brings a person working remotely, with their time schedule, into a physical space where there is a requirement to spend time for transferring to meeting locations. Given, as we have seen already, the that robots' movement is slow, this can result in wasting time and being late to meetings.

Participant 8: *"I don't know how this will change over the year to come. But I've gotten really in the habit of having zero minutes between meetings. And when you're in the office you know, time is a little bit more flexible because you can kind of see [...] so and so is coming and I'm just going toilet. But like, obviously, if you're a robot, you don't have those same cues that everyone has. Yeah, so you're like 'Ohh, no. And now I'm late.' "*

Those who worked with people from different time zones had even less time, as the window of overlapping working hours with their colleagues was shorter. Generally, work at the company could be fast-paced, which did not fit with the slow nature of robotic telepresence.

Participant 7: *"Meetings tend to be somewhat chaotic and reorganised at short notice. Then physical locations, when booked, tend to be spread out around the building and my schedule, as I showed you, tends to be back-to-back. So you know, being able to switch from one [meeting] to the next with Teams is convenient for those those shifts as as well."*

The above quote also hints at the second issue, physical space.

Physical Space

Apart from lack of time, presence in physical space was not very relevant to participants. When probed about whether the movement in space that

the robot provided was useful, their answers were negative. In part this was because they were used to communication through videoconferencing. Similar to comments made by participants in the first study (chapter 4), physical presence was not needed in order to pay attention to someone, as it might have been in the past.

Participant 1: *"That's a good question, but I don't think it's relevant anymore. Maybe it would have been three years ago. But I'm so used to it now [...] Keep in mind that I work a lot with the US, with the West Coast. So I have like many meetings from 3:00 PM sometimes to 10.00-11.00 PM on Teams. So I'm so used to it now."*

Moreover, their work did not really happen in physical space. Often there was not a single physical location on which to meet as team members were physically distributed over several locations.

Participant 7: *"So, there's often not been a physical place that people are collaborating in. It's often around documents and code and discussions. [...] I think much of our team is split over a couple of sites already and there are some people in the Redmond area, I'm in the Mountain View, CA area and some are on the East Coast. So, most people's schedules tended to be joining these Teams meetings as I mentioned often audio only and then just kind of going from one to the next."*

As Participant 5 also explains below, it could be said that the provision of MPR can create a bias, suggesting that the people and activities at the main office are more important than those outside of the office. It can imply that the office is where the core of the work is, where people should try to be.

Participant 5: *"It's interesting because it assumes that the people that you*

want to meet are actually in the office. [...] You know, in a way, advocating for the robot to enable that, pushes a bit more to exclude other people who are fully remote. You know, because you would focus more on having real life interactions with office people, but maybe then you don't focus so much on the other ones."

Of course, as the interviewees' reports show, this does not reflect the reality of their workflows. The majority of the work at Microsoft Research is done digitally and among teams distributed over many locations. Therefore, choosing to host an activity in the office (with remote employees joining via MRP), rather than entirely online (e.g., digital whiteboarding vs in-person whiteboarding) could be counter-intuitive. Whilst attempting to improve inclusivity, introducing MRP can then have the opposite effect.

More meaningful solutions

Whilst the interviews show that these employees were well equipped to handle hybrid work, the participants did express a need for more meaningful solutions for hybrid participation. In particular, they wished for better solutions for more social interactions and casual encounters, where it was felt that the existing tools did not fulfill their needs.

Participant 4 describes the efforts of her colleagues to create opportunities for non-work-related interactions whilst working remotely.

Participant 4: *"People tried doing just like a hallway channel and then you can sit in that. But like you don't go out and stand in the hallway and wait for people to come by. So, always hybrid chills are simply weird. [...] On the one hand, if robots became really common and was just a way... If you had other reasons to move around the office, you would actually bump into*

people and it would be nice. But I'm still kind of wondering if they would do that because they seem very purposeful. Like, if you go on the robot, you go to your meeting and you park the robot. Because otherwise it's like that weird hallway channel that you go in the robot in the hopes of casually walking around and meeting people"

During her answer, Participant 4 identifies that what is awkward about hybrid social hang outs is the planning behind them — a sense that it is a 'forced' serendipitous encounter. While elaborating on her thoughts on using MRP for that purpose, she concludes that it would result in similarly awkward situations. With MRP, the digital hangout is simply transferred to the physical hallways, but does not address the core problem.

What Participant 4 is touching on is that the existing organizational communication tools — whether they be a Teams chat or the telepresence robots — involve a certain intentionality which does not seem to be conducive to casual and social interactions. For a work-related matter it may be acceptable and effective to approach others purposefully and directly. One can send an email with questions in bullet points, raise a hand to get attention in a meeting, or overtly refer to the agenda in order to change the subject. Social interactions rely more on subtler and serendipitous cues. As Participant 4 further describes, this could be making eye contact with someone while passing by their office and gauging from that weather they are open to conversation. Whilst the MRP allows one to be in the office and walk through the hallways, it still does not support this level of subtlety.

Participant 4: *"When I'm at my desk in the open office space, people walk by and I just casually have eye contact, which even just that is nice sometimes. Or sometimes the eye contact turns into saying 'hi' or like 'you look tired' or like whatever. But when I don't have any peripheral vision, that's not gonna*

happen. Then I would have to stand and like face out and that would be like I'm spying on people. It becomes very black and white [with the MRP]. Like either there is interaction or there is not. People wouldn't happen to glance at me and then start a conversation. They would deliberately come up if they were starting a conversation, and that would be weird again."

As Participant 5 exclaims below, adding movement to video conferencing seems like a "quick fix" that does not really address this issue.

Participant 5: *"Well, I think. You know, solving this issue of casual encounters is tricky and you know, using robots is just probably one of many ways to do this. [...] I would like to see more functionality also in applications like Teams. To have casual hangout rooms or so. Because at the moment everything is a scheduled meeting and you have the group chats, but then it's not easy to actually hang out with people because the moment you press a button to start a call, then everyone gets notified [...] You would not do it because it's too disruptive, too invasive [...] You need improvements on all fronts. And it's not just having a robot as a kind of quick fix, it's one feature of the whole problem I think."*

8.3 Summary and discussion

8.3.1 Summary

This chapter presented a study exploring the non-use of MRP within an organisational setting. This work was inspired by literature on non-use, which advocates for a deeper examination of the relationship people have with technology they are avoiding or choosing not to use, and shows that non-use is possible to study through examination of the things people do

instead of use and their broader situated context(2.2.5). The study consisted of semi-structured interviews with users and non-users of MRP following a deployment at the offices of Microsoft Research. The participants were asked to describe the ways in which they conduct their work in a hybrid manner and discuss their reasons for using or not using the telepresence robots that had been made available to them. Specifically, this work approaches the issue from the perspectives of the employees themselves and with consideration of their reported needs and workflow practices. Through applying a thematic analysis approach on the data, I arrived at three themes which seek to explain the non-use or low use of MRP at that site. The first theme: "The knowledge workers were equipped to manage hybrid work", reveals that these users and non-users already had skills and equipment at their disposal, and where proactively engaged in the work of communicating and staying connected with their remote colleagues. As such, they might have been less in need of additional solutions, contrary to what might have been expected. The second theme: "The robots offered limited perceived value" outlines the limitations that the interviewees identified in the robots. Among these, the two most crucial ones were that the robots did not allow remote users to meaningfully participate in physical activities, and that the robots did not allow remote users to act in graceful and subtle ways so as to support them in engaging in unplanned and more social interactions. Finally, the third theme "The robots were a poor fit for the knowledge workers' physically distributed workflows" identifies the ways in which the features of the robots failed to align with the practical demands of the employees' workflows, specifically with regards to the time required to use them robots and the low relevance of physical space.

8.3.2 Discussion

This study addressed the second research question of this thesis: *How suitable is MRP technology for supporting hybrid spaces in organisations?*. Specifically, the study focused on the second part of that research question: *How well do MRP systems align with the practices and needs of the organisations' members?* Both this study and the one presented in the previous chapter stem from the same robotic deployment project. Whereas the previous chapter looked at the practical considerations of making such technology available in that office space, the present study looked at the fitness of the technology within the office's daily life. Having encountered very little use of the MRP following the deployment, the present study responds to the research question by drawing on literature on non-use and examining why employees did not opt to use the robots more. Through this exploration into non-users' perspectives, this study contributes to the discussion on understanding the suitability of MRP within organisations by examining the degree to which MRP can fulfil users' needs by enabling hybrid participation in office work and by supporting social presence at the office. Moreover, I explore the degree to which MRP fits within the workflows and practices of a knowledge work organisation and in doing so, demonstrate the use of this approach as a way of assessing the suitability of MRP in specific settings. Beyond these points, which relate to the question of using MRP in organisations, this study contributed to the broader understanding of MRP experiences and interactions by providing insights into how the interactions are experienced in an organisational context.

The participants in this study, as explained in the first theme, were very well equipped to manage working in a hybrid style both in terms of knowledge and in terms of access to technological resources. Whilst this made

them less open to using the robot, it also put them in a great position to truly scrutinise the value of the MRP for the office setting. That is, they were able to list many of MRP's technological limitations (for which they had better alternatives), and were then able to elaborate on what remained —the needs that telepresence technologies should address, which their existing resources could not. Specifically these were participation in physical activities and participation in serendipitous, social interactions. With regards to these two use cases, then, the study participants were able to quite clearly articulate the reasons why the MRP did not fulfil their needs. Their answers align with insights drawn from the studies presented earlier in this thesis.

With regards to participation in physical activities, the study revealed that the MRP placed the remote users at a significant disadvantage compared to their local colleagues. Namely, the participants described scenarios where the remote user would be reduced to a mere spectator during an activity where others were contributing through making physical actions in the environment (such as drawing on a whiteboard), or where they were not able to participate at all due to not having the possibility to make embodied movements (such as raising their hand). The asymmetry in capabilities here between remote and local users was not merely one of communication but more substantially, of not being able to take part in their work entirely. When raising this issue, participants without fail commented on resorting to digital ways of participating in the same or comparable activities (e.g., joining a meeting through Teams alongside the robot, switching to digital white-boarding). In this way, whilst forgoing a physical, embodied presence, the users gain a greater ability to participate. This further enforces the point raised in the first study (chapter 4) that a greater focus when developing and assessing MRP solutions should be placed on participation

rather than on immersion.

Second, the participants expressed a desire for better solutions to support hybrid, social interactions with their colleagues, outside of work meetings. Whilst they were capable of managing remote work, their existing resources did not provide affordances that could support casual and serendipitous encounters. In that sense, neither did MRP. MRP might be presented as a way for remote users to have a presence in the hybrid space so as to have such serendipitous encounters (e.g., to walk down the hallway and greet people, and have "watercooler" conversations). However, in practice, the participants in this study discovered that this was not possible to do. First, using the MRP was a highly intentional act. The remote user has to decide that they wish to use it, intentionally log in and intentionally drive it around areas of the office where they expect to meet people. Aside from the fact that, as discussed in the next paragraph, an employee is unlikely to want to spend the time doing that, even if they were to do it, this substantially differs from the way in which on-site employees move and encounter one another in the office. As a participant put it, logging into the MRP and going to stand in the hallway is akin to joining a casual "hang out" channel on Teams; just as awkward and not truly serendipitous. Moreover, it is also the way in which the MRP mediates behaviours which further hinders natural, social interactions. The remote user's behaviours through the MRP are not only characterised by conscious intentionality, but also, and in part because of this, they lack subtlety and grace. As shown in the first study (chapter 4), a user is almost always conscious of the MRP medium and the fact they are actively operating it in order to act in the mediated environment. Moreover, they can not perform many acts in small gradual increments. For example, they can not slowly approach a room; they are instantly transported in it when they log in. They can not

enact pre-beginning non-verbal cues (such as leaning forward, breathing in, (e.g., Scheffler and Pitsch, 2020) before they make an utterance. This results in abrupt, disruptive ways of speaking. Lacking the structural tools of formal meetings (agenda, hand raising) the resulting interactions are awkward for both sides and not conducive to casual conversation.

Beyond being insufficient in addressing the needs of hybrid office employees, the study also reveals that the ways in which the MRPs are meant to be used did not align with the routine practices and workflows of that setting. Specifically, this study highlights two obvious but taken-for-granted factors; using the MRP requires a certain amount of time outside of the activity for navigating, and the activity takes place in one physical location. In this case, the prospective users of this deployment project were not able to allocate within their schedule the time required to drive the MRP and they also did not have a specific physical location in which they needed to be. With limited overlapping work hours, their meetings were often scheduled back-to-back due to working across multiple time zones, leaving no time to drive the robots to and form meetings. Also, working within physically distributed teams, meant that there was not a single location in which the core of the team met in-person. Finally, their work was done mostly digitally —they had even managed to create online versions of physical activities (e.g., a virtual access to their lab experiments, digital whiteboard). Us such, having a presence in the physical space was mostly irrelevant within their work. Of course, this is not to say that the application of MRP in all organisational settings will be obsolete because of those reasons. Rather, this examination can be taken as an example of what future potential deployment projects should consider before investing in MRP technology.

This chapter concludes the empirical research section of this thesis. This

has consisted of 5 studies exploring MRP interactions and the potential application of this technology in organisational settings. The first three studies, an interview study and two observation studies, drew on phenomenology and Ethnomethodology and Conversation Analysis (EMCA) to build a detailed understanding of MRP experiences and interactions. The second two studies, stemming from a real-world deployment project, take on this understanding and examine the suitability of MRP in an organisational setting through an exploration into the practical considerations of providing MRP in that setting, and the ways in which the MRP fits within the needs and workflows of activities in that context. The next chapter will present discussions addressing the two research questions, consolidating all the findings raised by this work, and drawing out implications for future research on MRP.

Chapter 9

Discussion

This chapter revisits the research questions posed in the introduction and answers them through a discussion of the findings on Mobile Robotic Telepresence (MRP) collected in the thesis. The research questions, as presented in the introduction (chapter 1) were the following:

RQ1. How are MRP interactions conducted and experienced in practice?

- RQ1a. How is robot-mediated telepresence experienced by users?
- RQ1b. How are MRP-mediated interactions socially organised in terms of the interactional methods employed by users?

RQ2. How suitable is MRP technology for supporting hybrid spaces in organisations?

- RQ2a. What are the practical considerations and challenges of deploying MRP technology in an organisational setting?
- RQ2b. How well do MRP systems align with the practices and needs

of the organisations' members?

These questions arise from an observed lack of literature that can account for the evident absence of MRP use within organisational spaces, despite a magnitude of studies reporting on the capacity of the technology to create a 'sense of presence'. As outlined in chapter 2, studies present a rather mixed picture of MRP, reporting on its benefits but also raising various concerns around its technological and social shortcomings. Moreover, that picture is highly unclear. Whilst studies make reports of awkward social interaction, there is little information into the details of just how those interactions are done. And whilst studies report on the use of MRP in workplaces and other organisational settings, little is made known of how such technology is actually used and implemented in those settings and within the users' routines. In response, this thesis sought to make an in-depth exploration into the practical realities of how MRP is experienced, used in interaction and implemented in an organisation. Drawing from Phenomenology, Ethnomethodology and Conversation and Analysis (EMCA), Action Research and Deployment studies (chapter 3), I examine MRP in detail, in terms of how it is experienced, used and implemented in real-world scenarios.

To that end, this thesis reports on findings from five studies which build a comprehensive understanding of MRP, showcasing the technology's interactional reality and how it relates to practical considerations for use in organisations. First an interview study of real-world, long-term users introduced the subject through showcasing what MRP use looks like from the perspective of remote users. Then, two video studies examined interactions in more detail through an EMCA analytical approach. These presented how those interactions can be organised and the ways in which local and remote users manage or fail to communicate through the medium. Moving

to a more direct application of the technology, an Action Research-inspired case study presented the deployment work necessary to make MRP available in an office and the practical considerations the technology introduces in that space. Finally, following up on that deployment, an interview study of employees at that site examined how the technology failed to align with the needs and workflows of office work.

This chapter is structured into three main sections. The first section responds to the first research question, discussing the findings of the studies to present the features of MRP as a distinct category of interaction. The second section responds to the second research question, presenting a discussion into how findings drawn in this thesis apply to the use of MRP in organisational spaces. Finally, the third section outlines the key contributions of this work.

9.1 Understanding MRP-mediated interactions

Addressing the first research question, *How are MRP interactions conducted and experienced in practice?*, this section presents an understanding of MRP as a distinct interaction category. That is, the discussion aims to describe not just a specific robot device, but rather, the nature of interactions that are mediated by mobile robotic technology. I examine the reality of MRP-mediated interaction through the topics raised in the empirical studies presented in the previous five chapters; embodied mobility, situatedness, asymmetries, troubles and assistance and standing out. Then, taking this onboard, I present and discuss the the role and meaning of presence in telepresence and how it might be better re-framed as participation.

9.1.1 Embodied mobility in MRP

MRP as a medium is distinctly characterised by its mobility and embodiment; beyond video calling it affords the remote user a physical body, albeit robotic, which moves. Many communication media are not mobile; from static video calling to more immersive mixed reality architecture designed for passive connection, (e.g., Schnadelbach et al., 2003). A system can also be somewhat embodied, but not mobile (e.g., the Kubi tabletop robot which only turns its neck, or the embodied social proxy system presented by Venolia et al. (2010)). In MRP, movement and embodiment are intertwined, resulting in its distinct form of telepresence.

Existing literature on MRP, as presented in chapter 2 (section 2.2.2), has already examined the subject of its mobility to some capacity. For example, studies find the users tend to move and position the robot in similar formations to in-person interactions (e.g., Pathi et al., 2019), and that this movement lead to a greater sense of presence (e.g., Rae et al., 2014). Beyond this however, little had been made known as to what role embodied movement plays in-interaction. In this thesis, I have collected data that explores this and shows that movement impacts MRP interaction in certain distinct ways.

