Informatics

Inconsequential Encounters

Exploring Interactions with Sidewalk Robots in Public Spaces

DISSERTATION

zur Erlangung des akademischen Grades

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submitted in partial fulfillment of the requirements for the degree of

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to the Faculty of Informatics

at the TU Wien

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Erklärung zur Verfassung der Arbeit

Anna Dobrosovestnova, M.A. MSc

Hiermit erkläre ich, dass ich diese Arbeit selbständig verfasst habe, dass ich die verwendeten Quellen und Hilfsmittel vollständig angegeben habe und dass ich die Stellen der Arbeit – einschließlich Tabellen, Karten und Abbildungen –, die anderen Werken oder dem Internet im Wortlaut oder dem Sinn nach entnommen sind, auf jeden Fall unter Angabe der Quelle als Entlehnung kenntlich gemacht habe.
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Wien, 7. April 2025

Anna Dobrosovestnova

Publications

Publications Relevant to the Thesis

- Dobrosovestnova, Anna, Babel, Franziska, and Pelikan, Hannah (Mar. 2025). *Beyond the User: Mapping Subject Positions for Robots in Public Spaces*. In: *Proceedings of the 20th ACM/IEEE International Conference on Human-Robot Interaction (HRI)*. IEEE Press, pp. 163—173.
- Dobrosovestnova, Anna and Weiss, Astrid (Mar. 2024). *What we Learn on the Streets: Situated Human-robot Interactions from an Industry Perspective*. In: *Companion of the 2024 ACM/IEEE International Conference on Human-Robot Interaction*. New York, NY, USA: Association for Computing Machinery, pp. 407–411.
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- Vetter, Ralf, Frauenberger, Christopher, Dobrosovestnova, Anna, Brunnmayr, Katharina, Frijns, Helena. (2025). *Expanding the Concept of Personhood: Towards a Posthumanist Approach to Designing for Dementia.* In: Branco, R.M., Figueiredo, D., De Coen, A., Craig, C. (eds) Dementia Lab 2025: Ethics + Aesthetics in Design. D-Lab 2025. Design For Inclusion, vol 5. Springer.
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Kurzfassung

In dieser Arbeit werden Mensch-Roboter-Interaktionen im öffentlichen Raum am Beispiel von Starship-Lieferrobotern untersucht, um zu verstehen, wie diese Technologien Teil städtischer Gemeinschaften werden. Angesiedelt im Bereich der Mensch-Roboter-Interaktion (HRI) mit Inspiration aus der Wissenschafts- und Technikforschung (STS) hat diese Arbeit zum Ziel, die Nuancen der Interaktionen zwischen Robotern und Menschen in städtischen Gebieten, in denen die Roboter eingesetzt werden, zu erfassen. Methodisch baut sie auf einem Multi-Methoden-Ansatz auf, der ethnografisch inspirierte Beobachtungen, Interviews, Online-Inhaltsanalysen und auf Umfragen basierende quantitative Studien umfasst. Verschiedene Reaktionen auf Starship werden aufgezeigt - von flüchtigen Anpassungen bis hin zu freiwilliger Unterstützung - und untersucht, wie die Gemeindemitglieder Roboter als quasi soziale, zweckmäßige (wenn auch nicht unbedingt unmittelbar pragmatisch nützliche) Akteure wahrnehmen, die sie mit Stolz erfüllen. Die Ergebnisse zeigen, dass Sidewalk-Roboter nicht nur zu neuartigen Formen der Interaktion führen, sondern auch Differenzen hinsichtlich der Bedeutung dieser Interaktionen für verschiedene Interessengruppen aufzeigen. In Momenten freiwilliger Hilfeleistungen zeigen die Ergebnisse, wie diese als Fürsorge, Arbeit oder verzichtbare Abhängigkeit wahrgenommen werden. Es wird deutlich, dass Feedback aus diesen Begegnungen in der Öffentlichkeit in die iterativen Designprozesse auf Seite der Entwickler*innen einfließen.