First, the observational studies presented in this thesis show that remote users of MRP employ movement within their interactions as part of their communicative repertoire. That is, in MRP, movement is used along with other elements of the interaction, such as verbal language. This is particularly evidenced in the data from chapter 5. For example, in the first fragment of that study (section 5.2.1) we see that the remote user drives the robot to face a chair that is in her way in her effort to communicate to the local user that she has encountered trouble and needs help. By

making the robot face the chair, the remote user is enacting something akin to 'gaze'. She is drawing attention the object of this gaze, making it relevant to what she is talking about. This movement of the robot, in the context of everything that is going on, succeeds in communicating to the interaction partner what the problem is and how it may be resolved (by moving the chair out of the way). This allows the remote user to implicitly recruit assistance. She does not need to use explicit, verbal language to say, for e.g., 'this chair is blocking my path'. In this way, movement is used within communication, embedded within all the other communicative acts being employed. Importantly, as will be discussed below, this movement works as a communicative act within the broader situational context. In the fragments presented in chapters 5 and 6, movement is used throughout the interactions in more subtle ways alongside or instead of speech. Often this serves to indicate the focus of the remote users' interest or to direct the attention of the conversation. For example, in the second fragment presented in chapter 5, the remote user turns her gaze towards the local user, indicating to him that she has finished her previous task and is ready to follow him (section 5.2.1). In the study of MRP use in my home, 6, in the first fragment, showcasing an arrival, the remote user J moves towards me as part of his arrival act (section 6.2.2). He does not move in order to get to a particular location in the environment, he is moving to establish the fact that he has arrived and is now present and mobile in that space. Then, in the final fragment presented in that chapter (section 6.2.5), J is again seen moving towards me. In that instance, he does so perhaps to get a better view of what I am doing, but in doing so, he also communicates where his focus lies within this visit, on me. What these examples demonstrate is that when the remote users move the robot, they do more than just alter their position in the local environment, they participate the local environment. Moreover, the movement can be quite seamlessly woven into other things

happening within the given interaction and be read by the local users as a part of the remote user's communication and self-expression.

Beyond movement as a way of communication, movement in interaction also has the effect of changing the dynamic of control over the situation. This is because movement affords the remote user a degree of autonomy to act in certain ways. The local user then has to respond to or accommodate for that autonomy. This is a particularly distinct arrangement of abilities and responsibilities to other media. In a video call both parties have equal abilities (both can see and show things to the screen). Then, if one party wants to show something from their environment, they have to bring that something into view (e.g., Yang et al., 2018; Licoppe and Morel, 2014). In that case, they maintain control over what the other party has access to. With the mobility of MRP, however, this control is less one-sided. This phenomenon was most evident in chapter 6, where the remote users' autonomous behaviours contributed to creating a sense of co-presence and togetherness when using MRP at home. In the first fragment of that chapter (section 6.2.2), showcasing an arrival, we see the remote user making a playful show of his presence in the room, by moving (and singing) towards the local user (me). In response, I move backwards and play along. The remote user's movement has caused me to move. That is, in moving, not only is the remote user enacting their agency but is also, in doing so, affecting the actions of the local user. In addition, as shown in that fragment, whilst moving to avoid the remote user, I am monitoring the situation and ensuring that I remain within his frame of view — I lean forward and bring my head at the same level to the robot's screen. Being a local user then, also entails a form of responsibility for the interaction. Perhaps this is brought about by an understanding that the remote user has limited capabilities (section 9.1.4). As another example, in the third

fragment of the same study (section 6.2.4, M, as the remote user, is looking around my home and commenting on things she sees. Her movement means I am not responsible for showing her things, or leading the conversation (as I might have done if I was showing her my home through a video call). She is in charge or where her attention is directed. Consequently, she is also able to influence the direction of our conversation and broader interaction. Moreover, by having this type of agency, in that environment, she is capable of expressing interest in me and my life. Still, given that I move around the space at a faster speed than she is, and given that I can see her (or rather, that I can see the robot) better than she can see me, I maintain a certain vigilance over the situation to ensure I do not bump into her/the robot. Then, the final fragment of that study (section 6.2.5) demonstrates a moment of 'dwelling' (Ingold, 2011; O'Hara et al., 2014) —of existing together— made possible through this mobility. In that fragment, J simply moves towards me to observe me whilst I am engaged in another task. Whilst minimal action is taken, this interaction constitutes a significant moment of intimate togetherness, precisely because J was able to autonomously take part in it. This would not have been the same if I had placed him there myself. Togetherness involves two people, and it is a situation we both need to orient towards and arrive at mutually and *together*. By being able to move, J is able to do his part. The situations presented here show that the remote users' mobility lets them posses some control over what happens in the interaction — not just what they say but where the attention is focused, and even how the local user moves. Whilst MRP is largely characterised in terms of the limitations it poses to the remote users, the situations I present here also shows that the mobility of the medium can, in certain situations, enhance the users' experience.

Finally, the MRP's embodied mobility results in interactions taking on the

characteristics of 'visits' and engendering certain sequences of actions that frame those visits. To be present via an MRP means to be present not just in an interaction but also in a physical space. This entails having to make sense of that unusual form of presence, within regular life — having to arrive and leave that space, and in the meantime, to be successfully seen and responded to whilst moving in it. As shown in chapter 6, considerable part of an MPR interaction is spent in doing arrivals and departures. Whilst in theory the remote user can simply log in and appear in the local environment, in practice, the interactions entail doing things that make such an appearance normal, by responding to it in ways comparable to an in-person visit. For example, the guest doesn't just appear in the middle of the room, because that is difficult to process socially. They announce their appearance and are softly then embedded into the action happening in that space. To recap on the scene presented in chapter 6, fragment 1 (section 6.2.2), the remote user does not simply log in and directly begin being in the local environment. Instead, the two users go through a sequence in which the remote user announces his arrival and establishes his presence as a robotically-mediated visitor with the local user playing along and acknowledging that arrival.

Similarly, remote visitors do not just leave by logging out; they are gradually accompanied to the end of the visit. As shown in fragment 2 of the same study (section 6.2.3), there is quite an extended sequence of "departing". It begins with the two users agreeing that it is time to end the visit, followed by the remote user's announcement that they will drive the robot to its docking station and then embarking on that small journey there. These sequences can be prolonged or interrupted by new topics of conversation being introduced along the way, and do not end until the remote user has docked the robot and logged out. Of course, not every instance of end-

ing an MRP visit necessarily involves all those steps (for example a remote user may ask the local user to transport the robot to the docking station manually to save time), but what is generally observed is that there will be a closing sequence of some kind, during which both parties acknowledge that a visit is ending. Whilst this work of framing the MRP call within the norms of a visit can be a welcome way of enhancing connection in the home setting, in other situations it can also be time consuming and burdensome. In the final study (chapter 8) office employees described such sequences as one of the reasons for not using MRP, noting that they did not have the time to drive the MRP across different meeting rooms and to and from its docking station. In the first interview study, presented in chapter 4, a user described an experience where upon trying to leave a meeting room they were laughed at for accidentally bumping into furniture. Of course, a part of this can be explained not by the embodied mobility itself, but by the fact that remote users are expected to move from and to the MRP's docking stations. However, given existing literature on movement in MRP (section 2.2.2), as well as EMCA literature on "being ordinary" as something people actively work towards (Sacks, 1984), an argument can be made that the embodied and mobile medium sets an expectation that it ought to move and be interacted with, in accordance to norms set for in-person embodied and mobile humans. Indeed, in the final study presented in this thesis, chapter 8, participants described instances lacking such sequences in a negative light —e.g., abruptly entering a room or a conversation — resulting in awkward encounters. Certainly, the form of MRP, the embodied, mobile presence it provides requires a different type of orientation than to other media or forms of presence, and it invites the enactment of sequences that help embed it into normal interaction.

As the above section has demonstrated, MRP interactions are fundamen-

tally characterised by embodied mobility. Through being able to move, remote users are not only able to have greater access to the local environment (to have a practical sort of presence in it), but they are also able to incorporate this movement into the ways in which they communicate and interact with others. Moreover, the autonomy afforded by this movement results in a distinct dynamic between the remote and local parties. The remote users are able to influence the flow of the interaction, direct attention according to their interest and take an active part in shared moments. At the same time, this results in local users having to respond to that mobility by moving around the robot themselves, and monitoring its movements to provide assistance or avoid collisions. Finally. the mobility of the medium, by creating a physical type of presence in the space necessitates, and is used in, rituals or procedures that help frame that presence in a way that makes sense within the bounds of normal life, such as by treating it as a visit.

9.1.2 Situatedness in MRP

As hinted in the previous section, having a medium that can move in space makes the space a crucial part of the experience too. MRP interactions are not just embodied, but also situated — impacted by the circumstances in which the interactions occur and, in practical terms, by the actual, physical environment. With the exception of some studies of MRP in education and elderly care, highlighting the need for suitable spaces and infrastructure (e.g., Lister, 2020; Labonte et al., 2006), and Rae and Neustaedter's (2017) study raising the issue of scale for MRP use at conferences, the impact of situational circumstances is absent from the current discussions. Through the studies presented in this thesis, I find that in conjunction with mobility,

the environment in which MRP interactions occur is of great importance. It serves as a communicative tool, it is embedded in interactions as a topic of the conversation and it can shape the activities through the types of movement that it enables or necessitates.

First, the environment, when communicating via MRP, becomes an element of the interaction. That is, by moving, the remote users inevitably bring the environment into relevance and further, leverage it to enhance the meaning of their movement. One example can be found in the first fragment presented in chapter 5 (section 5.2.1), in which the remote user is using implicit means of communication to get the local user to assist her by moving a chair out of her path. In that interaction, instead of describing the trouble, the remote user simply moved towards the chair to communicate to her partner that the chair was in the way. This non-verbal, embodied cue was made understood because of the layout of the physical environment and because of the local user's pre-existing understanding of the demands of the task and of the ways in which MRPs move. That is, she already new that the remote user needed to reach a specific object, she could see that the object was behind the furniture and she may have had some understanding that the MRP is not be able to easily move between the furniture. The behaviour of moving towards the chair was situated in these circumstances and the users' understanding of them. Moreover, the environment was utilised as a part of the language (the remote user did not just move, she moved towards the chair). More subtle uses of and references to the environment can be seen throughout the reported interactions. For example, in the fourth fragment of chapter 5 (section 5.2.2), which shows an example of a local user providing unsolicited assistance, the remote user faces the object of their search (the same one that the local user had just unnecessarily pointed out) and asks "is it the the one I am

looking at right now?". That is, before asking, the remote user positioned himself (or the robot) in a specific way relative to the local environment, and his question can only be understood because of that positioning within that environment. In these ways, movement and the use of space are used in conjunction, among other forms of action, within the interaction.

Beyond involving the use of the physical environment for communication, the environment is also topicalised and becomes part of the content of the interaction. As explained in the previous section, movement during a remote visit allows the remote user greater freedom to view the local environment, and in moving through it direct the focus of the conversation. In turn, this allows the remote user to comment and bring features of the environment into the conversation. For example, the 3rd fragment presented in the study of home use in chapter 6 (subsection 6.2.4), shows the remote user looking around my kitchen. As she does this, she names the objects that grab her attention, bringing them to my attention too and making them a part of the conversation. As discussed in that chapter, drawing on Goffman's dramaturgical metaphors for the expression of the self (Goffman et al., 1978), the local environment is no longer the local user's backstage (as might be the case during a video call) but is instead the stage of the interaction of both users. In the case where this stage is someone's home, this might also be seen as an extension of that person's presentation of their self, resulting in them editing the space in order for it to be seen, commented and interacted with. We've seen something similar happen to a smaller degree with people decorating the backgrounds of their desks views with bookcases, so that during video calls they might present a certain, educated image and invite conversation into their interests (Marsden, 2022; Bullen, 2022). The implication here is that space matters greatly — an MRP visit would be boring or even pointless in an empty room with noth-

ing to see. At the same time, a very interesting space could derail the aim of the visit. This has more serious implications for settings where work needs to be done or for settings that require restricted access to protect sensitive information.

Furthermore, beyond its commutative and topicaliseable functions, the environment also has the potential to shape the structure of actions and activities (or disrupt them). As shown in chapter 6, in the second fragment (section 6.2.3), the length of a closing sequence depends on the time required to drive the MRP to the docking station. The environment plays a role there in terms of the physical distance, but also through the existence of 'distractions'. In that fragment one distraction occurs due to a misalignment of the path, which requires the remote user to turn and re-adjust their movement. That is, the environment can have an impact through the ease with which it allows the MRP to travel through it. The presence of narrow paths and obstacles can hinder the robots' path. Then, another distraction presents itself in the form of topicalisable items (in that fragment it is the electric fireplace), which can result in new conversations and activities. In fragment 4 (section 6.2.5), a similar issue engenders playfulness as the local user lets the remote user race against the closing door — at the risk of the door disrupting the robot's exit from the kitchen. Movement through features of environment provides an opportunity for play. In the last study (chapter 8), employees mention feeling bad walking through the office and distracting others. The path of the robot from its docking station to the place of the activity involved passing through open desk areas. This resulted in the remote user being seen by people and potentially interrupting their work and thus in the remote users feeling self-conscious and choosing not to use the robot. Space then also matters in terms of the distances the robot will have to cross, the ease of traveling those distances and what will

be encountered on the way. This trajectory of navigation can be enjoyable or disrupting.

As shown in this section, MRP interactions are, through their mobility, inherently embedded in and influenced by the spatial situatedness in which they occur. Within an MRP interaction, the environment can serve to support the creation of meaning in communication, it can become a part of the conversation through the topicalisation of objects in it and it can shape the interaction through the ways in which it forces the robot to move. As such, it is important to consider that each environment and spatial configuration will give rise to different emergent types of interactions.

9.1.3 The asymmetries of MRP

Of course, despite having some mobility and access to the local environment, the remote user's experience in it is still qualitatively different to that of in-person interactants. As outlined in the literature review (section 2.2.3), communicative asymmetries describe the differences that exist between users in their capacities to communicate in computer-mediated interaction as well differences in ways in which they access the mediated activity. In studying MRP, such asymmetries naturally exist. However, in this medium the asymmetries are not purely concerned with communicative matters, but with presence and participation in the environment more broadly. MRP is not merely a medium for communication; it serves to bring the person into a mediated environment where they may do things beyond talking with locals, such as inspect the environment, monitor local activities or take part in them. That is to say that whilst the asymmetries that exist have an impact on the quality of the communication, they have an impact in the quality of participation more broadly. The studies presented

in this thesis identify three specific types of asymmetries that exist in MRP interactions: asymmetries in mobility, perception and intersubjectivity.

First, there is asymmetrical mobility as the movement of the remote user substantially differs from that of the locals. The remote user is subject to slower, more cognitively burdensome and less flexible movement than the local users. In addition, the MRP is not able to navigate through narrow passages or manipulate objects (e.g., in order to move them out of the way or open doors). As such, the remote users' mobility is also strictly defined and limited by the shape of the local environment. The burden of driving MRP has been cited in previous literature (Heshmat et al., 2018; Neustaedter et al., 2018; Rae and Neustaedter, 2017; Takayama and Go, 2012; Lee and Takayama, 2011; Björnfot et al., 2018; Desai et al., 2011), but is also evident in the data presented in this thesis. In the study on assistance recruitment, in chapter 5, the encountered troubles were primarily related to the remote user's inability to move in certain ways (Fragments 1, 2, 3 and 5). Whilst other media (such as traditional video conferencing) offer less mobility than MRP or no mobility at all, the ways in which mobility is limited here are important precisely because, as discussed earlier, mobility (and communication through embodied movement) is a key feature of MRP interactions and is expected to be done in certain ways that align with in-person behaviour. Data from the assistance recruitment study also shows how the asymmetrical movement was a hindrance in certain interactions. In Fragment 3 (section 5.2.2), for example, the remote user was not able to move fast enough to successfully capture her partner's attention. The local user may have been expecting the remote user to be able to move around and thus was perhaps less attentive to them. In the next study, chapter 6, thanks to the more casual and intimate setting, these asymmetries were less disruptive but still evident in the interaction. For example, this is leveraged

in a playful way in fragment 4 (6.2.5), where the local user runs out of the kitchen and leaves the slower, remote user to race against the speed of the closing door. In fragment 3 of the same study (6.2.4), the local user is seen quickly moving back and forth in the kitchen whilst the remote use is slowly trying to just move a few centimeters backwards. Clearly, remote users' movement in space is not comparable to that of their local interlocutors and this can have repercussions in interaction and participation.

Following mobility, the two sides of the interaction, remote and local, also operate under asymmetrical perceptual capabilities. The remote users of MRP have limited (mediated) perceptive capability of sound and vision, impacting their ability to see and hear things in the environment or sense the location or movement of local members. These limitations have also been reported in some previous literature (Lee and Takayama, 2011; Heshmat et al., 2018; Neustaedter et al., 2018; Johnson et al., 2015). However, it is important to note that within interaction, such limitations are not merely sources of trouble, but also pose an asymmetry in relation to local users, resulting in breakdowns in interaction. For example, participants in the final study, presented in chapter 8, described how being limited in their ability to see and hear who was speaking in real time left remote users outside of conversations when interacting with more than one local user. The local users are matching one another's perceptual capabilities but not those of the remote person. It is also worth noting that the remote users' ability to perceive is tied to their ability to move. As shown in the first interview study, chapter 4, perception in MRP is a highly active undertaking. The remote user needs to move the robot around to see what is behind them, further backwards to get a wider view, or closer in to see faces more clearly and hear better. And as also shown in that study, performing such actions through the MRP is conscious work — the user

has to decide to move in a certain way and then press the buttons. Given the slow and limited movement of the MRP, and the intentional way in which it is operated, this can result in perceiving things at a much slower rate than local users. Moreover, in addition to perceiving the environment and others, in interaction it is also useful to be able to perceive oneself. Previous studies have reported that remote users do not have feedback on how loudly their own voice is being projected (Takayama and Go, 2012; Lee and Takayama, 2011; Desai et al., 2011), or on whether their MRP is taking up too much space and is in someones' way (Lee and Takayama, 2011; Björnfot et al., 2018; Neustaedter et al., 2018) — they are lacking 'mediated proprioception'. Because of this, not only is a remote user unable to perceive what is happening around them during an interaction, but they are also unable to perceive how their own behaviours come across and adjust them accordingly. This is exemplified in the 3rd fragment presented in the assistance recruitment study (chapter 5, section 5.2.2). There, we see the remote use encountering trouble, making a remark in order to get some assistance and being entirely ignored. Lacking that kind of 'mediated proprioception', and being limited in her perception of the environment, the remote user is not able to gauge whether she has been seen or heard. She is also not able to know where her partner is, in order to better direct her subsequent efforts at getting attention. As a result, the remote participant does not adjust her strategy and ultimately fails to get help. We see then that having limited perception compared to local users can result in remote users being left out of participating.

Finally, there is an asymmetry in intersubjectivity. That is, the two sides, remote and local, are not equally able to infer each other's perspectives and capabilities. When two people are co-located in-person, each person can, with relative ease, infer what the other person is able to see and hear in

their shared environment based on what they themselves can see and hear. Similarly, they can infer what actions the other person is able to make (e.g., can they reach and grab something or would they need help). This symmetry in inferring one another's perspectives is 'fractured' (Luff et al., 2003) when one person is accessing the environment through a telepresence robot. The local user, especially if they have not used MRP before, has less access to the remote users' perspective. The simple design of the robot perhaps also does not make the capabilities and actions of the remote user easily evident to the local users (e.g., it is not clear exactly what the remote user is looking at). This is clearly demonstrated in chapter 5, in the 4th fragment of the data (section 5.2.2) where the local user points out to his partner the pink paper, not realising that the remote user was already looking at it. In addition, this is evident in certain phrases and actions used by the participants, showing their uncertainty in what the other can hear or see. In Fragment 1, of the same study, the local participant at first expresses uncertainty on what her partner said ("Oh, you didn't get that?") and then pauses before offering help (section 5.2.1). In Fragment 2, the local participants raises his hand (much like a city tour guide would in a crowded space) and hesitantly keeps it close to his head, to better get his partners' attention (section 5.2.1). In Fragment 4, the local participant follows his assistance with the redress "I don't know if you can see it" (5.2.2). Indeed, statements such as "I don't know if you can *X*" were common from local participants in that study. On the other end, remote users' behaviours also betray a sense that they know their perspective is not well understood by the locals. In the same study, remote users commonly made playful comments as to their limitations and as well as status reportings of their troubles as they encountered them, even if they then proceeded to resolve them on their own. They might not have wished for assistance, but for understanding. In a similar light, a participant in the first interview study,

in chapter 4, described explaining to his local colleagues what he could see through the robot. Then in the study of use at home (chapter 6), the remote users playfully and perhaps strategically distanced their self from the device that embodied them by drawing attention to its robotic nature or talking to it as if it were a separate entity. In that way, they made evident to the local user that they were perhaps not fully in control of how the robot behaved, or that they were limited in their actions to those that can be expected from a clunky robot. These remarks, from both sides, can be interpreted as examples of compensatory work, for participants to make their perspectives (their limitations or lack of understanding) explicit to one another (Hindmarsh et al., 1998). Ultimately, the MRP as a medium lacks a certain reciprocity of the users' perspectives. At its current form, it does not allow local users to easily make sense of the remote user's capabilities and accurately anticipate what that user can and can't do.

The limitations of MRP, with regards to its capacity to move and perceive the environment do not exist in a vacuum. They do not simply render the remote users' experience less immersive, but substantially impact the capability of the remote user to properly participate in the mediated environment. Further, whilst it is evident to local users that certain limitations are in effect, they still do not have a clear access to the remote users' perspective and capabilities. Interactions then are marked by users' work to compensate for those limitations and build a greater understating of one another.

9.1.4 Troubles and assistance

As already mentioned above, a lot of MRP interactions are characterised by the presence of limitations. These result in encounters of trouble and

in a need for regular assistance. Specifically, as outlined in the previous section, the asymmetries skew towards disadvantaging the remote user and putting them in a position of requiring help from the local users.

The first study presented in this thesis, chapter 4, which looked at the experience of MRP from the remote users' perspectives, shows that these limited capabilities were a very prevalent element of the experience of telepresence. The participants reported that the visual and audio fidelity was low, driving was burdensome, that they were not able to manipulate their environment, and relied on consistent internet connection. While these reports reaffirm previous literature, the study shows that such issues disrupt the experience in important ways and this impact persists even after extended use. In conjunction with the absence of manipulators and dependence on internet, the remote user is rendered reliant on their local peers. Participants in that study reported variable attitudes towards this, with some being more comfortable asking for help than others.

The following study then, presented in chapter 5 specifically explored this in practice. The study focused on interactions related to the report of troubles and recruitment of assistance, showing the various ways in which recruitment and assistance emerged around troubles and were practically dealt with by local and remote participants. The analysis of the fragments shows that the physical limitations of the MRP, which manifested as asymmetries in the interaction, resulted in the remote users relying on the help of their local partners but also made recruiting that help challenging. For example, the third fragment of that study shows a remote user who is trying to recruit assistance to overcome an obstacle in her path by voicing a question, but is unfortunately ignored. As explained in the previous subsection, the remote user is unable to adjust her strategy effectively as she has little feedback on whether she has been heard or not, and is not able

to quickly and smoothly turn around and see where her local colleague is.

With regards to how help is solicited, the data from that study (chapter 5) found a preference for relatively 'implicit' methods of recruitment. Specifically, participants mainly made use of trouble reporting (e.g., Fragment 1) and projecting troubles (e.g., Fragment 2). Despite the time constraint, they did not at any point make explicit requests for help, even though those might have been more direct. For example, users did not go beyond describing the trouble to suggest a resolution such as "can you move the chair?". Instead, remote participants simply reported what trouble they were experiencing, such as "there is a chair", and allowed their partner to formulate a resolution for it (or at times ignore the recruitment attempt). At the same time, local participants appeared to consider their partner's mobility limitations without prompting as they frequently, observably anticipated when trouble might arise and responded to it in advance. Examples of this often involved moving furniture out of the way of the remote users' projected path.

The embodied design of the MRP does provide certain mobility affordances that support implicit recruitment, enabling more subtle, expressive ways asking for help than in other media — e.g., remote gestures in videoconferencing (Kirk and Fraser, 2005). Furthermore, as previous literature has suggested, indirectness on the part of the requester could be indicative of a low sense of entitlement to make the request (Heinemann, 2006; Curl and Drew, 2008). This entitlement, or lack thereof, is itself established within a sequence of interaction rather than as part of static intrinsically 'entitled' relationship. Indeed, participants in the the interview study in chapter 8 reported that they didn't like asking for help — suggesting that there is a reluctance to impose on the locals. However, whilst sharing that sentiment, they also reported getting used to asking for help in more direct ways after

using the MRP for an extended period. The way in which assistance is approached then within an interaction can vary based on context.

Nonetheless, it is important to acknowledge the fact that troubles on MRP tend to be very prevalent, and that the need for assistance is mostly one sided. This form of imbalance could have an impact on a user's capacity to take part in mediated activities. Of course, encountering troubles is an unavoidable part of life and does not necessarily require technical solutions — there are normal, natural troubles, as pointed out by Garfinkel and Bittner (1967). For example, not being able to open doors, and needing someone else's help could be a normal, natural trouble that users learn to manage. However, as evidenced in the studies, other troubles can significantly, practically impede on an interaction. Not being able to perceive part of the interaction happening in the local environment outright disrupts the users' ability to communicate effectively. Not being able to move and interact in the environment at the same speed and capacity as others might render the user unable to participate in the local environment altogether. Having to ask for accommodations to these troubles in a work setting can put users in uncomfortable positions. Even a normal, natural trouble could be cause for concern if compounded, with the reliance on help placed consistently unevenly. The assistance recruitment study found that recruitment exclusively flowed in the direction of the local participant; there were no instances in the data in which the local participant instead recruited the remote participant for assistance. Beyond the communicative asymmetries identified in the previous section then, there is also another type of potential imbalance between remote and local users, an imbalance with regards to the users' power to give and receive the assistance that is vital for ensuring the presence and participation of remote users within an interaction.

9.1.5 Standing out, being in-ordinary

Another prominent element of the experience of MRP-mediated presence is that the remote user stands out and at times fails to pass as an ordinary participant in the mediated environment. I use the term "ordinary" here in an EMCA sense, to describe a quality that allows someone to be interacted with and be a part of social activity. Of course, interacting with someone embodied as a robot is unusual — it is not ordinary with the everyday sense of the word. But beyond this, an MRP user is not ordinary in interaction. There is a certain friction and awkwardness to the interactions, which suggests that the MRP is not seamlessly incorporated into the social organisation of interaction, but is oriented to as something unusual which needs to be made sense of.

This issue is first revealed in the users' accounts reported in the first study, in chapter 4. Those participants described experiences where their mere presence in the office environment, as a robot, drew the attention of colleagues and bystanders. Whilst one user playfully described it as a positive thing (a way of socially connecting with colleagues), he and other interviewees also described the experience as unpleasant. Drawing that kind of attention disrupted the remote users and slowed them down on their way to their meetings. Then, whist in meetings, participants reported feeling conscious of drawing attention when making movements, which could be disrupting to the meeting. These concerns were also shared by interviewees in the last study of this thesis, chapter 8. One participant in that study even reported that he avoided using the robots during busy hours of the day as they felt weary of disturbing on-site employees. These reports show that simply moving in or through a space as an MRP attracts attention to the MRP in a way that is different to the attention given to an in-person

individual moving in similar ways. Being present in a space as a robot, unsurprisingly perhaps, is treated differently to being there in-person. The resulting treatment towards the remote user can be positive or negative, but it will likely entail receiving attention that the remote user themselves did not mean to elicit.

What is more concerning, is not that remote users attract attention but that the way in which they are oriented to can sometimes be outside of the norms of what we expect for human-human interaction. One characteristic instance of this is in a story shared by Participant 6 in chapter 4, where the remote user was laughed at for failing to quietly leave a meeting room. Based on politeness theory, the expected behaviour there would be for local users to let such mistakes go 'unnoticed' to help the other person save face (Brown and Levinson, 1978). However, we find that this does not happen to remote users of MRP. Instead we see that local users might draw attention to weird behaviours displayed by the robots, or navigation mistakes made by the remote users. While some users report that they can take being laughed at and made the center of a joke in good humour, this phenomenon is still indicative of the fact that remote users are oriented to differently. Indeed, incidents where remote users are not afforded this commonplace politeness or where they are oriented to more as an object than as a person have also been reported in other literature (e.g., Stoll et al., 2018; Berisha et al., 2015; Lee and Takayama, 2011; Rae and Neustaedter, 2017). And whether this orientation manifests in inherently negative interactions or not, what is evident is that the telepresent person is unavoidably oriented to by their local peers not as 'just another person' but as something slightly different.

Drawing on the work of Sacks, on the processes by which people actively do 'being ordinary', it is possible to read this phenomenon as a result

of the MRP not allowing the remote user to successfully act so as to be perceived as ordinary and blend in. Sacks (1984), posited that to be normal, to be ordinary, is something people do by behaving in ways that they deem as ordinary based on what we expect other people to be doing. In that sense, ordinary is not something we are but something we do. To be ordinary during a conversation then would entail doing the things we consider normal to do in that setting (e.g., make eye contact, wait for someone to finish talking and respond with something relevant). As the data presented in this thesis shows, it is not easily possible for remote users to do things like that. Remote users have reported that they are not always able to hear what is being said and determine who is speaking. They also report that it is difficult for them to smoothly interject into a conversation without interrupting. This results in them failing to do "being ordinary" — to behave in ordinary ways, and therefore to be perceived as normal. Further, based on given evidence on the social organisation of MRP interactions, and particularly the impact of asymmetries in the reciprocity of perspectives, it is apparent that the MRP does not fully allow for local users to make sense of the remote user. That is, it does not make the actions and capabilities of the MRP easily available to observers so that they may accurately anticipate what the MRP/remote user will do. As such, the behaviours of the remote users are seen as even less ordinary. They do not just break social norms, but do so in ways that are difficult for others to anticipate and systematically incorporate into an updated interaction norm. Their orientation towards MRP then is hesitant, conscious and rife with breakdowns. As such, the MRP-mediated person is not able is smoothly blend into the action of ordinary life in the local environment.

9.1.6 Presence and participation in MRP

Having now demonstrated what occurs during MRP interactions, we can return to addressing the initial question of the nature and role of presence, through a more informed understanding of what matters in interactions.

Presence in MRP

The matter of presence is very prominent in how MRP is talked about in research. As outlined in the literature review (section 2.2.1), approaches to presence can vary, from clear-cut definitions measuring presence as a sense of "being there" and an "illusion of non-mediation", to approaches that see presence as product of interaction with others and the environment. Many studies on MRP report that the remote users feel a sense of presence when using the robots but in most of those little explanation is given to what exactly presence means in that context or why this matters (e.g., Schouten et al., 2022; Björnfot et al., 2018). Some studies have that examined presence on MRP more closely, but still using surface level definitions, such as on whether the mediated environment felt real or testing how well the remote users can recall it (e.g., Kristoffersson et al., 2011a; Rae et al., 2014). Selected studies suggest that a sense of presence depends on the ease of use of the MRP, and on the orientation of local users (e.g., Kaptelinin et al., 2021; James et al., 2019). Still, the literature lacked any discussion on the experiential qualities of that presence —what does it feel like to be telepresent?— and on how this becomes relevant in supporting effective mediated interactions.

In addressing this gap, the first interview study presented in this thesis, (chapter 4), examined the experience of telepresence through first-person

perspective descriptions reported by long-term remote users of MRP. As the descriptions showed, the experience is often characterised by the limitations of the medium. The remote users have limited capabilities to perceive the world and act in it compared to the physically present persons. The participants reported that the visual and audio fidelity was low, driving was burdensome, that they were not able to manipulate their environment, and that they did not have consistent internet connectivity. Similar issues were reported by the short-term users who were interviewed in chapter 8 and in findings from previous literature (2.1.3). Moreover, the reports in chapter 4 show that perception of the environment is an active undertaking — users have to consciously move and position the robot in order to access different parts of the mediated environment. This is also evidenced in the subsequent observational studies. For example, in the home study (chapter 6), in fragment 3 (6.2.4), the remote user is seen talking to the robot in the 3rd person, as she is driving it backwards. She is not merely moving backwards, she is actively engaged in making the medium she embodies move backwards. The above examples show that experiencing the world as an MRP differs from experiencing it in-person; the remote user is experiencing the world through the limited window of the robot and through the work they put into operating it. To use the phenomenological lens, the medium does not become a background to the users' experience of the mediated world, but remains in the foreground. As such, presence in telepresence can not be truly immersive — it can not provide an illusion of non-mediation.

Indeed, when specifically asked about whether they felt present, the participants in chapter 4, did agree to feeling present but not 'really'. As one participant put it "I did, yeah. Clearly, not literally.". That is, as inferred already, their experience of presence in MRP means something different to

really "being there". That same participant followed up his response with "But it certainly made me feel like I was in the community." When describing experiences where they felt present, participants described two things. First, they described instances where they were truly able to participate in the remote interaction, and get the attention of their local colleagues in meetings (described in contrast to instances where they were ignored during meetings when using traditional videoconferencing). And second, in situations where they were able to do things in the environment. For example, one participant described touring an office as similar to using google street view. Google street view can in no way be described as a truly immersive, 'illusion of non-mediation' type of experience, and yet for that user that experience qualified as presence due to the ability to independently navigate a space. As such, we can see that to users presence relates to a capacity to act, and be part of the activities in the mediated environment.

Presence through participation

The above shows that the prevailing focus on the experience of immersion and presence on MRP are almost a sort of red herring when it comes to understanding what makes MRP-mediated interactions work. I argue instead, that what ought to be considered first is the capacity of remote users to participate effectively.

One part of this involves understanding the value of mobility as MRP's main feature that distinguishes it from to other media. The mobility of MRP, as previously outlined, is limited and as other literature has shown, friction in driving the MRP reduces the users' sense of presence (Kaptelinin et al., 2021). A sensible proposal then is to improve the movement capa-

bilities of MRP devices. However, it is worth considering first, just how and when mobility matters. As we have seen throughout the thesis so far, the mobility of the medium plays a big role in how the interactions are socially organised. Beyond its role in enhancing the communicative actions of users, it also serves to allow the user to exert more influence over the mediated interaction — to act on their own accord, direct the focus of the conversation, and take an active part in mutual moments of togetherness. In that sense, it is not the mobility in and of itself that makes a differences, but the autonomy that it enables. This is worth pointing out, because autonomy can be achieved through other means. For example, in the interview study following the deployment at Microsoft Research (chapter 8), the interviewees often opted for media other than MRP, such as video conferencing or digital whiteboards because although those had no mobility, they allowed the user to participate in a much more comparable way to the on-site workers. As a result, they also felt more included when participating in this way. As such, it is not enough to simply make the mobility of MRP better (e.g., faster, more flexible, more automated). Other areas of telepresence, such as they ways in which users access and manipulate the environment need to also be addressed.

In addition, improvements in the remote users' different forms of autonomy, can improve the experience of interactions with local members. As stated by long-term users in the first interview study (chapter 4), they felt present when they were treated by local users as present. And as discussed in the previous section, the orientation towards remote users of MRP by local users as a regular, ordinary interactant can often be challenging. This is because the remote user is prevented from acting in ways that are in line with in-person ways of doing "being ordinary" and because the MRP does not make this limited perspective of the remote user available to the locals,

so that they can anticipate and incorporate it smoothly in the interaction. As such, a focus on enhancing the remote users' ability to act according to how they wish to be perceived can also improve their experience of presence. The sense of presence here however, is more of a by-product of successful interaction experiences and not their cause.

Given the above, this thesis calls for research and design work in this domain to re-frame its focus, from designing for presence, to designing for participation. This means focusing more on how interaction between local and remote users is practically accomplished so as for the remote user to be 'in on the action' in an embodied way which will allow for meaningful engagement with the local environment and activities in it.

9.2 MRP suitability for organisational spaces

The previous section has presented an understanding of MRP as it is used and oriented to in interaction, laying out a detailed image into just what occurs during use and examining the different factors which support or hinder the user experience. This section will now answer to the second main research question: *How suitable is MRP technology for supporting hybrid spaces in organisations?* To do this, this section will be taking concepts presented in the previous section and drawing out the implications they raise for the material circumstances of using the technology in an organisational setting. In addition, the discussion will be drawing on the deployment case study presented in chapter 7 and follow-up interviews from chapter 8, as a reference to a real-world concrete example. In examining this, I will be discussing the Health and Safety considerations, the matter of space, the alignment of the technology with workflows, and the suitability

of MRP for participation in hybrid work and for social presence.

9.2.1 Health and Safety considerations

As shown through the case study of the deployment, in chapter 7, making MRP technology available in an office presented us with several Health and Safety challenges. During the course of the case study we found that it was not enough to simply put the an MRPs at the office, other infrastructure and set ups were needed. The Health and Safety assessment we carried out flagged several issues regarding the accessibility and inclusivity of the robots, the security of having them in the office around classified information but also the safety of local users. As outlined in that chapter, dealing with these issues was work that required several weeks, and the collaboration of various teams with different domains of expertise and responsibility. The measures we created took many forms, from IT procedures, physically augmenting the MRP, setting up a system with the local building staff to look after the robots and creating a multitude of instructional material on how to use and handle the robots and their environment. Once the robots are deployed in the space, continuing to have them also required some continuous peripheral support to ensure that safety measures were maintained and that the robots were charged and usable. Many of the challenges in covering those issues stemmed from the fact that the technology consisted of large devices that were expected to be moving in a big and populated space.