Diese Arbeit ist ein signifikanter Beitrag zum Verständnis der HRI, da sie Forschungslücken in Bezug auf „vergessene“ Teilnehmende, wie etwa nicht-initiierende Nutzende und weniger direkte Interaktionen aufzeigt, sowie einen theoretischen Rahmen liefert, der Mensch-Roboter-Beziehungen in den Bereichen Dienstleistung, Straßenleben und öffentlichem Diskurs abbildet. Methodisch trägt die Arbeit eine Weiterentwicklung von Erhebungsinstrumenten wie der Skala zu Attitudes Towards Social Robots (ASOR) bei und bietet praktische Einblicke für die Erforschung von kommerziellen Robotern in realen Kontexten.

Ausgehend von den Erfahrungen bei der Durchführung des Projekts plädiere ich dafür, dass künftige Forschung die vorliegenden Ergebnisse erweitert, indem sie die Perspektiven sozioökonomisch diverser Gruppen untersucht und die breiteren sozioökonomischen Auswirkungen der Verwendung von Robotern berücksichtigt, einschließlich der Verdrängung von Arbeitskräften und der Auswirkungen der Automatisierung auf prekär Beschäftigte. Die weltweite Verbreitung von kommerziellen Lieferrobotern in öffentlichen Räumen

unterstreicht den Bedarf an ethisch fundierter und sozial integrativer Forschung. Diese Arbeit liefert eine Momentaufnahme eines sich rasant entwickelnden Feldes und legt den Grundstein für das Verständnis der dynamischen Rollen und Bedeutungszuschreibungen von Robotern im städtischen Leben.

Abstract

This thesis explores human-robot interactions in public spaces, using Starship delivery robots as a case study, to understand how these technologies integrate into urban communities. Situated within Human-Robot Interaction (HRI) and informed by Science and Technology Studies (STS), the research relies on a multi-method approach, including ethnography inspired observations, interviews, online content analysis, and survey based quantitative studies, to capture the nuances of interactions between robots and people native to the community where robots are deployed. It highlights diverse responses—from fleeting adjustments to voluntary assistance—and examines how community members perceive robots as quasi-social, purposeful (though not necessarily immediately pragmatically useful) actors, fostering pride. The findings highlight that sidewalk robots invite not only novel forms of interactions but allow to articulate tensions regarding what these interactions may mean for different stakeholders. Related to instances of voluntary assistance, the thesis illustrates how such help can be perceived as care, work, or unnecessary dependency. Feedback from these street-level encounters also significantly informs iterative design processes.

Taken together, the thesis advances HRI by addressing gaps concerning "forgotten" participants, such as non-lead users and less direct interactions, while contributing a theoretical framework that maps human-robot relationships across service, street life, and public discourse ecologies. Methodologically, the work refines tools like the Attitudes towards Social Robots (ASOR) scale and offers practical insights for studying commercial robots in real-world contexts.

Based on the experience of conducting the project, I argue future research should expand on these findings by examining the perspectives of more socio-economically diverse groups and considering the broader socio-economic implications of robot deployment, including labor displacement and automation's impact on precarious workers. As delivery robots scale globally, the need for ethically grounded and socially inclusive research becomes even more urgent. This thesis provides a snapshot of a rapidly evolving field, laying the groundwork for understanding the dynamic roles and meanings of robots in urban life.

Contents

CHAPTER 1

Introduction

1.1 Preface

It was beginning of December 2021 and I still had nothing but intuitions that kept deterring me from doing what I had laid out in the initial draft of the proposal that had secured me a fellowship from the Austrian Academy of Sciences to conduct my PhD research. At the center of that proposal was a small creature-like robot Vector. My supervisor Astrid Weiss and I had our minds set on exploring (robot) identity as a conceptual shift from personality traits models dominating the field of human-robot interaction (HRI). Methods wise, the plan was to invite participants to our lab, have them customize the robots, and then take their Vector robot home. A series of household visits would follow to investigate whether a unique robot identity emerged in interactions over time. Something about the idea, however, did not quite click. It was not the theory – a move towards a more dynamic and situated view on robot personality did seem sensible against the static signaling paradigm (Jung, 2017) based views on personality. Apart from a theoretical paper proposing a conceptual path for this shift (Dobrosovestnova, Reinboth, and Weiss, 2024) and a project title associated with my position in the digital bureaucratic labyrinths of the TU Wien not much has remained from this project since.