In the previous section, I have outlined the practical details of how MRP is used in interaction. Aspects of this include the mobility of the medium; MRP is a device that moves around the space. This means that the entire accessible space of the organisation needs to be appropriately prepared to

support the presence of the robots. The same applies for all the people that are likely to be in that space. Much of the previous section has been concerned with issues relating to how users make sense of the technology (or fail to do so). In particular there is considerable asymmetry in reciprocity as the medium does not clearly make its capabilities available to local users, resulting in some confusion over how to treat the robots. This is important when it comes to deploying the MRP in organisational settings, where the robots are likely to come into contact with various people, many of who will not have been properly onboarded to the technology so that they are aware of how to interact with the robots effectively and safely. As such, big part the work of the deployment involved adjusting the space, and creating information placed in that space so as to safeguard against on-site people responding to the robots inappropriately (e.g., grabbing the robots while in use) or handling the robots in ways that would render them unusable (e.g., blocking their access to their charging docks). Deploying MRP then means making preparations that span the entire organisations both in terms of the space and the people.

The practical considerations of using MRP across organisational settings might be difficult to provide for, creating an additional obstacle to use. A strong internet connection and an accessible flat floor are required whether MRP is used in a private home, in a school or in an office. It is also important to consider that the company or institution is liable to keeping their members safe within their environment and may need to follow stricter assessment criteria. In addition, whereas in a more private setting it is possible to account in advance for the kinds of people who will be using the MRP, an organisational space might welcome a wider range of people with varying degrees of familiarity with MRP or robotic technology and also with different accessibility needs. As such, it is important to ensure that

the technology is accessible and does not exclude anyone from interacting with it. Furthermore, it is important to be proactive in providing ways of clearly communicating to incidental local bystanders what the MRP is and how to use it in order to safeguard against inappropriate actions. Whilst in this case the company took on the burden of making the robots compliant with Health and Safety, this may not be affordable to other organisations. In the future these considerations could be designed into the MRP. For example, we can reduce the likelihood that people grab the robot in a way that might make it fall through clearer user guidelines, by making the body of the robot less grab-able, but also by making MRP devices more sturdy and safer to handle.

9.2.2 Telepresence robots in space

MRP is inherently a medium tied to physical space. The point of being robotically telepresent is not simply to communicate with others but to be with them in a physical location. And moreover, to be with them and mobile in that space. Not only is movement in space the main reason to use this medium over others, but it is also, as explained in the previous section, a key element of how the medium is used. Embodied movement is a prominent feature in MRP interaction, and consequently, the physical environment is also unavoidably drawn into the interactional stage. As such, both for the use of MRP to have purpose and for it to be possible and effective, the space must be appropriately supportive of the robots' movements in it. This is something rarely considered when it comes to marketing MRP for office applications. As noted in the introduction chapter, MRP is often presented as a way for remote employees to maintain a presence in the office by being able 'walk' through the hallways, yet studies have found that

this is not truly viable in practice (Tsui et al., 2011). Beyond that, what does it mean to have and use these MRP in such a space?

In the case study of deploying MRP at the offices of Microsoft Research, described in chapter 7, it become evident that even the location of the robots' charging stations was a bigger challenge than originally expected. During the deployment, we discovered that even finding the right locations to park the robots and their docking stations was a challenge. As outlined in that chapter, there were certain safety rules with regards to the robots not blocking fire exit pathways or posing a tripping hazard which restricted the possible locations. Beyond that, we had to consider factors related to the use of the robots. As was explained in the previous section, the environment can impact how the robots move and are used in it. The arrivals and departures of MRP are particularly affected by the distance of the docking station from the desired activity location, and as will be discussed below, in the setting of the office there is less tolerance for time spent doing such extended driving. Furthermore, MRP has the tendency to make the remote users stand out, which can be uncomfortable for the remote users and disruptive to the local users. As such, the placement of the docking stations should limit the distance required to drive them to different locations, and not require the robots to travel through areas where they might pose a distraction to others. Additionally, to facilitate driving, the docking stations should be in locations that have strong internet connection and do not have too any pieces of furniture. Even in a large, contemporary office, it is was difficult to find many appropriate locations.

Then, beyond the placement of the robots' docking stations, there needs to be a consideration of the broader movement of the robots in the space. The layout of the space and the objects in it can shape or hinder movement. In planning such a deployment an organisation should consider what forms of

movement are relevant to the activities taking place in that setting. For instance, if the objective is to view 3-dimensional artefacts, then the space around them should be made accessible to the MRP. If the objective is to have remote users mingle socially among on-site people, then space for the MRP should be provided between the furniture of the social areas. Moreover, the spaces in which remote users are expected to participate should have strong internet connection and be near docking stations. The paths that the MRP will be expected to take should also not be blocked by doors or other obstacles. In addition, the organisation needs to reconsider their security practices around the keeping of sensitive information. As the robots make it possible for people to remotely roam the organisation space, new procedures are needed to ensure that classified documents are kept out of reach of freely roaming MRP. The space then will need to be designed so as to account for telepresence devices moving in it.

9.2.3 MRP and hybrid work(flows)

As explained in the introduction and literature review chapters, in part the motivation for this thesis has been a curiosity at not seeing MRP used commonly despite claims of its benefits. Throughout this thesis so far, I have examined in detail how exactly interactions between MRP remote users and locals are organised. As demonstrated, mobility and use of space as enabled by MRP can enhance an interaction, but can also inhibit it. Moreover the interactions are characterised by asymmetries between the local and remote sides, an one-sided reliance on help, and a difficulty in incorporating the MRP within interactions as an "ordinary" form of existence. Then, as explained in the above two sections, there are practical challenges in implementing MRP, with regards to health and safety concerns and use

of space. Still, when it comes to examining the suitability of the technology in an organisational setting, a complete understanding requires comparing all this against the realities of how things are done at that setting and what the hybrid participation demands of that setting actually are.

The deployment of MRP at the offices of Microsoft Research, which provided the basis for the studies presented in chapters 7 and 8, found very little use of the robots in that particular case. Literature on workflows shows that successfully implemented technology needs to not disrupt the existing ways in which workers' routines are coordinated (section 2.2.4). Further, literature on non-use shows that a deeper understanding of technology can be gained by examining people's relationship with technology more critically based on how it fits within their social lives, rather than simply explaining lack of use by listing its limitations (2.2.5). Talking to employees at Microsoft Research, in the study presented in chapter 8, revealed that MRP was not just avoided due to having limited technical capabilities, but, more importantly, because the ways of using the robot did not align with the realities of office life. Taking onboard the teachings of non-use literature, it is worth noting that the following considerations did not 'hinder' use, as that would imply that MRP use will be inevitably embraced once those factors are removed —an attitude which assumes the inherent superiority of MRP over other media. Rather, these considerations are presented here in order to broaden the understanding of when MRP is actually beneficial and when it is not.

In practical terms, factors impacting the suitability of MRP can relate to the use of time and the relevance of physical space, as well as the the teams' structure and the broader technological ecosystems of their work. Time is important because, as demonstrated, MPR moves slowly. In addition, there are certain procedures within the interactions, such as arrivals and other

compensatory work, which serve to normalise the MRP presence, which also take time. Finally, there is a need for various forms assistance towards the remote user, which also require some work and time. The time needs to be available to the prospective users, as does a willingness to give up that time and to take part in the work necessary. In the case of Microsoft Research, for example, most employees did not have that time in their schedule. The interviewees reported having their meetings back-to-back, and not wanting to spend extra time at the office. In addition some commented on being put off by the need to assist or be assisted, given that they had other ways of meeting and doing their work.

Then, with regards to space, MRP use naturally needs to take place in a specific local environment. This makes sense when an organisation has one specific space in which their members need or want to be. In the case of Microsoft Research, the employees were physically distributed over various locations, with some working from home or based in other Microsoft offices. Therefore, there was not an inherent motivation for the remote employees to want to be at that particular office where the robots were deployed. As one interviewee further commented, introducing an MRP in such a case biases the remote users to interact with the employees who are at that office over other remote employees. As some other studies have suggested, MRP then might be more suitable for hub-and-satellite team configurations, where the majority of the team are in one location with one or two remote employees joining them from elsewhere (Venolia et al., 2010). In addition, to the distribution of the members, there is also the relevance of the space to the activities that need to be supported. Again, in the case of Microsoft Research, the majority of the work the employees were engaged in was done digitally and did not require the use of physical space. Organisations then need to carefully consider the importance of members being physically

present in that space, and what they are expected to do in it.

Finally, in terms of context, it is important to account for the broader technological ecosystem of the organisation — what other media and technologies are the organisations members using? How satisfied are they with it? How familiar are they with computer-mediated communication technology? As demonstrated through the interviews in chapter 8, the employees at Microsoft Research were well equipped with resources and knowledge on how to manage hybrid work. This meant that they had less need for another solution, and less capacity to incorporate it into their routines. Further, as reported in the interviews, they would need to use the MRP in conjunction with their current system (Microsoft Teams) rather than replace it altogether. Some even noted that it might have been easier to use the MRP if it was accessible through their Teams interface. Given, as mentioned, that their work was done digitally (often through Teams) having to join a meeting through MRP in fact meant leaving the Teams environment where their work was actually happening. MRP then might prove more useful in a less digitally-bound settings, where the type of access enabled by moving through space is more relevant.

To reiterate, these factors are not presented here as reasons to critique MRP in its entirety, but as practical considerations that can affect the suitability of the technology in certain settings. The next two sections will now then delve into whether and how MRP can fulfil specific needs of hybrid organisations.

9.2.4 MRP for participation in hybrid collaboration

For MRP to have a truly meaningful place in hybrid organisations, it needs to support the participation of remote attendees in local activities on a level equal to those participating locally. As discussed in the previous section (9.1.6), drawing on the reports of users from chapter 4, what matters to remote users in terms of what evokes a sense of presence in the mediated environment is feeling that they are "geared into" the action of the local activity. This comes about when remote users are able to act in that environment in ways that fulfil the demands of the activity at hand. This becomes particularly important in the applications of MRP in organisational settings, where participation can often involve the cooperation and contribution to work tasks or work-related decision-making.

In interviews presented in chapter 8, following up from the deployment at Microsoft Research, the participants also brought up the matter of participation. Those interview participants explained that even if the technical limitations of MRP (such as the sound quality) were improved, they would still see little point in using the robots because it did not really allow them to participate in physical activities in the same way as the people on-site. The interviewees described activities in which they had tried to participate via the MRP, such as whiteboard ideation sessions, and explained that the medium did not really allow them to take part in the same way as their local co-workers. Given the limited capabilities of the medium, even if they were able to move in the space, the users were not able to draw things on the board. Therefore, they were not able to quickly share their ideas like the rest of the participants were doing. In such a scenario, the capabilities required for the activity were not afforded by the MRP. This resulted in the remote users being left out of the activity — essentially

leading to a less inclusive hybrid set up. When this is a matter of making contributions to ongoing work, such exclusion can have an impact on users' careers. In contrast, the interview participants described doing a similar activity in a fully digital space, where, although the physical presence was lost, everyone was in an equal capacity to contribute. As advocated by work on non-use then (e.g., Selwyn, 2003), the use of MRP technology is not an improvement in absolute terms but only in as far as it enables the construction of meaning within the broader scope of people's lives; only in as far as it enables participation. Of course this is not to say that MRP has no place in hybrid activities at all. As demonstrated in this thesis, MRP can support rich and immersive shared experiences through the ways in which users incorporate movement in their interactions. It also allows for meaningful interaction with the environment — although remote users can not manipulate the environment they can topicalise and move in it to direct the focus of the interaction. MRP then can prove useful in activities based in physical space, which involve complex communication about elements of that space —for example, monitoring ongoing physical work or inspecting of 3d prototypes — but not in activities that require acting in that space. In terms of the application of the current technology then, prospective deployments should first consider the types of hybrid activities that the MRP is expected to support.

9.2.5 MRP for unplanned social interactions

Another commonly proposed use of MRP in organisational spaces is as a way to allow remote members to have a presence in the environment so that they can engage with locals in social, unplanned interactions. While organisations may have found that knowledge work can be done remotely,

one of the drawbacks of working from home may be the loss of unplanned encounters outside of formal meetings. The possibility to roam around the space using MRP then might be considered a solution. However, in practice it is evident that such interactions are not well supported by MRP.

The ways in which the MRP allows a remote user to act are not very conducive of serendipitous encounters and unplanned interaction. First, the use of MRP by the remote users is highly intentional, both in terms of the instigation of MRP-mediated visits and in terms of the actions made during those visits. Indeed, whilst the marketed image of MRP in hybrid spaces is one of remote users casually roaming hallways and greeting locals they bump into, this is not reflected in the practical reality of use. As participants noted in the interviews in chapter 8, a user needs to intentionally decide to log into the robot, which negates the idea of serendipity. The visit then becomes similar to remote employees creating a meeting channel in order to "hang out", which, lacking serendipity, has also been characterised as awkward. Given the time constraints of employees, it is also unlikely that someone would take time out of their day to simply drive around the workplace solely in the hope of "serendipitously" bumping into their colleagues. Of course, it is possible that such encounters might happen when a remote user is navigating the space on their way to a meeting location, but then in such cases the remote user is also likely to be in a hurry.

Beyond the circumstances in which encounters could occur, social interaction is also made difficult by the communicative elements available to the users. As shown through the reports of participants in both interview studies (chapters 4 and 8), operating the robot takes a degree of conscious effort. In addition, the presence of the remote user is still limited to a 2-dimensional screen, with limited capability to move quickly and flexibly. As result the remote user lacks a certain subtlety and grace. That

is, many of the subtle parts of human behaviour which serve as cues in interaction (breathing, leaning, making small utterances) are not translated on the robot. The medium only projects the more overt actions (bigger movements, speaking). As such, the behaviour of the remote user can appear abrupt. Moreover, further limitations and communicative asymmetries (outlined in 9.1.3), can also make it difficult for the remote user to smoothly interject themselves in a conversation. Outside of structured activities then, such as work meetings, with an agenda or an expectation for everyone to have a turn at presenting their work, or more intimate one-on-one interactions, where the is a mutual, pre-established motivation to communicate, MRP is missing the affordances that would in enabled users to mingle and connect effectively in unplanned, casual, social encounters.

9.3 Contributions and implications

This thesis presents an examination into the practical realities of MRP use. This involved revealing how MRP is experienced and used in interaction, the work of deploying it in organisational spaces and how it aligns with the needs and practices of members of those spaces.

As outlined in chapter 2, although there is a considerable body of research on MRP devices, there still remain substantial gaps in our understanding of robot-mediated communication technology and whether it can support hybrid spaces for organisations. Existing studies claim that the technology is generally well received by participants who trial it in offices, conferences, schools and homes (e.g., Lee and Takayama, 2011; Björnfot et al., 2018; Neustaedter et al., 2016; Yang et al., 2017; Newhart et al., 2016), but also point to several drawbacks. Besides technical limitations in the devices'

movement, perceptual capabilities and reliance on internet, studies also point at frictions between remote and local users —awkward interactions, impolite behaviours, exclusion (see 2.1.3). Nonetheless, the literature, did not examine how these limitations are dealt with in practice —and therefore how they impact use— nor how those frictions arise. In addition, the existing research does not account for the general lack of MRP use, which seems contrary the multitude of generally positive results.

Beyond failing to clearly demonstrate the realities of MRP use through more in-depth, critical research, previous work had also overlooked concepts and approaches from other traditions. As presented in chapter 2, for instance, despite a lot of MRP research talking about presence(e.g., Lee and Takayama, 2011; Rae et al., 2014), there had been little consideration into what this means and why it matters. While many studies looked at MRP use in organisational settings, there had been little connection to concepts from CSCW literature, such as work on communicative asymmetries or on successfully embedding technology within team dynamics and workflows (e.g., Luff et al., 2003; Ellis et al., 1991). Finally, for a form of technology that is not broadly used, and even observably avoided (e.g., Tsui et al., 2011), there has been a stark lack of engagement with the non-use literature and with more holistic explorations into how the technology fails to support meaning-making in people's social lives (e.g., Baumer et al., 2015a; Chatman, 1996).

The present thesis drew on the aforementioned areas and addressed these gaps through detailed studies of MPR from the perspectives of users and non-users, looking at both the moment-by-moment use and the broader organisational context. With regards to the first research question, *How are MRP interactions conducted and experienced in practice?*, as the discussion in the early part of this chapter reveals, both the experience of being telep-

resent and the organisation of inter-subjective interaction are characterized by situated material circumstances. The experience of being telepresent —of accessing the world via MRP— involves a distinct awareness of the medium and active engagement in using it. Presence as experienced by users is not about feeling that they are really "there", but about being engaged in the activities occurring there, being able to do autonomously do things in that environment and participate in what is going on in it. Interactions involve the use of movement and the environment, resulting in the emergence of different ritual behaviours (e.g., arrivals), and a distinct dynamic between the users. In addition, when looked at from the lens of interaction, the technical limitations of MRP (previously reported in literature) can be understood as communicative asymmetries which can manifest in interactional breakdowns, reliance on assistance, and in the treating the remote user in ways that deviate from "normal" human interaction. With regards to the second research question, *How suitable is MRP technology for supporting hybrid spaces in organisations?*, this thesis identifies several considerations for assessing the suitability of MRP in specific settings. The case study of the office deployment revealed that there are practical implications when it comes to allowing the free use of remotely controlled mobile devices in spaces managed by an organisation that hosts a magnitude of different types of visitors. These include investing work and resources into ensuring the physical safety of users, abiding by building regulations, maintaining security of the building, providing appropriate information around use at relevant points where people encounter the robots and ensuring that technology is inclusive and accessible to all. Moreover, the suitability depends on having an appropriate space, on whether the affordances of MRP fulfil the needs of prospective users and on whether the demands of using MRP align with people's routine practices with regards to having the ability to perform the work required to use MRP.

Resulting from this work, this thesis also makes the following additional contributions: 1. Introducing the use of auto-ethnographic methods in HRI research, 2. Respecifying the focus of telepresence research from presence onto participation and 3. Identifying the functions and implications of mobility in robot-mediated communication technologies.

9.4 Using auto-ethnographic methods in HRI research

One of the methods I used in this thesis to address the gaps in the literature was auto-ethnography. In chapter 6, instead of observing others, I studied my own use of MRP. Whilst auto-ethnography is a well-established research method in other social science disciplines, it has not yet been leveraged in HRI research (Chun, 2019). Through employing this method in my thesis, I demonstrate how it can be used as a way of gaining a deeper understanding of the realities of robot use, and in doing so I bring it into the domain of HRI.