I understand now that it was the methodological approach – the idea of simply giving technology to people who volunteer – that unsettled me. Later in the project, when exploring science and technology (STS) literature I encountered a text by Clarke and Star that captured the unsettling intuition I had so precisely. Calling it elitist, they characterized simply giving technology to people and waiting to see what happens as "Just throw it over the wall (and let users deal with it as best they can" (A. Clarke and Star, 2008, p. 119) approach and contended it disregarded the actual lived reality of the so-called users. Reluctant to pursue the same path while not knowing what else I could do, the first semester as a PhD student I threw myself into taking courses and endlessly revising the personality theory paper – anything to halt me from actually conducting the work we had planned. At about the same, videos of people assisting delivery robots to cross the street, or digging them out on the snow-covered streets of Tallinn surfaced on social media. The videos were shared among my colleagues in the HCI group as a kind of entertaining curiosity to which five minutes of joint lunch time could be allocated. A fading curiosity it remained until some weeks later I was sitting in my stepdad's rental car on the way from Tallinn airport. As we approached one of the busy cross-roads in the center of Tallinn (a place that soon enough became one of the sites for my field work) I saw the very same robot ploughing its way through similarly heavy snow. The robot was labeled Starship, developed by Starship Technologies. So they *are* real! And they are really *out there*! Fifteen minutes later, my sister and I were on the corner of Tehnika street interviewing a woman whom we had witnessed, a cup of coffee in her hand, clearing the snow on the robot's path with her foot. And so it began.

What was first an entirely new way to spend the Christmas holidays chasing robots through snow and rain – a deadly combo any person coming from Estonia is well familiar with – grew into a much larger project mischievously titled "Inconsequential encounters: Exploring Interactions Beyond Use with Robots in Public Spaces". I see now how in this spontaneous – and most definitely unprepared at first – dive into exploring robots stuck in snow some of the driving forces for my research came together: the genuine excitement I feel for the "mess" (Law, 2004) of the so-called "real world", my interest in social and affective dimensions of human-robot interactions, and my personal rebellion against all things efficient, useful, pragmatic, and quantifiable that ever so often characterize how we think about and evaluate technologies. I wanted to study something fleeting, something seemingly *useless*; but in its lack of narrowly understood utility not deprived of *meaning*. What kind of meaning is it? And is it really that *inconsequential*?

Figure 1.1: Selfie of the author with a Starship robot on the background.

1.2 Proliferation of Autonomous Vehicles in Public Spaces

In recent years, the presence of sidewalk delivery robots has grown considerably in communities worldwide. Delivery robots are compact self-driving vehicles that rely on sensors, cameras, and GPS technology to navigate public spaces and transport goods from distribution centers or local vendors to customers' doorsteps. Primarily designed for short distance deliveries, these robots operate on sidewalks and pedestrian pathways.

While lauded by many for their potential to provide cost-effective, scalable, and sustainable solutions c.f. (Kottasova, 2015), the development and roll-out of last-mile delivery robots continues to pose many challenges and open questions. These challenges include regulatory (Hoffmann and Prause, 2018; Mintrom et al., 2022; Shivakumar, 2021; Thomasen, 2020), safety, privacy, and surveillance related (Woo, Whittington, and Arkin, 2020), and the need for robust infrastructure. A significant obstacle remains the establishment of a strong business model. For example, Amazon, after acquiring robotics company Dispatch to develop its Scout delivery robot, announced in January 2023 that it would scale back the program. The company cited feedback from its limited field test indicating that certain aspects of the program had failed to meet customer expectations and needs (Heater, 2022).

Despite the said challenges, global interest in automating last-mile delivery sector continues to grow. Starship Technologies, a pioneer and one of the leaders in the field, reported having over 2,000 robots in daily service (Zura, 2023), and as of December 2024, its fleet of robots having driven over 8 million miles globally, completing 7 million deliveries. In the last mile delivery sector, apart from Starship Technologies and Amazon, several other companies continue exploring the field. Among these are Nuro founded in 2016 by two veterans of the Google self-driving car project (Hawkins, 2024). In China, the giant of online merchandise Alibaba Group, has also deployed a fleet of autonomous delivery vehicles Xiaomanlv (Liao, 2023).

1.3 Robots in Public Spaces Challenge Established Categories in HRI

In response to the increasing interest to and the ongoing roll-out of autonomous service robots globally, in recent years the Human-robot interaction (HRI) community too has picked up on this rapidly expanding domain, investigating a wide range of topics concerning functional service robots in public spaces [1] including user reactions and conflicts e.g., (Babel, Kraus, and Baumann, 2022), trust e.g., (Martinez et al., 2023), pedestrian acceptance e.g., (Groot, 2019), and many others.

[1] In here and in what follows, I define public spaces a site characterized by free access, public ownership or oversight. Public spaces serve as arenas for social interactions, communication, and facilitate a range of uses such as recreation, transit, and commerce. Importantly, while public spaces can include semi-institutional and semi-closed settings such as libraries, hospitals, schools, the focus of this monograph is first and foremost on what I call 'open' public spaces. While the two groups of public spaces share many similarities, the differences between them concern rules of governing (semi-closed public spaces can be governed by institutions and private bodies), different degree of access (semi-closed public spaces are as a rule less universally accessible), and security protocols.

To be sure, studies of robots in public spaces had existed prior to the ongoing wave of expansion of service robots in the "real world" e.g., (Salvini et al., 2010; Weiss, Bader, et al., 2014). While earlier studies were often constrained by prototype limitations, one-off interactions, and more scripted scenarios, they nonetheless provided valuable insights into the key considerations for future studies of HRI in natural environments. One crucial aspect highlighted by these studies is the necessity of conducting research in contexts where technology is naturally used, with attention to both the physical infrastructure and the social norms of the setting (S. Šabanović, Michalowski, and Simmons, 2006). Another important point is the need to understand experiences from multiple perspectives, recognizing the diversity of interactions that occur (Young et al., 2010). Third, these studies emphasized the growing need for exploring experiences over time, to capture the evolving dynamics of human-robot interactions (Forlizzi, 2007; Kurvinen, Koskinen, and Battarbee, 2008). Together, these works advocated for methodological approaches that appreciate the complexity of HRI, calling for tools capable of uncovering themes and providing deep, nuanced descriptions of the socio-technical realities that shape these interactions.

For the current generation of HRI scholars, the deployment of Starship robots in Milton Keynes in 2018 (Starship, 2024) marked a pivotal moment, not only by expanding the research possibilities that align with the aforementioned proposals but also by highlighting the conceptual shift that needs to follow. One of the key concepts in HRI disrupted by the emergence of sidewalk robots is the traditional notion of the 'user'. In much the same way as in Human-Computer Interaction (HCI), users have long been the central focus in HRI. While the vast majority of the scholarly work in HRI continues to view and study people as interchangeable subjects who engage with robotic systems in controlled lab environments (H. Lee et al., 2022), shifting focus to robots in public spaces have led Rosenthal-von der Pütten et al. (2020) to propose the term incidentally copresent persons (InCoPs) referring to people "who do not deliberately seek an interaction with a robot (users) but find themselves in coincidental presence with robots" (Astrid Rosenthal-von der Pütten et al., 2020, p.656).

I see my thesis project as a direct response to the calls for research that both critically examines the complexity of situated interactions with robots in their real-world deployment and addresses the need for conceptual development within the field of HRI in response to new knowledge resulting from such empirical work. At the center of my research pursuits are Starship delivery robots deployed in Tallinn, Estonia. In the time period between December 2021 - February 2023, I visited Tallinn several times to conduct observations and interviews (refer to Section 3.1.2 for a detailed overview of methods and project phases). Before I detail the aims and research questions of my thesis project in Section 1.5, in what follows, I introduce Starship Technologies and Starship robots, and give a brief account on central Tallinn as the main context for my field studies.

1.4 Starship Robots Deployed in Tallinn

Starship Technologies was founded in 2014 and has since developed and deployed a global network of autonomous delivery robots across the United States, United Kingdom, Germany, Finland, and Estonia. The company, headquartered in San Francisco, also has engineering offices in Tallinn, Estonia, where it originated, and Helsinki, Finland. Starship's pilot services began in 2016, followed by the launch of commercial services in 2017. In April 2018, the company introduced its autonomous delivery service in Milton Keynes, England, partnering with Co-op and Tesco to deliver groceries, takeaways, and packages (Starship, 2024).