The majority of research conducted in the field of HRI follows a broadly positivist paradigm. Whilst HRI is a multidisciplinary area, most of studies present quantitative data from hypothesis-driven experiments. That said, there is a growing movement towards more critical and reflexive research approaches (e.g., Winkle et al., 2023). Still, a review on qualitative research in HRI, by Veling and McGinn (2021), found that the majority of qualitative studies use observations, interviews and focus groups; with self-study methods being absent. And as Chun (2019) explain, although ethnographic methods are used in broader HCI, they still tend to take on a positivist approach in examining the data; lacking reflexivity on the role of the re-

searcher and their circumstances in the knowledge production. As such, my use of autobiographical data, used within an ethnomethodologically-infomed, reflexive, ethnographic framework brings a novel approach to doing HRI research.

As I show in this thesis, using autoethnography offers practical benefits in terms of data collection but also fosters a closer understanding of the technology being studied. In terms of the practical benefits, autoethnography allowed me get data on use with little to no participant recruitment and mimimal effort spent managing data collection logistics; all I had to do was turn on a camera when I was using the robot. Moreover, this ease of obtaining data made it easier to collect more frequent, as well as longitudinal data; no need to chase-up participants or be impeded by them withdrawing from the study. This allowed me to get more rich data of mundane, everyday use; thus filling a gap in this previous literature. In the field of HRI, the technologies being studied are often more commonly purchased by research labs rather than by the general public, with many robot models not even being available as consumer products (Mahdi et al., 2022). This makes it difficult to recruit participants who are familiar, expert users of robotics; resulting in research of mostly short-term use, reporting on reactions to novelty. As such it is a missed opportunity for us researchers, who have access to the technology, familiarity with it and a predisposition for analytical reflection, not to use the robots ourselves as a way of learning about them. Furthermore, beyond the logistical benefits, the use of autoethnography, within an ethnomethodological framework, allows for a closer and more in-depth understanding of the technology. As demonstrated in my study, this approach allows for insights into what it feels like to use the robot and have it become part of one's life (e.g., changing my relationship with my space), for the opportunity to notice interesting

aspects as they are encountered through lived experience (e.g., noticing my body leaning towards the robot to accommodate its field of view), and for a richer understanding of the situation from having deeper contextual knowledge (e.g., knowing my mother's manner of speaking). These are elements that might be unavailable to a researcher who is merely observing or interviewing other users. The use of autoethnographic research methods then can be hugely beneficial in the field of HRI.

9.5 From presence to participation; respecifying the focus of telepresence

Through the work presented in this thesis I make the case that the focus on achieving a sense of presence through telepresence technologies is misguided. Instead, the field will benefit more from a focus on supporting participation. This is a respecification of the way in which we approach the research and design of telepresence technologies.

This position is informed by the findings discussed earlier in this chapter, and in opposition to trends observed in the previous literature. As outlined in chapter 2, studies of MRP often make claims as to the quality of MRP by reporting that users felt a sense of presence (e.g., Rae et al., 2014; Choi and Kwak, 2017; Lee and Takayama, 2011). In addition, some studies which have explored this in more depth adopted definitions that pertain to presence as an immersive experience of the mediated environment (e.g., Kristoffersson et al., 2013b; Tsui et al., 2015). However, as demonstrated in chapter 4 and select other studies (James et al., 2019; Kaptelinin et al., 2021), users do not experience the mediated environment as if they were really there, but they may feel 'present' when there are minimal break-

downs, when they are able to do things in the environment and when they are treated by others as present. Still, there is little evidence that striving to improve this sense of presence is an appropriate approach. Hollan and Stornetta (1992) who have also criticised this tendency in communication technologies, argued that design ought to identify needs and map them against possible media and mechanisms. Indeed, when participants described having good experiences with MRP, these involved situations in which the affordances of the technology allowed them to be in the mediated environment in ways which were relevant to the activities at hand (i.e., their needs were met). For example, having an embodied, physical form only mattered when everyone else was there in person and interacting in an embodied way; at other times this form made little difference. In addition, as non-users reported in chapter 8, they chose not to use MRP because it did not allow them to *participate* in hybrid activities; it did not allow them to perform the actions needed in order to take active part in what was going on. From the perspective of interaction as well, EMCA analyses in chapters 5 and 6 show that 'successful' interactions, where the participants are able to reach a mutual understanding of the situation they are in, involve the remote user being able to act in ways that are understood by the local and vice versa; i.e., being able to act in ways relevant to what is going on. Whilst this may result in a sense of co-presence, this was not due to the medium fading in the background of the experience, but due to it being used in ways that allowed the users to be engaged into the ongoing action of interacting and doing activities together. As such, future work ought to focus on understanding what this participation truly means and how it can be achieved.

In practice, this re-specification can be applied in how we study telepresence and in how design decisions are made. In terms of research, one simple

change can be in the questions asked to users after testing the technology. Instead of asking whether they felt present and how accurately they experienced the mediated environment, users should be asked questions pertaining to their participation; e.g., did you feel included in the activity? did you feel that you contributed? were you able to do all the things you wanted to do using the robot? More open ended questions with a focus on descriptions of use in practice can also be insightful. For example, in my interview study in chapter 4, participants were able to describe what they did and comment on the qualities of those experience. This revealed what kinds of actions were important within specified contexts. Taking this a step further, approaches such as EMCA, which break down the observable details of interaction into the users' actions and how those are responded to, can also enlighten as to what modalities and affordances matter in achieving meaningful participation. An important element of understanding participation, as demonstrated in this thesis, particularly in the follow up interviews in chapter 8, is taking into account contextual factors and acknowledging that different activities have different participation needs. Overall, research ought to look for affordances and situated actions which successfully integrate the remote user into the action of hybrid activities.

Design, then, should follow from an understanding of participation. The selection of affordances and modalities of interaction should be aimed at enabling actions that are necessary for achieving communication and collaboration in hybrid activities, rather than being aimed at immersing the user in the mediated environment. A notable existing example is the use of additional displays for students to display their work in classrooms (Yeung and Fels, 2005). As discussed below, it should not be assumed that simply moving in space will enhance meaningful engagement. Instead, we might envision devices of different shapes, sizes and function, depending on the

kinds of actions the need to be supported and the parts of the environment that need to be accessed. Consequently, a single, generic telepresence robot may not support all types of work being done in an organisation. To combat that, we might see telepresence devices specialised to given settings. Alternatively, generic MRP might benefit from having more adaptable forms, such as additional modules for specific tasks, and integration with other platforms so that it can be adjusted and included to fit in with a variety of activities. Adopting this approach, the limitations of MRP that have been identified in this and in previous works (see 2.1.3) are worth fixing not because they break immersion, but because they impede on participation.

9.6 Mobility in computer-mediated communication technologies

As discussed in the earlier part of this chapter, mobility is a central element of mobile robotic telepresence technology. The vast majority of the findings presented in this thesis relate, in some way, to the fact that MRP robots move in space and the repercussions this has on their use and deployment. My examination of MRP here provides an understanding of the various ways in which mobility matters in robot-mediated communication technology which was previously overlooked. Future work on such technologies can draw on this understanding for a more informed outlook into how mobility can be effectively implemented in communication media.

Mediated mobility during communication and collaboration serves multiple functions. On a surface level, it allows the remote user to move in the environment and access it from many angles. From a practical standpoint this can be useful for certain activities, although not always (e.g., it is not use-

ful in a meeting), but conceptually, this functionality does not distinguish it from tele*operation* technologies. However, mobility does make robotic tele*presence* a distinct modality of interaction in several ways.

To reiterate from the earlier discussion, mobility serves as a mode of communication, it brings the space into relevance and affects the dynamic of the interactants. As demonstrated in the fragments presented in chapters 5 and 6, movement is used as a form of embodied language employed alongside other communication methods. In the instances explored it is used most commonly as gaze direction, to make visible the user's attention and allow for more implicit forms of speech. That said, the studies also reveal that in many ways the movement of the current MRP models is inadequate and does not allow for the subtle communicative cues that are needed for smoothly interjecting into a conversation. Secondly, movement in the environment makes that environment a relevant 'stage' of the interaction. Through movement, the environment is used to aid in communication, and has the potential to become topicalised— either enriching or derailing the conversation. At the same time, the form of the space can hinder, facilitate or prolong movement, which in turn shapes the quality and duration of the interaction. This means that certain spaces are more suitable for MRP use than others. Finally, the mobility of the remote user creates a distinct dynamic of control and responsibility between the interactants. As the remote user is able to move, they have a certain degree of control over what they are able to see, comment on and topicalise. Although they are more limited in their capabilities compared to the local users, they are able to direct the focus of the interaction. In fact, exactly because of the robot's limited mobility, the locals may be forced to follow the remote user's pace; conceding to them control over the rhythm and focus of the interaction. In addition, because of this rudimentary movement, the local users also

assume more responsibility in having to look out for the remote user, make accommodations for them in the environment (e.g., moving chairs out of the way) and adjust their position in response to the robot. As such, interactions through MRP are not merely video-conferencing interactions where the remote user is able to see more; the movement brings about an entirely distinct way of doing remote communication.

However, despite the unique interactional possibilities offered by MRP, it is also worth highlighting that, as mentioned above, the current technology also presents drawbacks. As shown throughout the thesis, the movement of MRP is very limited in terms of speed and flexibility. In interaction this results in an asymmetrical relationship between the local and remote users; with the remote users being at a disadvantage, relying on help and ending up left out. To revisit the previous literature, studies of MPR have shown that remote users tend to move and position their robot in manners drawn from in-person proxemics behaviours (Pathi et al., 2019; van Oosterhout and Visser, 2008), and prefer being able to independently do so (Nakanishi et al., 2008). Yet, the current movement capabilities of MRP do not truly support completely natural movements. In addition, as shown in chapter 8 and previous literature (Tsui et al., 2011), the movement of MRP is not always relevant to the activities people wish to do remotely. As such, mobility in robotic telepresence does not simply need improvement, it needs a re-imagining.

Taking these leanings onboard, future work on developing telepresence can implement movement in more effective ways. The current models of MRP follow a very uniform mobility paradigm; moving as one piece with limited degrees of freedom for movement (basically just moving forwards, turning and rotating). There is little to no justification for this design choice. In theory, such movement may have aimed at imitating in-person movement;

a large body that can move in space. In practice, however, MRP simply gives the remove user the ability to move across a room or down a corridor, whereas in-person movement consists of so much more (smaller movements, neck turning, leaning, gestures, idle movements ect). And beyond human movements, the robotic form should free-up our imagination to even more movement possibilities (e.g., movement on top of surfaces, from the ceiling, along walls). There are so many other forms of movement that can be explored.

In moving forward with re-imagining the mobility of telepresence robots, the insights presented here should inform the design directions. Thus, considerations should include affordances for participation, communicative expression, suitability to space and social dynamics. As discussed above, participation ought to be a central consideration of MRP design. Mobility in and of itself does not help people feel 'present' in hybrid activities. What would help is moving in ways that are relevant to the tasks at hand and comparable to ways in which other interactants are engaging in the action. With regards to communicative expression, MRP design can benefit from a closer understanding of just what kinds of actions —what "members' methods"— are conducive to establishing a common ground understanding between users. Participants in this thesis specifically spoke about lacking subtle, gradual and graceful cues. Movements of that smaller scale might be more relevant in supporting communication —especially in unplanned social contexts. Then in terms of suitability to the environment, this might vary across use cases in different settings. It is worth considering what kinds of environments the robot might need to move through, what kinds of objects it will need to approach and at what scale (e.g, large posters across a wall or small items over a table). In an office setting, moving from one meeting room to the next is actually not that useful to

remote users —however, inside the meeting room it might be useful to have movement capabilities relevant to their meetings (e.g., being able to nod to other speakers, 'raise a hand' etc). Finally, in considering social dynamics, the design of mobility ought to take into account what freedoms and limitations are given to the remote user (what asymmetries are created) and what responsibilities are given to the locals. Mobility overall needs to be considered in context, informed by an understanding of the interactional realities of hybrid communication and collaboration and with consideration of the practical needs of users.

Chapter 10

Conclusions

This thesis presented an examination of Mobile Robotic Telepresence (MRP), through a combination of qualitative research approaches, including a real-world deployment study. It sought to understand the practical realities of the of MRP in terms of how the medium is experienced by users, in terms of how interactions through the medium are achieved by remote and local users, and in terms of the implications of deploying the technology in organisational settings.

In the backdrop of growing interest in solutions for remote work and hybrid communication, MRP has received attention for mediating embodied, autonomous movement in space. However, whilst many studies report on both positive attitudes towards the technology, as well as on its various shortcomings, very limited research actually demonstrates the practical details of use. Further, whilst studies report on the medium providing a 'sense of presence', the meaning of this presence has been unclear and the relevance of this experience on the effectiveness of the medium for supporting hybrid communication and collaboration as been unscrutinised. The approaches taken on in this thesis address these gaps by providing a close

and detailed look into what using MRP actually looks like and examining it within real-world contexts. The empirical work begun with three studies (one interview study and two video-based observation studies), which built an understanding of MRP as a distinct category of mediated interaction. The studies demonstrate that interactions through MRP are driven by the embodied mobility and situatedness of the medium, but are also characterised by communicative asymmetries which result in a reliance on assistance, and a difficulty in incorporating the remote user as an "ordinary" member of the interaction. Further, the work shows that a sense of presence arises when remote users are able to 'gear into' the mediated environment, take autonomous action in it and be treated by locals as present there. As such the work shows that what matters during use is the capability for participation rather than total immersion. Next, studying a real-world office deployment of MRP, two studies look into the considerations of applying MRP in organisational spaces. The first uncovers the material and infrastructural requirements needed for supporting safe and inclusive ongoing use, whilst the second unpacks how the affordances and ways of using the medium align or fail to align with the routine practices and needs of prospective users. Beyond building this comprehensive understanding of the practical realities of MRP, my thesis makes three key contributions. First, it introduces the use of auto-ethnographic methods in HRI research. Second, it makes a case for re-specifying the direction of future research and design work on telepresence systems from attempts to understand and improve presence to a focus on understanding and designing for participation. Lastly, it identifies the functions and implications of mobility in robot-mediated communication technologies. In the remainder of this chapter, I reflect on the limitations of the studies conducted for this thesis and present suggestions for future work.

10.1 Limitations

Practical difficulties in making MRP technology easily available to users, and obstacles to conducting research posed by the Covid-19 pandemic, resulted in some limitations in the work carried out for this thesis. These pertain to a narrow sample of users and settings, and a limited depth and scope in studying the application of MRP in organisations.

10.1.1 Sample limitations

With regards to the sample of participants it is fair to say that they represent very specific demographic of users. In the first interview study (chapter 4), the interviewees were all men, working either in academia or in the tech industry. Whilst gender was better balanced in the subsequent studies, the participants again came entirely from white collar positions, with the participants in the second (chapter 5) and final (chapter 8) studies all being Microsoft Research employees.

Unfortunately, this sampling limitation came about due to the inherent inaccessibility of the technology. The cost of MRP and of the resources required in deploying it mean that it is mostly only made available in well-funded, technologically advanced spaces (or, in private use, to individuals with high disposable income). Even within this narrow demographic, it is difficult to find real-world users of MRP, as the technology is not widespread. Whilst I tried to recruit more diverse participants though social media, searching for special interest communities and emailing institutions that had deployed MRP, I had no success. The people who participated in my studies were found through word of mouth, peer networks or through my sponsor, Microsoft Research.

Naturally, these participants represent a demographic of a certain income and privilege, including familiarity with technology and access to other technological resources (as was demonstrated in the final study). This may have resulted in more critical attitudes towards the MRP — which are valuable as well-informed competent critiques — but it may also have resulted in an unwillingness to overlook some of the medium's limitations so as to further explore its capabilities. An exploration of use by groups more in need of technological solutions may have highlighted different potential advantages. At the same time, participants of other demographics, especially less privileged ones, may have raised different concerns about the technology, especially with regards to its ability to provide an accurate and favourable representation of the remote user, enable autonomy and allow for equal participation in hybrid spaces. This is something future research needs to address.

Another aspect of the limited sampling is that only one organisation was studied when looking at the real-world deployment and use of MRP. Despite the issues raised in chapter 7, the offices of Microsoft Research in Cambridge presented a promising space for a deployment given the company's resources and interest in supporting flexible and hybrid work. Still, this constituted only one specific type of organisational setting; one where the members were engaged in mostly digital knowledge work, worked in international, physically distributed teams, had busy schedules, and operated in a well-resourced technological ecosystem. The office was a large space, hosting many teams and providing a centre for activities and events, but it was not a vital space for the day-to-day work of the organisation. Of course, the considerations raised by the deployment and follow-up work at that setting can be used to extrapolate implications for other settings. For example, showing that robot placement was a challenge in this deployment

indicates that space should be a consideration in any prospective deployment. Nonetheless, deployments in organisations with different features, such as with spaces of different layouts and sizes or spaces used for different purposes may have yielded different or additional considerations. They may also have produced different patterns of use, resulting in different accounts for use and non-use. As such, whilst this thesis raises the subject of considering the practical realities of deployment and use of MRP, further studies in different organisational settings would help to build a more complete picture of what those considerations are.

10.1.2 Depth and scope in studying MRP applications

The present thesis is limited in its study of the suitability of MRP in organisational spaces with regards to the depth and scope of the examination. Due to restrictions in terms of time, access, and resources, I have studied the application of MRP in one organisation and only through the angles that were available to me. That is, the application of MRP was explored in terms the hands-on work of carrying out the deployment and the use or non-use of the technology was explored through the perspectives reported by the employees willing to be interviewed about it.

The considerations I was able to identify then, for informing future deployments and for assessing the suitability of MRP for organisations are limited to that scope. Ideally a more in-depth examination would involve spending more time at the site, documenting the routines and workflows of the organisation through ethnography, and learning more about its organisational structure. Building a more detailed understanding of the activities at the site and of the technological ecosystem in place could allow to better

pinpoint if, where and how MPR could be included in that organisation. Further, in terms of scope it is possible that there are more factors involved in deployment decisions or with regards to the use and non-use which were not accounted in this thesis. A study of broader scope could have explored more parts of the process and spoken to more stakeholders, such as those involved in purchasing and managing the equipment and facilities of the space, as well as to a wider range users and non-users, from different departments and team configurations. Future work, looking at other organisational settings, should spend more time understanding the features of the organisation prior to deployment and take a wider range of factors into account.