In Tallinn, the service officially launched in September 2021 (ibid.), about three months before I conducted my initial field observations. It is important to note that the service arrival in Tallinn did not coincide with the robots' first public appearance. Tallinn served as one of Starship's test beds before its global launch, and locals had already seen Starship robots accompanied by their handlers in Tallinn districts, such as residential district Mustamäe. The field observations primarily took place in central Tallinn neighborhoods like Kalamaja, Telliskivi, and Uus Maailm, which were home to many vendors partnering with Starship at the time (2021-2022). These areas were once notorious for high levels of alcohol and drug consumption, as well as crime. However, in the last 25 years, these districts have undergone significant gentrification, with soaring real estate prices and an influx of middle- and upper-class families. Today, they are known for their bohemian, youthful atmosphere, and are home to contemporary museums, small galleries, coffee shops, restaurants, and other businesses. As I elaborate in Chapter 5, the introduction of sidewalk robots in these neighborhoods during the early stages of Starship's commercial roll-out aligns with the socio-demographic and cultural shifts in the area.

From a technical standpoint, Starship robots are six-wheeled autonomous service robots. The robots measure 697 mm in length, 569 mm in width, and 571 mm in height (excluding the LED flag) (refer to Figure 1.2). They are equipped with various safety and navigation features, including ultrasonic sensors, 12 cameras, radar, GPS, an alarm system, reflectors, a signal flag, and Time-of-Flight (TOF) cameras. Each unit weighs approximately 35 kilograms and can carry an additional load of up to 10 kilograms. Traveling at a maximum speed of 6 km/h, the robots operate on sidewalks and pavements. According to Starship's official website, these robots are designed to deliver packages within a 5-kilometer radius.

Starship robots operate autonomously for the most part, and are capable of navigating obstacles and preventing collisions. They can adjust their speed and pause at crossings, enabling them to integrate with pedestrian and vehicular traffic. In critical situations, human operators can remotely intervene and take control (Kottasova, 2015). Additionally, the robots feature microphones and speakers, facilitating dialogue-based interactions with humans.

Figure 1.2: On a foggy winter day, a couple at the background of the picture are turning their heads to take a look at a Starship robot. Photo taken by Aron Urb.

1.5 Research Aims and Guiding Research Questions

While I situate myself in the field of Human-Robot Interaction (HRI) and consider HRI scholars as the main target audience of my work, as I elaborate in Sections 2.2 and 3.1.1 of Chapter 3, the project relies heavily on concepts and methodological approaches from the field of Science and Technology studies (STS). Using Starship robots as a case study[2], my thesis combines multiple methodologies, including naturalistic observations, ethnographic interviews and online survey study (detailed in Section 3.1.2), to address the following aims:

- Aim 1: Investigate human-robot interactions that transpire (and relations that emerge based on these) as the robot makes its way from the site of vendor to the point of delivery.
- Aim 2: Explore what these interactions mean for different actors (passersby, vendors, developers).

[2] In STS literature, case study is a research methodology used to examine a particular instance, or phenomenon in-depth to generate insights about technological and social dynamics.

- Aim 3: Informed by the empirical data, to put to test and refine existing theories and methods in HRI, more specifically as these concern how we frame people and interactions as well as social and affective processes underpinning human-robot relations.
- Aim 4: Formulate methodological suggestions for HRI research in the contexts of robot deployment.

These objectives are addressed through specific research questions, as elaborated below.

- Research Question 1.1. and 1.2: What types of interactions occur between people and robots deployed in their communities? What situational, social, and design factors shape these interactions?
- Research Question 2.1. and 2.2.: How do community members perceive robots on their city streets, and how do they interpret their (often incidental) encounters? From the developers' perspective, what role, if any, do these encounters play in the design process?
- Research Question 3.1. and 3.2: If these interactions cannot be categorized as 'use,' what alternative conceptual frameworks can capture them? How does studying robots in public spaces challenge and enrich existing theoretical frameworks?
- Research Question 4.1 and 4.2: What challenges and opportunities arise when studying robots as socio-technical actors in community settings; how can insights from the field studies further enrich and inform methodological approaches in HRI?

1.6 Contributions

The contributions of this thesis project are threefold.