10.2 Future work

As mentioned above there is scope for additional work in MRP to expand on the current understanding of the technology and its use in organisations by looking at more diverse range of users and contexts. Furthermore, the discussion of the work conducted for this thesis, presented in the previous chapter, resulted in three implications for future work. Recapping these here, I present suggestions for enhancing future research on robotic telepresence in the future.

10.2.1 Phenomenology and EMCA for understanding robot-mediated interaction

The present thesis has demonstrated the value of Phenomenology and Ethnomethodology and Conversation Analysis (EMCA) as approaches for un-

derstanding mediated experiences and interactions. These approaches focus on understanding experiences, such as presence, not as abstract psychological states, but as material phenomena that are observable during interaction or accessible through people's accounts. When it comes to examining MRP then, which is not just a medium for communication, but a medium for remotely experiencing a different environment, such approaches are vital for truly uncovering the realities of use. Understanding the experience of tele-presence through Phenomenology in this case is not about the user reporting whether they felt present, but about understanding what the user could, in practical terms see, hear and do. Understanding interaction through an EMCA lens is not about whether a user completed a task successfully, but about identifying the methods employed by users during the interaction in order to communicate and reach a shared understanding of the situation. Such information lends itself to more in-depth scrutiny and allows for more precise explanations of the realities of using the medium. The work of this thesis has provided ample examples of using those approaches, which future work can draw on. As detailed above it is important to carry out additional research on MRP use and interactions in more settings and types of users, for a more complete understanding of the technology. Taking onboard the current learnings, this work should draw on Phenomenology and EMCA to continue examining the practical realities of MRP as a category of mediated interaction in more contexts.

10.2.2 Streamlining deployments: pre-deployment exploration and re-evaluation of success criteria

As the deployment presented in this thesis has found out, use of the MRP by an organisation's members is not always guaranteed. At the same time

conducting research in real-world scenarios, such as through deployment studies and Action Research approaches, yields a more rounded understanding of MRP technologies. Still, as shown in chapter 7, a deployment requires a significant amount of work and time as well as funding and material resources. In other words, there is a significant cost to doing a deployment. To reduce the likelihood of unsuccessful deployments, future efforts should first consider more whether and organisation can shoulder this cost, whether the needs of the organisation can be supported by the affordances of MRP and whether the MRP can be integrated into prospective users' routines.

To streamline the process, this thesis has identified a series of considerations that could be addressed prior to deployments to evaluate whether MPR is likely to be suitable for a given space. First and foremost, an organisation ought to identify their hybrid needs, and assess whether the affordances of MRP are likely to provide an appropriate solution. As part of that, the project should consider the relevance of physical space in the activities they expect the MRP to mediate, and whether the embodied but limited movement of the MRP is likely to be suitable for those activities. Next, it is also vital to assess whether the work of using the technology can be embedded within the existing practices and workflows of the members. Some questions to ask are: Where and how are they doing their work or activities? Will they have the time and capacity to operate the robots? What other technologies are they using? Then, the project ought to include an evaluation of the space, with consideration of where the robots are going to be placed, how they will move through the environment and what impact their presence will have on the space and people in it. Finally, the project should consider how matters of safety, security and inclusive access can be addressed. Taking those factors into consideration prior to deploying MRP

can help avoid committing resources into projects where use of MRP would not be appropriate and instead focusing on more worthwhile efforts.

In addition, future work on MRP applications should consider appropriate criteria for assessing the success of a deployment. In the case presented in this thesis, the deployment was ultimately terminated due to security concerns. However, the decision to stop the project entirely rather than explore solutions was made due to the fact that use of the MRPs was deemed low. Indeed, as the follow-up study showed (chapter 8), the technology did not fit within the employees' daily work routines. Nonetheless, it is not accurate to say that the technology offered no value at all; there were few special occasions during which users enjoyed having the robots. While frequent, daily use may not be possible or desirable, infrequent use of MRP may still be add value if it provides meaningful participation to specific events. In addition, previous studies have claimed that the technology can be an accessibility solution for individuals who are not able to travel easily (e.g., Cogburn, 2018; Okundaye et al., 2019). As such, even where MRP may not align with an organisation's everyday practices, they might still choose to deploy the technology for selected members with particular access needs who might use it regularly or for specific occasions. Whether a deployment is considered successful then may not be accurately measured by the amount of use, but with the quality of improvements it makes to how people access and participate in the organisation.

10.2.3 Participation-driven research and design

Future work on robotic telepresence will need to identify the value of this medium more concretely. I propose that his can be achieved with a situated, participation-driven approach to research and design. While there

has been research reporting on the benefits and limitations of MRP, there have been few notable use cases in the real world harnessing those benefits and few design iterations providing substantial improvements. These reports ultimately do not pertain to practical applications of the technology, nor propose meaningful improvements.

Through a closer examination of the phenomenological experience of robotic tele-presence and through detailed unpacking of the social organization of MRP interactions between remote and local users, this thesis has shown that what is actually crucial to address is participation. Before concerns over improving the mobility or the immersion provided by the MRP, what needs to be understood is how participation is achieved, both in interaction and within broader cooperative activities. As this thesis has shown, participation in interaction through MRP is about granting the remote user membership into the action of the local environment. It is about making the user part of the action unfolding in the local environment, ensuring they are 'geared into' that action through the capabilities afforded to them and the ways in which they can act. In addition, participation in interaction involves communicative efforts, or compensatory work, to manage the inherent asymmetries of the medium, and thus enable the users to make sense of the MRP and incorporate it into the activity. Understanding participation in interaction then, is about understanding the interactional affordances that enable such work, or identifying design features that might alleviate the need for it.

Beyond participation in the interaction, there is also participation in the broader sense, as the ability to take active part in hybrid activities. As this thesis has shown, this is a more nuanced matter than simply providing mobility. The mediating technology needs to provide ways of meaningfully taking part in the task, by enabling relevant modalities of action. Where

this was not afforded by the MRP, people preferred fully digital solutions, forgoing physical presence for more equal access. Solutions for meaningful participation should cater to what is necessary for the activity at hand. This might involve improving the remote users' mobility, but this again should be in accordance with task demands. As explained in the previous chapter, it might involve moving faster and more flexibly or it might involve moving different parts of the body or moving in different scales. Beyond movement, solutions might also involve giving the remote user autonomy through different means, such as being able to manipulate specific parts of the environment or being able to access their interface without sacrificing access to other remote work systems. In line with that, it may be time for work on MRP to move beyond the 'tablet-on-a-stick' design model, to more innovative forms of robotic telepresence informed by an understanding of how participation is accomplished in specific contexts. In line with that, the field should move beyond seeing work on MRP as work on understanding and improving just this one type of device, and instead approach it as a broader the field of robot-mediated communication and cooperation, where rather than imitating in-person shapes and forms of movement, devices take forms that respond to the participation demands of various hybrid tasks.

Bibliography

V. Ahumada-Newhart and J. S. Olson. Going to school on a robot: Robot and user interface design features that matter. *ACM Transactions on Computer-Human Interaction (TOCHI)*, 26(4):1–28, 2019.

L. Anderson. Analytic autoethnography. *Journal of contemporary ethnography*, 35(4):373–395, 2006.

A. Bagherzadhalimi and E. Di Maria. Assessing mobile robotic telepresence based on measures of social telepresence. *International Journal of Electronics and Communication Engineering*, 9(2):649–656, 2015.

E. Bartis and N. Mitev. A multiple narrative approach to information systems failure: a successful system that failed. *European Journal of Information Systems*, 17:112–124, 2008.

H. B. Barua, C. Sarkar, A. A. Kumar, A. Pal, et al. I can attend a meeting too! towards a human-like telepresence avatar robot to attend meeting on your behalf. *arXiv preprint arXiv:2006.15647*, 2020.

E. P. Baumer, P. Adams, V. D. Khovanskaya, T. C. Liao, M. E. Smith, V. Schwanda Sosik, and K. Williams. Limiting, leaving, and (re) lapsing: an exploration of facebook non-use practices and experiences. In *Proceedings of the SIGCHI conference on human factors in computing systems*, pages 3257–3266, 2013.

E. P. Baumer, J. Burrell, M. G. Ames, J. R. Brubaker, and P. Dourish. On the importance and implications of studying technology non-use. *interactions*, 22(2):52–56, 2015a.

E. P. Baumer, S. Guha, E. Quan, D. Mimno, and G. K. Gay. Missing photos, suffering withdrawal, or finding freedom? how experiences of social media non-use influence the likelihood of reversion. *Social Media+ Society*, 1(2):2056305115614851, 2015b.

G. Beraldo, M. Antonello, A. Cimolato, E. Menegatti, and L. Tonin. Brain-computer interface meets ros: a robotic approach to mentally drive telepresence robots. In *2018 IEEE international conference on robotics and automation (ICRA)*, pages 4459–4464. IEEE, 2018.

R. Bergmann, S. Rintel, N. Baym, A. Sarkar, D. Borowiec, P. Wong, and A. Sellen. Meeting (the) pandemic: Videoconferencing fatigue and evolving tensions of sociality in enterprise video meetings during covid-19. *Computer Supported Cooperative Work (CSCW)*, 32(2):347–383, 2023.

A. Berisha, R. Kölle, and J. Griesbaum. Acceptance of telepresence robots during group work. In *Re: inventing information science in the networked society. Proceedings of the 14th international symposium on information science (ISI 2015). Zadar, Croatia*, pages 350–356, 2015.

P. Björnfot. *Being connected to the world through a robot.* PhD thesis, Umeå University, 2022.

P. Björnfot and V. Kaptelinin. Probing the design space of a telepresence robot gesture arm with low fidelity prototypes. In *2017 12th ACM/IEEE International Conference on Human-Robot Interaction (HRI*, pages 352–360. IEEE, 2017.

P. Björnfot, J. Bergqvist, and V. Kaptelinin. Non-technical users' first encounters with a robotic telepresence technology: an empirical study of office workers. *Paladyn, Journal of Behavioral Robotics*, 9(1):307–322, 2018.

A. Bleakley, D. Rough, J. Edwards, P. Doyle, O. Dumbleton, L. Clark, S. Rintel, V. Wade, and B. R. Cowan. Bridging social distance during social distancing: exploring social talk and remote collegiality in video conferencing. *Human–Computer Interaction*, pages 1–29, 2021.

N. Bloom. Hybrid is the future of work. *Stanford Institute for Economic Policy Research (SIEPR): Stanford, CA, USA*, 2021.

N. Bloom, P. Mizen, and S. Taneja. Returning to the office will be hard. *VoxEU Column*, 2021.

R. Bloss. High school student goes to class robotically. *Industrial Robot: An International Journal*, 38(5):465–468, 2011.

D. Boden. The world as it happens: Ethnomethodology and conversation analysis. In *Frontiers of social theory. The new syntheses*, pages 185–213. Columbia University Press, 1990.

J. Bowers, G. Button, and W. Sharrock. Workflow from within and without: Technology and cooperative work on the print industry shopfloor. In *Proceedings of the Fourth European Conference on Computer-Supported Cooperative Work ECSCW'95: 10–14 September, 1995, Stockholm, Sweden*, pages 51–66. Springer, 1995.

V. Braun and V. Clarke. Using thematic analysis in psychology. *Qualitative research in psychology*, 3(2):77–101, 2006.

P. Brown and S. C. Levinson. Politeness. universals in language usage: Politeness phenomenon, 1978.

P. Brown, S. C. Levinson, and S. C. Levinson. *Politeness: Some universals in language usage*, volume 4. Cambridge university press, 1987.

C. Bullen. "your bookshelf is problematic": Progressive and problematic publishing in the age of covid-19. In *Bookshelves in the Age of the COVID-19 Pandemic*, pages 69–92. Springer, 2022.

G. Button. Moving out of closings. *Talk and social organization*, 10:ll, 1987.

A. Butz, T. Hollerer, C. Beshers, S. K. Feiner, and B. MacIntyre. An experimental hybrid user interface for collaboration. 1999.

J.-J. Cabibihan, W.-C. So, S. Saj, and Z. Zhang. Telerobotic pointing gestures shape human spatial cognition. *International Journal of Social Robotics*, 4:263–272, 2012.

A. F. Cameron and J. Webster. Unintended consequences of emerging communication technologies: Instant messaging in the workplace. *Computers in Human behavior*, 21(1):85–103, 2005.

A. Cesta, G. Cortellessa, A. Orlandini, and L. Tiberio. Evaluating telepresence robots in the field. In *Agents and Artificial Intelligence: 4th International Conference, ICAART 2012, Vilamoura, Portugal, February 6-8, 2012. Revised Selected Papers 4*, pages 433–448. Springer, 2013.

E. Cha, S. Chen, and M. J. Mataric. Designing telepresence robots for k-12 education. In *2017 26th IEEE international symposium on robot and human interactive communication (RO-MAN)*, pages 683–688. IEEE, 2017.

K. Chandan, J. Albertson, X. Zhang, X. Zhang, Y. Liu, and S. Zhang. Learning to guide human attention on mobile telepresence robots with

360 vision. In *2021 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, pages 5297–5304. IEEE, 2021.

E. A. Chatman. The impoverished life-world of outsiders. *Journal of the American Society for information science*, 47(3):193–206, 1996.

X. Cheng, Y. Jia, J. Su, and Y. Wu. Person-following for telepresence robots using web cameras. In *2019 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, pages 2096–2101. IEEE, 2019.

J. J. Choi and S. S. Kwak. Who is this?: Identity and presence in robot-mediated communication. *Cognitive Systems Research*, 43:174–189, 2017.

M. Choi, R. Kornfield, L. Takayama, and B. Mutlu. Movement matters: effects of motion and mimicry on perception of similarity and closeness in robot-mediated communication. In *Proceedings of the 2017 CHI conference on human factors in computing systems*, pages 325–335, 2017.

B. Chun. Doing autoethnography of social robots: Ethnographic reflexivity in hri. *Paladyn, Journal of Behavioral Robotics*, 10(1):228–236, 2019.

D. Cogburn. Beyond being there, for" all of us": Exploring webconferencing and mobile remote presence devices for accessible global governance. In *Proceedings of the 51st Hawaii International Conference on System Sciences*, 2018.

S. W. Cook and M. K. Tanenhaus. Embodied communication: Speakers' gestures affect listeners' actions. *Cognition*, 113(1):98–104, 2009.

A. Cosgun, D. A. Florencio, and H. I. Christensen. Autonomous person following for telepresence robots. In *2013 IEEE International Conference on Robotics and Automation*, pages 4335–4342. IEEE, 2013.

T. S. Curl and P. Drew. Contingency and action: A comparison of two forms of requesting. *Research on language and social interaction*, 41 (2):129–153, 2008.

J. Darling-Aduana and C. Heinrich. the potential of telepresence for increasing advanced course access in high schools. *Educational Researcher*, 49(6):415–425, 2020.

R. C. Davies. Adapting virtual reality for the participatory design of work environments. *Computer Supported Cooperative Work (CSCW)*, 13: 1–33, 2004.

D. De Jong. Telepresence robots: a phenomenological study of perceptions of graduate students and professors. *Journal of Higher Education Theory and Practice*, 21(5):143–161, 2021.

A. R. Dennis and B. A. Reinicke. Beta versus vhs and the acceptance of electronic brainstorming technology. *MIS quarterly*, pages 1–20, 2004.

M. Desai, K. M. Tsui, H. A. Yanco, and C. Uhlik. Essential features of telepresence robots. In *2011 IEEE Conference on Technologies for Practical Robot Applications*, pages 15–20. IEEE, 2011.

P. Drew and K. Chilton. *Calling to keep in touch: regular and habitualised telephone calls as an environment for small talk*, pages 137–162. Longman, 2000.

R. Drew. Technological determinism. *A companion to popular culture*, pages 165–183, 2016.

B. L. Due. Robodoc: Semiotic resources for achieving face-to-screenface formation with a telepresence robot. *Semiotica*, 2021(238):253–278, 2021.

L. L. Ellingson and C. Ellis. Autoethnography as constructionist project. *Handbook of constructionist research*, 445, 2008.

C. Ellis. "there are survivors": Telling a story of sudden death. *The Sociological Quarterly*, 34(4):711–730, 1993.

C. A. Ellis and G. J. Nutt. Modeling and enactment of workflow systems. In *International Conference on Application and Theory of Petri Nets*, pages 1–16. Springer, 1993.

C. A. Ellis, S. J. Gibbs, and G. Rein. Groupware: some issues and experiences. *Communications of the ACM*, 34(1):39–58, 1991.

H. Elmimouni, C. Young, S. Sabanovic, and J. Rode. Does robotic telepresence make the classroom accessible? In *Companion Publication of the 2023 ACM Designing Interactive Systems Conference*, pages 194–197, 2023.

D. I. Fels, J. K. Waalen, S. Zhai, and P. L. Weiss. Telepresence under exceptional circumstances: enriching the connection to school for sick children. In *Interact*, pages 617–624, 2001.

A. J. Fischer, B. S. Bloomfield, R. R. Clark, A. L. McClelland, and W. P. Erchul. Increasing student compliance with teacher instructions using telepresence robot problem-solving teleconsultation. *International Journal of School & Educational Psychology*, 7(sup1):158–172, 2019.

N. T. Fitter, Y. Joung, M. Demeter, Z. Hu, and M. J. Matarić. Design´ and evaluation of expressive turn-taking hardware for a telepresence robot. In *2019 28th IEEE International Conference on Robot and Human Interactive Communication (RO-MAN)*, pages 1–8. IEEE, 2019.

N. T. Fitter, L. Rush, E. Cha, T. Groechel, M. J. Matarić, and L. Takayama. Closeness is key over long distances: Effects of in-

terpersonal closeness on telepresence experience. In *Proceedings of the 2020 ACM/IEEE international conference on human-robot interaction*, pages 499–507, 2020.

J. Freeman, J. Lessiter, and W. IJsselsteijn. Immersive television. *The Psychologist*, 14(4):190–194, 2001.

H. Garfinkel. Ethnomethodology. *Studies in ethnomethodology*, 1967.

H. Garfinkel and E. Bittner. Good organizational reasons for "bad" clinic records. *Englewood Cliffs*, 1967.

R. Garg. An analysis of (non-) use practices and decisions of internet of things. In *Human-Computer Interaction–INTERACT 2019: 17th IFIP TC 13 International Conference, Paphos, Cyprus, September 2–6, 2019, Proceedings, Part IV 17*, pages 3–24. Springer, 2019.