First, focusing on the situated interactions and lived experiences, my work offers novel *empirical* contributions with respect to the situated interactions between Starship robots on city streets and people populating the community. More precisely, the empirical studies conducted offer insights about instances of voluntary assistance to robots, how people make sense of these behaviors, and elaborates on the tensions at the intersection of different construals of help (as work, as care, as a nice-to-have but not necessary dependency). Importantly, the research conducted highlights how fleeting – seemingly inconsequential encounters – influence developers' perspectives, revealing that much design effort targets these superficially trivial moments rather than conventional 'use.' This underscores the dialogic relationship between the design and interaction spaces. Drawing on interviews with passersby and vendors, the work also examines how facets of identity influence the acceptance of robots and the emerging social norms governing interactions with them. Furthermore, the findings address robots as social actors in communities, providing data-driven support for the concept of sociomorphing (Seibt, Vestergaard, and Damholdt, 2020) rather than anthropomorphizing.

Second, inspired by these empirical findings, this monograph makes theoretical contributions by proposing a descriptive framework that maps subject positions (J. Bardzell and S. Bardzell, 2015) beyond 'users' into three ecologies (Forlizzi, 2007): service ecology, street life ecology, and public discourse ecology. Within these ecologies, robots are conceptualized as actors in service provision, material and social actors navigating shared streets, and, using Latour's term, "matters of concern" (Latour, 2004) respectively. The proposed theoretical framework aims to systematize the diversity of human-robot relationships in public spaces while encouraging holistic approaches to designing sustainable human-robot interactions.

Third, the work makes *methodological* contributions by offering a detailed, reflective account of the challenges and decisions involved in studying commercial robots in the contexts of their deployment. This includes site selection, access challenges, and data analysis strategies, with an honest reflection on both successes and difficulties to guide early-career HRI scholars striving to conduct similar research. Beyond reflective insights, the monograph refines the methodological toolkit of HRI through an evaluation of the Attitudes towards Social Robots Scale (ASOR) (Damholdt, Vestergaard, et al., 2020), advancing its use as a quantitative survey tool for assessing robot sociality dimensions.

1.7 Structure of this Monograph

The remained of this monograph is structured as follows. Chapter 2 offers theoretical and related work background to my thesis by anchoring robots as socio-technical systems; discussing how people are commonly framed in the fields of Human-Computer Interaction and Human-Robot Interaction, along with an overview of related studies on service robots in public spaces.

Chapter 3 situates my thesis project epistemologically and methodologically. Here, I outline my disciplinary influences, positionality, ethical dimensions relevant to my research; and specify methodological approaches that influenced my work, specifically focusing on ethnography, and provide a detail overview of the thesis project phases and respective methods.

Chapter 4 is dedicated to the first empirical phase of the project detailing a mixed-method study, integrating naturalistic observations, online content analysis, conducted in December 2021 and focused on instances of people voluntarily assisting Starship robots.

Chapter 5, deepens the insights of the first study through an account of the semi-structured interviews, and their analysis, with Starship vendors and passersby in the communities where robots are deployed.

In the Chapter 6, I shift the focus to developers' perspectives: I detail the process of interviewing, and respective analysis and themes developed, of three representatives of Starship Technologies closely involved in the robot development process.

In Chapter 7, I introduce two online studies investigating dimensions of sociality attributed to Starship as functional service robots and comparing to those attributed to more conventionally understood social robots. This chapter introduces in more detail the notion of sociomorphing, and Ontology of Asymmetric Social Interactions (OASIS) (Seibt, Vestergaard, and Damholdt, 2020) framework that I used to theoretically ground the two studies. I also explain my motivation to work with the the Attitudes Towards Social Robots scale (ASOR) (Damholdt, Vestergaard, et al., 2020) and proceed to detail the set-up, analysis and outcomes of the two online studies.

Chapter 8 is dedicated to the theory development, outlining the three ecologies of subject positions as these concern interactions with functional robots in public spaces. The thesis concludes with Discussion 9, summarizing the project's outcomes, addressing research questions, and suggesting future directions, and Conclusion 10, which discusses the limitations at the level of the project, and overviews its main contributions.

Notably, the empirical chapters are each accompanied by discussion sections where I address limitations, reflect on methodological challenges, and explore conceptual developments as they pertain to the specific studies presented in the chapter.

CHAPTER 2

Background and Related Work

This chapter provides an overview of related work relevant to this thesis project. Specifically, Section 2.1 draws on Science and Technology Studies (STS) to formulate a foundational theoretical principle of my work, that is, when we talk about robots deployed in the real world, we must view them as *socio-technical* systems (as opposed to only being technical artifacts). In Section 2.2, I review how humans, and their relationships with technologies, are framed within HCI and HRI, laying ground for the conceptual shift beyond 'users'. The chapter concludes with an outline of HRI studies focusing on (service) robots in public spaces.

2.1 Robots as Socio-Technical Systems

As an interdisciplinary field pursuing "an integrative understanding of the origins, dynamics, and consequences of science and technology" (Felt et al., 2016, p.1), STS challenges technological determinism – the notion that technology evolves independently and shapes society in a unidirectional way – by emphasizing instead the mutual co-construction of technology and society. Although a comprehensive review of how STS addresses the co-construction of technology and society is beyond the scope of this thesis, three influential frameworks merit mentioning: the social construction of technology (SCOT), large-scale technological systems (LTS), and actor-network theory (ANT) (Bijker, Hughes, and Pinch, 2012). Despite their differences, these approaches share a focus on the interplay between social and technical domains, shifting attention from individual inventors to broader networks of actors, including relevant social groups (SCOT), system builders (LTS), and human and nonhuman actants (ANT). The three framework also share a methodological commitment to integrating empirical research with theoretical analysis, often relying on "thick" (Geertz, 2008) ethnographic descriptions (ibid.) and interpretative analysis of data to explore how socio-technical boundaries are constructed and enacted. Originating in SCOT, the concept of *interpretative flexibility*, as Bijker and Pinch argue, extends across all three frameworks. This metaphor highlights that technological artifacts lack a singular, unified meaning inscribed into them by engineers and developers. If their meaning were solely defined by engineers, there would be no space for social analysis (Akrich, 1992; Bijker, Hughes, and Pinch, 2012).

As STS has developed and grown, these foundational approaches have evolved through critique and refinement, while new perspectives have also emerged. SCOT, for example, has expanded to encompass diverse construction processes, including social institutions, sociotechnical ensembles, and normative questions about politics (Winner, 1993). Feminist scholarship in STS has deepened this evolution, challenging binary oppositions such as subject/object, human/nonhuman, and nature/culture. Through philosophical critique and historical analysis, feminist scholars have elaborated the politics underpinning these divisions and the practices that sustain them (Lucy Suchman, 2008).

Although much work remains with respect to the entangling of ideas from STS and dominant HRI discourses (Dobrosovestnova, Pagter, and Weiss, 2023), some scholars working on topics related to (social) robotics and HRI have been receptive to ideas from STS, particularly with respect to the interplay between technical and social. The work of Lucy Suchman is concerned with the question of what assumptions and ideas about human, and human action, are realized in the fields of AI and robotics (Lucille Suchman, 1987). Drawing on feminist STS, Alac examined how embodied technologies for social interaction challenge traditional notions of the body and embodiment in robotic practices (Alač, 2009). In later work, Alac explored how a robot's social agency is constituted through its materiality, emphasizing the need to consider its thing-like and social agent-like aspects to understand its sociality (Alač, 2016). From within HRI, in line with the socio-technical co-construction paradigm, Selma Šabanović, 2010 analyzed scientists' discourses on the social impacts and accessibility of robotics, arguing for a non-deterministic framework of mutual shaping and co-production. This approach offers an alternative to the technologically deterministic perspective, enabling the exploration of the dynamic interplay between robotics and society. Weiss, 2021 also outlines the co-shaping approach in HRI (alongside the Human-translated and Stakeholder Involvement approaches) as a framework that views human-robot interaction as a complex socio-technical arrangement, shaped by the situational, cultural, and institutional contexts of both human and non-human actants.

In summary, framing robots as socio-technical systems entails the following key properties: i) Some features of socio-technical systems can only be assessed after deployment, ii) These systems are non-deterministic, meaning the same input can lead to different outcomes, iii) It is impossible to predict all ways humans will interact with a system at the design stage: people will engage with systems in unexpected ways, and iv) Humans and technical systems co-shape each other: people not only adapt to systems, but also modify them, with systems evolving based on how they are interpreted by humans (Mariani, 2016).

2.2 People as (non-)Users of Technology

This section further explores the co-construction of technology and society, with a particular focus on how people and their roles in relation to technology are understood within STS, HCI, and HRI.