W. Gaver, J. Bowers, T. Kerridge, A. Boucher, and N. Jarvis. Anatomy of a failure: how we knew when our design went wrong, and what we learned from it. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 2213–2222, 2009.

D. Georgakopoulos, M. Hornick, and A. Sheth. An overview of workflow management: From process modeling to workflow automation infrastructure. *Distributed and parallel Databases*, 3:119–153, 1995.

G. Giannachi. Environmental presence. *Archaeologies of Presence: Art, Performance and the Persistence of Being, Gabriella Giannachi, Nick Kaye and Michael Shanks, eds., Routledge, Abingdon and New York*, 2012.

E. Goffman et al. *The presentation of self in everyday life*. Harmondsworth London, 1978.

I. Gonsher, Y. Han, K. Desingh, and A. Gokaslan. Prototyping mixed reality large screen mobile telepresence robots. In *5th International Workshop on Virtual, Augmented, and Mixed Reality for HRI*, 2022.

J. González-Jiménez, C. Galindo, and J. Ruiz-Sarmiento. Technical improvements of the giraff telepresence robot based on users' evaluation. In *2012 IEEE RO-MAN: The 21st IEEE international symposium on robot and human interactive communication*, pages 827–832. IEEE, 2012.

J. Grudin. Computer-supported cooperative work: History and focus. *Computer*, 27(5):19–26, 1994a.

J. Grudin. Groupware and social dynamics: Eight challenges for developers. *Communications of the ACM*, 37(1):92–105, 1994b.

J. Grudin and L. Palen. Why groupware succeeds: Discretion or mandate? In *Proceedings of the Fourth European Conference on Computer-Supported Cooperative Work ECSCW'95: 10–14 September, 1995, Stockholm, Sweden*, pages 263–278. Springer, 1995.

M. Handel and J. D. Herbsleb. What is chat doing in the workplace? In *Proceedings of the 2002 ACM conference on Computer supported cooperative work*, pages 1–10, 2002.

K. M. Hansen and C. H. Damm. Instant collaboration: Using context-aware instant messaging for session management in distributed collaboration tools. In *Proceedings of the second Nordic conference on Human-computer interaction*, pages 279–282, 2002.

D. M. Hayano. *Poker faces: The life and work of professional card players*. Univ of California Press, 1983.

G. R. Hayes. Knowing by doing: action research as an approach to hci. *Ways of Knowing in HCI*, pages 49–68, 2014.

C. Heath and P. Luff. Disembodied conduct: Communication through video in a multi-media office environment. In *Proceedings of the SIGCHI conference on human factors in computing systems*, pages 99–103, 1991.

C. Heath and P. Luff. Media space and communicative asymmetries: Preliminary observations of video-mediated interaction. *Human–Computer Interaction*, 7(3):315–346, 1992.

C. Heath, H. Knoblauch, and P. Luff. Technology and social interaction: the emergence of 'workplace studies'. *The British journal of sociology*, 51(2):299–320, 2000.

C. Heath, M. S. Svensson, J. Hindmarsh, P. Luff, and D. Vom Lehn. Configuring awareness. *Computer Supported Cooperative Work (CSCW)*, 11:317–347, 2002.

C. Heath, J. Hindmarsh, and P. Luff. *Video in qualitative research*. Sage Publications, 2010.

M. Heidegger. *Being and time*. Harper & Row, 1967.

T. Heinemann. 'will you or can't you?': Displaying entitlement in interrogative requests. *Journal of Pragmatics*, 38(7):1081–1104, 2006.

A. Hepburn and G. B. Bolden. The conversation analytic approach to transcription. *The handbook of conversation analysis*, 1:57–76, 2013.

J. D. Herbsleb, D. L. Atkins, D. G. Boyer, M. Handel, and T. A. Finholt. Introducing instant messaging and chat in the workplace. *Ann Arbor*, 1001:48109, 2001.

S. C. Herring. Robot-mediated communication. *Emerging trends in the social and behavioral sciences: An interdisciplinary, searchable, and linkable resource*, pages 1–16, 2015.

Y. Heshmat, B. Jones, X. Xiong, C. Neustaedter, A. Tang, B. E. Riecke, and L. Yang. Geocaching with a beam: Shared outdoor activities through a telepresence robot with 360 degree viewing. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*, pages 1–13, 2018.

J. Hindmarsh, M. Fraser, C. Heath, S. Benford, and C. Greenhalgh. Fragmented interaction: establishing mutual orientation in virtual environments. In *Proceedings of the 1998 ACM conference on Computer supported cooperative work*, pages 217–226, 1998.

A. Hiyama, A. Kosugi, K. Fukuda, M. Kobayashi, and M. Hirose. Facilitating remote communication between senior communities with telepresence robots. In *Human Aspects of IT for the Aged Population. Applications, Services and Contexts: Third International Conference, ITAP 2017, Held as Part of HCI International 2017, Vancouver, BC, Canada, July 9-14, 2017, Proceedings, Part II 3*, pages 501–515. Springer, 2017.

J. Hollan and S. Stornetta. Beyond being there. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 119–125, 1992.

N. L. Holt. Representation, legitimation, and autoethnography: An autoethnographic writing story. *International journal of qualitative methods*, 2(1):18–28, 2003.

L. Hung, J. Mann, J. Wong, and E. Young. Using telepresence

robots to support family virtual visits during the covid-19 pandemic. *Alzheimer's & Dementia*, 18:e062745, 2022.

D. Ihde. *Experimental phenomenology: An introduction*. Suny Press, 1986.

T. Ingold. *Being alive: Essays on movement, knowledge and description*. Routledge, 2011.

T. Jacks. Research on remote work in the era of covid-19, 2021.

H. Z. Jahromi, I. Bartolec, E. Gamboa, A. Hines, and R. Schatz. You drive me crazy! interactive qoe assessment for telepresence robot control. In *2020 Twelfth International Conference on Quality of Multimedia Experience (QoMEX)*, pages 1–6. IEEE, 2020.

T. Jakonen and H. Jauni. Mediated learning materials: visibility checks in telepresence robot mediated classroom interaction. *Classroom Discourse*, 12(1-2):121–145, 2021.

M. James, D. Wise, and L. Van Langenhove. Virtual strategic positioning to create social presence: reporting on the use of a telepresence robot. *Papers on social representations*, 28(1):2–1, 2019.

G. Jefferson. (1972). side sequences. *Studies in Social Interaction*, pages 294–338, 1972.

S. Johnson, I. Rae, B. Mutlu, and L. Takayama. Can you see me now? how field of view affects collaboration in robotic telepresence. In *Proceedings of the 33rd annual acm conference on human factors in computing systems*, pages 2397–2406, 2015.

B. Jones, J. Maiero, A. Mogharrab, I. A. Aguliar, A. Adhikari, B. E. Riecke, E. Kruijff, C. Neustaedter, and R. W. Lindeman. Feetback: augmenting robotic telepresence with haptic feedback on the feet. In *Proceed-*

ings of the 2020 international conference on multimodal interaction, pages 194–203, 2020a.

B. Jones, Y. Zhang, P. N. Wong, and S. Rintel. Vroom: virtual robot overlay for online meetings. In *Extended Abstracts of the 2020 CHI Conference on Human Factors in Computing Systems*, pages 1–10, 2020b.

B. Jones, Y. Zhang, P. N. Wong, and S. Rintel. Belonging there: Vroom-ing into the uncanny valley of xr telepresence. *Proceedings of the ACM on Human-Computer Interaction*, 5(CSCW1):1–31, 2021.

N. P. Jouppi. First steps towards mutually-immersive mobile telepresence. In *Proceedings of the 2002 ACM conference on Computer supported cooperative work*, pages 354–363, 2002.

N. P. Jouppi and S. Thomas. Telepresence systems with automatic preservation of user head height, local rotation, and remote translation. In *Proceedings of the 2005 IEEE international conference on robotics and automation*, pages 62–68. IEEE, 2005.

N. P. Jouppi, S. Iyer, W. Mack, A. Slayden, and S. Thomas. A first generation mutually-immersive mobile telepresence surrogate with automatic backtracking. In *IEEE International Conference on Robotics and Automation, 2004. Proceedings. ICRA'04. 2004*, volume 2, pages 1670–1675. IEEE, 2004.

V. Kaptelinin, P. Björnfot, K. Danielsson, and M. U. Wiberg. Mobile remote presence enhanced with contactless object manipulation: An exploratory study. In *Proceedings of the 2017 CHI Conference Extended Abstracts on Human Factors in Computing Systems*, pages 2690–2697, 2017.

V. Kaptelinin, P. Björnfot, and K. Danielsson. Exploring the relationship between physical presence, user experience, and task parameters in robotic telepresence. In *Proceedings of the 32nd European Conference on Cognitive Ergonomics*, pages 1–5, 2021.

L. Karsenty. Cooperative work and shared visual context: An empirical study of comprehension problems in side-by-side and remote help dialogues. *Human-Computer Interaction*, 14(3):283–315, 1999.

K. H. Kendrick and P. Drew. Recruitment: Offers, requests, and the organization of assistance in interaction. *Research on Language and Social Interaction*, 49(1):1–19, 2016.

M. S. L. Khan, S. ur Réhman, P. La Hera, F. Liu, and H. Li. A pilot user's prospective in mobile robotic telepresence system. In *Signal and Information Processing Association Annual Summit and Conference (APSIPA), 2014 Asia-Pacific*, pages 1–4. IEEE, 2014.

D. S. Kirk and D. S. Fraser. The effects of remote gesturing on distance instruction. In *Proceedings of Th 2005 Conference on Computer Support for Collaborative Learning: Learning 2005: The next 10 Years!*, CSCL '05, page 301–310. International Society of the Learning Sciences, 2005. ISBN 0805857826.

A. Kiselev, G. Mosiello, A. Kristoffersson, and A. Loutfi. Semi-autonomous cooperative driving for mobile robotic telepresence systems. In *Proceedings of the 2014 ACM/IEEE international conference on Human-robot interaction*, pages 104–104, 2014.

A. Kiselev, A. Kristoffersson, and A. Loutfi. Combining semi-autonomous navigation with manned behaviour in a cooperative driving system for mobile robotic telepresence. In *Computer Vision-ECCV 2014 Work-*

shops: Zurich, Switzerland, September 6-7 and 12, 2014, Proceedings, Part IV 13, pages 17–28. Springer, 2015a.

A. Kiselev, A. Kristoffersson, F. Melendez, C. Galindo, A. Loutfi, J. Gonzalez-Jimenez, and S. Coradeschi. Evaluation of using semi-autonomy features in mobile robotic telepresence systems. In *2015 IEEE 7th International Conference on Cybernetics and Intelligent Systems (CIS) and IEEE Conference on Robotics, Automation and Mechatronics (RAM)*, pages 147–152. IEEE, 2015b.

J. Kofman, X. Wu, T. J. Luu, and S. Verma. Teleoperation of a robot manipulator using a vision-based human-robot interface. *IEEE transactions on industrial electronics*, 52(5):1206–1219, 2005.

A. Kristoffersson, S. Coradeschi, and A. Loutfi. Towards evaluation of social robotic telepresence based on measures of social and spatial presence. In *Human Robot Interaction*, 2011a.

A. Kristoffersson, S. Coradeschi, A. Loutfi, and K. Severinson-Eklundh. An exploratory study of health professionals' attitudes about robotic telepresence technology. *Journal of Technology in Human Services*, 29 (4):263–283, 2011b.

A. Kristoffersson, S. Coradeschi, and A. Loutfi. A review of mobile robotic telepresence. *Advances in Human-Computer Interaction*, 2013, 2013a.

A. Kristoffersson, K. Severinson Eklundh, and A. Loutfi. Measuring the quality of interaction in mobile robotic telepresence: A pilot's perspective. *International Journal of Social Robotics*, 5:89–101, 2013b.

H. Kuzuoka, Y. Furusawa, N. Kobayashi, and K. Yamazaki. Effect of displaying a remote operator's face on a media robot. In *2007 In-*

ternational Conference on Control, Automation and Systems, pages 758–761. IEEE, 2007.

D. Labonte, F. Michaud, P. Boissy, H. Corriveau, R. Cloutier, and M. A. Roux. A pilot study on teleoperated mobile robots in home environments. In *2006 IEEE/RSJ International Conference on Intelligent Robots and Systems*, pages 4466–4471. IEEE, 2006.

B. Lal, Y. K. Dwivedi, and M. Haag. Working from home during covid-19: Doing and managing technology-enabled social interaction with colleagues at a distance. *Information Systems Frontiers*, pages 1–18, 2021.

M. K. Lee and L. Takayama. " now, i have a body" uses and social norms for mobile remote presence in the workplace. In *Proceedings of the SIGCHI conference on human factors in computing systems*, pages 33–42, 2011.

M. Lei, I. M. Clemente, and Y. Hu. Student in the shell: The robotic body and student engagement. *Computers & Education*, 130:59–80, 2019.

A. Lenhart and J. B. Horrigan. Re-visualizing the digital divide as a digital spectrum. *IT & society*, 1(5):23–39, 2003.

K. Lewin. Action research and minority problems. *Journal of social issues*, 2(4):34–46, 1946.

H. Li, N. Vincent, J. Tsai, J. Kaye, and B. Hecht. How do people change their technology use in protest? understanding. *Proceedings of the ACM on Human-Computer Interaction*, 3(CSCW):1–22, 2019.

C. Licoppe. 'connected'presence: The emergence of a new repertoire for managing social relationships in a changing communication

technoscape. *Environment and planning D: Society and space*, 22(1): 135–156, 2004.

C. Licoppe. Showing objects in skype video-mediated conversations: From showing gestures to showing sequences. *Journal of Pragmatics*, 110: 63–82, 2017.

C. Licoppe and J. Morel. Video-in-interaction:"talking heads" and the multimodal organization of mobile and skype video calls. *Research on Language & Social Interaction*, 45(4):399–429, 2012.

C. Licoppe and J. Morel. Mundane video directors in interaction: Showing one's environment in skype and mobile video calls. In *Studies of video practices*, pages 143–168. Routledge, 2014.

T. Lister. Meaningful engagement via robotic telepresence: An exploratory case study. *Current Issues in Emerging eLearning*, 6(1):6, 2020.

E. Livingston. *Making sense of ethnomethodology*. Taylor & Francis, 1987.

M. Lombard and T. Ditton. At the heart of it all: The concept of presence. *Journal of computer-mediated communication*, 3(2):JCMC321, 1997.

C. Lueg, M. Castles, and M. C. Wong. We are here and we are many: Using a telepresence robot for shared exploration and learning (and fun). *Proceedings of the Association for Information Science and Technology*, 57(1):e381, 2020.

P. Luff, J. Hindmarsh, and C. Heath. *Workplace studies: Recovering work practice and informing system design*. Cambridge university press, 2000.

P. Luff, C. Heath, H. Kuzuoka, J. Hindmarsh, K. Yamazaki, and S. Oyama. Fractured ecologies: creating environments for collaboration. *Human–Computer Interaction*, 18(1-2):51–84, 2003.

S. Lukosch, M. Billinghurst, L. Alem, and K. Kiyokawa. Collaboration in augmented reality. *Computer Supported Cooperative Work (CSCW)*, 24:515–525, 2015.

M. Lynch. Against reflexivity as an academic virtue and source of privileged knowledge. *Theory, Culture & Society*, 17(3):26–54, 2000.

D. G. Macharet and D. A. Florencio. A collaborative control system for telepresence robots. In *2012 IEEE/RSJ International Conference on Intelligent Robots and Systems*, pages 5105–5111. IEEE, 2012.

H. Mahdi, S. A. Akgun, S. Saleh, and K. Dautenhahn. A survey on the design and evolution of social robots—past, present and future. *Robotics and Autonomous Systems*, 156:104193, 2022.

G. Mark, A. L. Kun, S. Rintel, and A. Sellen. Introduction to this special issue: the future of remote work: responses to the pandemic. *Human–Computer Interaction*, 37(5):397–403, 2022.

M. L. Markus. Toward a "critical mass" theory of interactive media: Universal access, interdependence and diffusion. *Communication research*, 14(5):491–511, 1987.

J. H. Marler, X. Liang, and J. H. Dulebohn. Training and effective employee information technology use. *Journal of Management*, 32(5):721–743, 2006.

S. Marsden. "i take it you've read every book on the shelves?" demonstrating taste and class through bookshelves in the time of covid. *English Studies*, 103(5):660–674, 2022.

J. Masters. The history of action research. *first published*, 1995.

M. Merleau-Ponty and J. F. Bannan. What is phenomenology? *CrossCurrents*, 6(1):59–70, 1956.

J. R. Methot, E. H. Rosado-Solomon, P. E. Downes, and A. S. Gabriel. Office chitchat as a social ritual: The uplifting yet distracting effects of daily small talk at work. *Academy of Management Journal*, 64(5): 1445–1471, 2021.

F. Michaud, P. Boissy, D. Labonté, S. Briere, K. Perreault, H. Corriveau, A. Grant, M. Lauria, R. Cloutier, M.-A. Roux, et al. Exploratory design and evaluation of a homecare teleassistive mobile robotic system. *Mechatronics*, 20(7):751–766, 2010.

C. Miller, P. Rodeghero, M.-A. Storey, D. Ford, and T. Zimmermann. " how was your weekend?" software development teams working from home during covid-19. In *2021 IEEE/ACM 43rd International Conference on Software Engineering (ICSE)*, pages 624–636. IEEE, 2021.

M. Minsky. Telepresence. omni magazine, 2 (9), 45–51, 1980.

P. H. Mirvis, A. L. Sales, and E. J. Hackett. The implementation and adoption of new technology in organizations: The impact on work, people, and culture. *Human Resource Management*, 30(1):113–139, 1991.

R. Mishra, Y. Ajmera, N. Mishra, and A. Javed. Ego-centric framework for a three-wheel omni-drive telepresence robot. In *2019 IEEE International Conference on Advanced Robotics and its Social Impacts (ARSO)*, pages 281–286. IEEE, 2019.

L. Mondada. onventions for transcribing multimodality, 2021. URL https://www.lorenzamondada.net/multimodal-transcription.

G. Mosiello, A. Kiselev, and A. Loutfi. Using augmented reality to improve usability of the user interface for driving a telepresence robot. *Paladyn, Journal of Behavioral Robotics*, 4(3):174–181, 2013.

W. Moyle, C. Jones, T. Dwan, T. Ownsworth, and B. Sung. Using telepresence for social connection: views of older people with dementia, families, and health professionals from a mixed methods pilot study. *Aging & mental health*, 23(12):1643–1650, 2019.

W. Moyle, C. Jones, and B. Sung. Telepresence robots: Encouraging interactive communication between family carers and people with dementia. *Australasian journal on ageing*, 39(1):e127–e133, 2020.

M. Muratbekova-Touron and E. Leon. "is there anybody out there?" using a telepresence robot to engage in face time at the office. *Information Technology & People*, 36(1):48–65, 2023.

H. Nakanishi, Y. Murakami, D. Nogami, and H. Ishiguro. Minimum movement matters: impact of robot-mounted cameras on social telepresence. In *Proceedings of the 2008 ACM conference on Computer supported cooperative work*, pages 303–312, 2008.

B. A. Nardi, S. Whittaker, and E. Bradner. Interaction and outeraction: Instant messaging in action. In *Proceedings of the 2000 ACM conference on Computer supported cooperative work*, pages 79–88, 2000.

T. Neumayr, M. Augstein, and B. Kubicek. Territoriality in hybrid collaboration. *Proceedings of the ACM on Human-Computer Interaction*, 6 (CSCW2):1–37, 2022.

C. Neustaedter and P. Sengers. Autobiographical design: what you can learn from designing for yourself. *interactions*, 19(6):28–33, 2012.

C. Neustaedter, G. Venolia, J. Procyk, and D. Hawkins. To beam or not to beam: A study of remote telepresence attendance at an academic conference. In *Proceedings of the 19th acm conference on computer-supported cooperative work & social computing*, pages 418–431, 2016.

C. Neustaedter, S. Singhal, R. Pan, Y. Heshmat, A. Forghani, and J. Tang. From being there to watching: Shared and dedicated telepresence robot usage at academic conferences. *ACM Transactions on Computer-Human Interaction (TOCHI)*, 25(6):1–39, 2018.

V. A. Newhart, M. Warschauer, and L. Sender. Virtual inclusion via telepresence robots in the classroom: An exploratory case study. *The International Journal of Technologies in Learning*, 23(4):9–25, 2016.

M. Niemelä, L. Van Aerschot, A. Tammela, I. Aaltonen, and H. Lammi. Towards ethical guidelines of using telepresence robots in residential care. *International Journal of Social Robotics*, 13:431–439, 2021.

G. J. Nutt. The evolution towards flexible workflow systems. *Distributed Systems Engineering*, 3(4):276, 1996.

K. P. O'Hara, M. Massimi, R. Harper, S. Rubens, and J. Morris. Everyday dwelling with whatsapp. In *Proceedings of the 17th ACM conference on Computer supported cooperative work & social computing*, pages 1131–1143, 2014.

O. Okundaye, F. Quek, and S. Chu. Broadening participation for remote communities: Situated distance telepresence. In *Proceedings of the 18th ACM International Conference on Interaction Design and Children*, pages 494–500, 2019.

O. Okundaye, S. Chu, F. Quek, A. Berman, G. Hordemann, L. Powell, and L. Yang. Telepresence robotics for hands-on distance instruction. In *Proceedings of the 11th Nordic Conference on Human-Computer Interaction: Shaping Experiences, Shaping Society*, pages 1–11, 2020.

A. Orlandini, A. Kristoffersson, L. Almquist, P. Björkman, A. Cesta, G. Cortellessa, C. Galindo, J. Gonzalez-Jimenez, K. Gustafsson,

A. Kiselev, et al. Excite project: A review of forty-two months of robotic telepresence technology evolution. *Presence: Teleoperators and Virtual Environments*, 25(3):204–221, 2016.

W. J. Orlikowski. The duality of technology: Rethinking the concept of technology in organizations. *Organization science*, 3(3):398–427, 1992.

A. Ozimek. The future of remote work. *Available at SSRN 3638597*, 2020.

A. Paepcke, B. Soto, L. Takayama, F. Koenig, and B. Gassend. Yelling in the hall: using sidetone to address a problem with mobile remote presence systems. In *Proceedings of the 24th annual ACM symposium on User interface software and technology*, pages 107–116, 2011.

S. K. Pathi, A. Kristoffersson, A. Kiselev, and A. Loutfi. F-formations for social interaction in simulation using virtual agents and mobile robotic telepresence systems. *Multimodal Technologies and Interaction*, 3(4): 69, 2019.

E. Paulos and J. Canny. Prop: Personal roving presence. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 296–303, 1998.

M. Perifanou, M. Galea, A. A. Economides, T. Wernbacher, and P. Häfner. A focus group study on telepresence robots in education. 2022.

S. Radmard and E. A. Croft. Overcoming occlusions in semi-autonomous telepresence systems. In *2013 16th International Conference on Advanced Robotics (ICAR)*, pages 1–6. IEEE, 2013.

I. Rae and C. Neustaedter. Robotic telepresence at scale. In *Proceedings of the 2017 chi conference on human factors in computing systems*, pages 313–324, 2017.

I. Rae, L. Takayama, and B. Mutlu. One of the gang: supporting in-group behavior for embodied mediated communication. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 3091–3100, 2012.

I. Rae, B. Mutlu, and L. Takayama. Bodies in motion: mobility, presence, and task awareness in telepresence. In *Proceedings of the SIGCHI conference on human factors in computing systems*, pages 2153–2162, 2014.

S. Reeves, C. Greiffenhagen, and E. Laurier. Video gaming as practical accomplishment: Ethnomethodology, conversation analysis, and play. *Topics in Cognitive Science*, 9(2):308–342, 2017.

G. Reyes-Cruz, I. Phypers, A. Boudouraki, D. Price, J. Fischer, S. Reeves, M. Galvez Trigo, and H. Maior. Augmented robotic telepresence (art): A prototype for enhancing remote interaction and participation. In *Proceedings of the First International Symposium on Trustworthy Autonomous Systems*, pages 1–6, 2023.

L. Riano, C. Burbridge, and T. McGinnity. A study of enhanced robot autonomy in telepresence. In *Proceedings of Artificial Intelligence and Cognitive Systems, AICS*, pages 271–283. AICS, 2011.

S. Rintel. Video calling in long-distance relationships: The opportunistic use of audio/video distortions as a relational resource. *The Electronic Journal of Communication/La Revue Electronic de Communication (EJC/REC)*, 23, 2013.

G. Riva, J. A. Waterworth, E. L. Waterworth, and F. Mantovani. From intention to action: The role of presence. *New Ideas in Psychology*, 29 (1):24–37, 2011.

G. Riva, J. Waterworth, and D. Murray. *Interacting with Presence: HCI and the Sense of Presence in Computer-mediated Environments*. Walter de Gruyter GmbH & Co KG, 2014.

A. B. Robillard. *Meaning of a disability: The lived experience of paralysis*. Temple University Press, 1999.

J. Rooksby. Wild in the laboratory: a discussion of plans and situated actions. *ACM Transactions on Computer-Human Interaction (TOCHI)*, 20(3):1–17, 2013.

A. Rosenthal-von der Pütten, D. Sirkin, A. Abrams, and L. Platte. The forgotten in hri: Incidental encounters with robots in public spaces. In *Companion of the 2020 ACM/IEEE International Conference on Human-Robot Interaction*, pages 656–657, 2020.

E. Saadatian, H. Samani, A. Vikram, R. Parsani, L. T. Rodriguez, and R. Nakatsu. Personalizable embodied telepresence system for remote interpersonal communication. In *2013 IEEE RO-MAN*, pages 226–231. IEEE, 2013.

B. Saatçi, R. Rädle, S. Rintel, K. O'Hara, and C. N. Klokmose. Hybrid meetings in the modern workplace: Stories of success and failure. In *International Conference on Collaboration and Technology*, pages 45–61. Springer, 2019.

B. Saatçi, K. Akyüz, S. Rintel, and C. N. Klokmose. (re) configuring hybrid meetings: Moving from user-centered design to meeting-centered design. *Computer Supported Cooperative Work (CSCW)*, 29:769–794, 2020.

H. Sacks. On doing "being ordinary". inj. m. atkinson & j. heritage (eds.),

structures of social action: Studies in conversation analysis (pp. 413–429), 1984.

H. Sacks. Lectures on conversation: Volume i. *Malden, Massachusetts: Blackwell*, 1992.

M. Sakashita, E. A. Ricci, J. Arora, and F. Guimbretière. Remotecode: Robotic embodiment for enhancing peripheral awareness in remote collaboration tasks. *Proceedings of the ACM on Human-Computer Interaction*, 6(CSCW1):1–22, 2022.

C. Satchell and P. Dourish. Beyond the user: use and non-use in hci. In *Proceedings of the 21st annual conference of the Australian computer-human interaction special interest group: Design: Open 24/7*, pages 9–16, 2009.

J. Scheffler and K. Pitsch. Pre-beginnings in human-robot encounters: Dealing with time delay. In *Proceedings of the 18th European Conference on Computer-Supported Cooperative Work: The International Venue on Practice-Centred Computing on the Design of Cooperation Technologies-Exploratory Papers, Reports of the European Society for Socially Embedded*, 2020.

E. A. Schegloff. *Sequencing in conversational openings*. De Gruyter Mouton, 2018.

M. Schmucker, A. Reiswich, C. Pfeifer, V. De Mey, and M. Haag. Mobile robotic telepresence between hospital and school: Lessons learned. In *dHealth 2020–Biomedical Informatics for Health and Care*, pages 256–262. IOS Press, 2020.

H. Schnadelbach, A. Penn, S. Benford, and B. Koleva. Mixed reality architecture: Concept, construction, use. 2003.

A. P. Schouten, T. C. Portegies, I. Withuis, L. M. Willemsen, and K. Mazerant-Dubois. Robomorphism: Examining the effects of telepresence robots on between-student cooperation. *Computers in Human Behavior*, 126:106980, 2022.

N. Selwyn. Apart from technology: understanding people's non-use of information and communication technologies in everyday life. *Technology in society*, 25(1):99–116, 2003.

S. Shen, H. Tennent, H. Claure, and M. Jung. My telepresence, my culture? an intercultural investigation of telepresence robot operators' interpersonal distance behaviors. In *Proceedings of the 2018 CHI conference on human factors in computing systems*, pages 1–11, 2018.

D. Sirkin, W. Ju, and M. Cutkosky. Communicating meaning and role in distributed design collaboration: how crowdsourced users help inform the design of telepresence robotics. *Design thinking research: Studying co-creation in practice*, pages 173–187, 2012.

M. Slater, M. Usoh, and A. Steed. Depth of presence in virtual environments. *Presence: Teleoperators & Virtual Environments*, 3(2):130–144, 1994.

N. Soares, J. C. Kay, and G. Craven. Mobile robotic telepresence solutions for the education of hospitalized children. *Perspectives in health information management*, 14(Fall), 2017.

R. Solly. Telepresence robots to help enable access to hastings contemporary art gallery, 2022. URL https://www.roboticsforgood.co.uk/post/telepresence-robots-to-help-enable-access-to-hastings-contemporary-art-

B. Stoll, S. Reig, L. He, I. Kaplan, M. F. Jung, and S. R. Fussell. Wait,

can you move the robot? examining telepresence robot use in collaborative teams. In *Proceedings of the 2018 ACM/IEEE International Conference on Human-Robot Interaction*, pages 14–22, 2018.

J. Streeck and J. S. Jordan. Projection and anticipation: The forward-looking nature of embodied communication. *Discourse processes*, 46 (2-3):93–102, 2009.

L. A. Suchman. *Plans and situated actions: The problem of human-machine communication*. Cambridge university press, 1987.

D. Sudnow. *Pilgrim in the Microworld*. Warner Books New York, 1983.

D. Sudnow and H. L. Dreyfus. Ways of the hand: A rewritten account. 2001.

L. Takayama and J. Go. Mixing metaphors in mobile remote presence. In *Proceedings of the acm 2012 conference on computer supported cooperative work*, pages 495–504, 2012.

L. Takayama, E. Marder-Eppstein, H. Harris, and J. M. Beer. Assisted driving of a mobile remote presence system: System design and controlled user evaluation. In *2011 IEEE international conference on robotics and automation*, pages 1883–1889. IEEE, 2011.

J. W. Treem. Technology non-use as avoiding accountability. *CHI'14 Extended Abstracts on Human Factors in Computing Systems*, pages 65–68, 2014.

T.-C. Tsai, Y.-L. Hsu, A.-I. Ma, T. King, and C.-H. Wu. Developing a telepresence robot for interpersonal communication with the elderly in a home environment. *Telemedicine and e-Health*, 13(4):407–424, 2007.

K. M. Tsui and H. A. Yanco. Design challenges and guidelines for social interaction using mobile telepresence robots. *Reviews of Human Factors and Ergonomics*, 9(1):227–301, 2013.

K. M. Tsui, M. Desai, H. A. Yanco, and C. Uhlik. Exploring use cases for telepresence robots. In *Proceedings of the 6th international conference on Human-robot interaction*, pages 11–18, 2011.

K. M. Tsui, M. Desai, and H. A. Yanco. Towards measuring the quality of interaction: communication through telepresence robots. In *Proceedings of the workshop on performance metrics for intelligent systems*, pages 101–108, 2012.

K. M. Tsui, J. M. Dalphond, D. J. Brooks, M. S. Medvedev, E. McCann, J. Allspaw, D. Kontak, and H. A. Yanco. Accessible human-robot interaction for telepresence robots: A case study. *Paladyn, Journal of Behavioral Robotics*, 6(1), 2015.

J. van Houwelingen-Snippe, J. Vroon, G. Englebienne, and P. Haselager. Blame my telepresence robot joint effect of proxemics and attribution on interpersonal attraction. In *2017 26th IEEE international symposium on robot and human interactive communication (RO-MAN)*, pages 162–168. IEEE, 2017.

T. van Oosterhout and A. Visser. A visual method for robot proxemics measurements. In *Proceedings of Metrics for Human-Robot Interaction: A Workshop at the Third ACM/IEEE International Conference on Human-Robot Interaction (HRI 2008). Citeseer*, pages 61–68. Citeseer, 2008.

L. Veling and C. McGinn. Qualitative research in hri: A review and taxonomy. *International Journal of Social Robotics*, 13:1689–1709, 2021.

G. Venolia, J. Tang, R. Cervantes, S. Bly, G. Robertson, B. Lee, and K. Inkpen. Embodied social proxy: mediating interpersonal connection in hub-and-satellite teams. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 1049–1058, 2010.

F. Vetere, M. R. Gibbs, J. Kjeldskov, S. Howard, F. Mueller, S. Pedell, K. Mecoles, and M. Bunyan. Mediating intimacy: designing technologies to support strong-tie relationships. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 471–480, 2005.

S. Virkus, J. Leoste, K. Marmor, T. Kasuk, and A. Talisainen. Telepresence robots from the perspective of psychology and educational sciences. *Information and Learning Sciences*, (ahead-of-print), 2023.

A. Voida, S. Voida, S. Greenberg, and H. A. He. Asymmetry in media spaces. In *Proceedings of the 2008 ACM conference on Computer supported cooperative work*, pages 313–322, 2008.

D. Vom Lehn. *Harold Garfinkel: The creation and development of ethnomethodology*. Left Coast Press, 2014.

S. Wall. An autoethnography on learning about autoethnography. *International journal of qualitative methods*, 5(2):146–160, 2006.

E. Wende, R. Alt, and G. King. Towards genuine virtual collaboration: Designing the use of mobile remote presence in offshore-outsourced projects. 2017.

R. M. Williams. All robots re disabled a. *Social Robots in Social Institutions: Proceedings of Robophilosophy 2022*, 366:229, 2023.

K. Winkle, D. McMillan, M. Arnelid, K. Harrison, M. Balaam, E. Johnson, and I. Leite. Feminist human-robot interaction: Disentangling power,

principles and practice for better, more ethical hri. In *Proceedings of the 2023 ACM/IEEE International Conference on Human-Robot Interaction*, pages 72–82, 2023.

T. Winograd, F. Flores, and F. F. Flores. *Understanding computers and cognition: A new foundation for design*. Intellect Books, 1986.

G. Yang, H. Lv, Z. Zhang, L. Yang, J. Deng, S. You, J. Du, and H. Yang. Keep healthcare workers safe: application of teleoperated robot in isolation ward for covid-19 prevention and control. *Chinese Journal of Mechanical Engineering*, 33(1):1–4, 2020.

L. Yang and C. Neustaedter. Our house: living long distance with a telepresence robot. *Proceedings of the ACM on Human-Computer Interaction*, 2(CSCW):1–18, 2018.

L. Yang and C. Neustaedter. An autobiographical design study of a long distance relationship: When telepresence robots meet smart home tools. In *Proceedings of the 2020 ACM Designing Interactive Systems Conference*, pages 129–140, 2020a.

L. Yang and C. Neustaedter. An autobiographical design study of a long distance relationship: When telepresence robots meet smart home tools. In *Proceedings of the 2020 ACM Designing Interactive Systems Conference*, pages 129–140, 2020b.

L. Yang, C. Neustaedter, and T. Schiphorst. Communicating through a telepresence robot: A study of long distance relationships. In *Proceedings of the 2017 CHI Conference Extended Abstracts on Human Factors in Computing Systems*, pages 3027–3033, 2017.

L. Yang, B. Jones, C. Neustaedter, and S. Singhal. Shopping over distance

through a telepresence robot. *Proceedings of the ACM on Human-Computer Interaction*, 2(CSCW):1–18, 2018.

J. Yeung and D. I. Fels. A remote telepresence system for high school classrooms. In *Canadian Conference on Electrical and Computer Engineering, 2005.*, pages 1465–1468. IEEE, 2005.

M. Yokoyama, M. Matsuda, S. Muto, and N. Kanamaru. Politel: Mobile remote presence system that autonomously adjusts the interpersonal distance. In *Proceedings of the adjunct publication of the 27th annual ACM symposium on User interface software and technology*, pages 91–92, 2014.

J. Yunde, X. Bin, S. Jiajun, and P. Mintao. Telepresence interaction by touching live video images, 2015.

D. Zahavi. *Husserl's phenomenology*. Stanford University Press, 2003.

G. Zhang, J. P. Hansen, K. Minakata, A. Alapetite, and Z. Wang. Eye-gaze-controlled telepresence robots for people with motor disabilities. In *2019 14th acm/ieee international conference on human-robot interaction (hri)*, pages 574–575. IEEE, 2019.

M. Zhang, P. Duan, Z. Zhang, and S. Esche. Development of telepresence teaching robots with social capabilities. In *ASME International Mechanical Engineering Congress and Exposition*, volume 52064, page V005T07A017. American Society of Mechanical Engineers, 2018.