2.2.1 Users in STS

The maxim "users matter" has long dominated social studies of technology and innovation, as evidenced by the SCOT framework, which replaced the view of users as passive consumers and challenged the linear model of innovation and technology development (Oudshoorn and Pinch, 2005, 2007). In SCOT, users are seen as key social groups in the construction of technology (Bijker, Hughes, and Pinch, 2012). The concept of "interpretative flexibility", as mentioned above, arises from the differing meanings assigned to technology by different groups of people. However, while SCOT focuses on user practices and investigating how boundaries between design and use, production and consumption are destabilized, it has been critiqued for not fully addressing the diversity of users, exclusion, and the politics of non-use. Alternatives within SCOT have emerged, examining how user groups can modify and re-appropriate "stable" technologies (Mackay and Gillespie, 1992).

Feminist STS scholars, too, have offered their perspective, challenging traditional notions of users and highlighting how women and marginalized groups have been excluded from historical accounts of technological development. Adopting a feminist lens to study users involves examining how diverse groups can challenge dominant narratives that position men as the primary drivers of technology construction and use. Diversity and inclusivity are central to feminist approaches, which view the question "who is the user?" as complex and non-trivial (Oudshoorn and Pinch, 2007). Different groups bring distinct resources and perspectives to the design of technologies, and these groups are not homogeneous. Factors such as race, gender, and socioeconomic status all play a role, suggesting that not all users are equally positioned in relation to a given technology.

Another relevant perspective emerging in STS draws on semiotics and focuses on the concepts of *configuring* and *scripts* (Akrich, 1992). Particularly, Woolgar and Cooper, 1999 argues that users' interpretations – though exceeding those inscribed by designers – will nevertheless be constrained by the design and production process, configuring users in certain ways. This critique is later echoed in HCI and design, particularly by Redström, 2006, who warns against user-centered design approaches that conflate designing physical forms with designing user experiences. Redström cautions that by optimizing designs based on limited knowledge of users, designers risk creating "over-determined" systems that leave little room for users to improvise or act freely.

This overview only briefly touches on the topic of use and users in STS, but the key point I wish to emphasize is that all these perspectives view people as active agents in interpreting, "descripting" (Akrich, 1992), and co-shaping technologies.

2.2.2 Critically Reflecting and Diversifying Users in HCI

In HCI, the notion of "users" evolved significantly over time, reflecting broader shifts in how we understand technology and its role in society. According to Baumer and Brubaker, 2017, the idea of 'user' has its roots in modernist values of efficiency, calculability, and predictability. With the growing diversification of technological relationships and the transition from the so-called first wave of HCI to the second and third waves (S. Bødker, 2006), HCI scholars presented and explored categories of people that were either excluded from, or remained invisible in the existing user frameworks. These categories included people who live in communities in the Global South (Lazem et al., 2022), people who may not have direct access to technologies due to financial or infrastructure constraints (Sambasivan et al., 2010), queer communities (Spiel, Keyes, et al., 2019), people with disabilities (Spiel and Angelini, 2022), or those who remained not captured by the notion of "user" altogether e.g., non-users (Augustin et al., 2021; Satchell and Dourish, 2009).

To underscore the difference between users as a technical construct and actual people experiencing technology, J. Bardzell and S. Bardzell, 2015 differentiated between *subject positions* and *subjectivities*, with the latter referring to people as embodied, situated actors, while subject positions capturing structural roles envisioned or assumed by technology developers and scholars. Subject positions, such as power users, non-users, makers and hackers, gamers, and many more, can encompass both social and technical roles. These are the people explicitly considered in design, when subjectivities refers to how these roles are experienced and performed by people (ibid.). Importantly, subject positions are *relational* – they emerge because of, and are defined by their relationships with other subject positions (Baumer and Brubaker, 2017).

2.2.3 How People are Construed and Studied in HRI

Similarly to HCI, in HRI the notion of "user" has been foundational. At an earlier stage of HRI burgeoning as an independent field of research, several (conceptual) classificatory frameworks were proposed that specified the roles of humans and types of interactions with the robots. Commonly, these frameworks were aimed at offering a tool for systematically evaluating human-robot interactions, and included factors, such as task type, robot morphology, the role of humans, and others. For example, for child-robot interactions – with respect to how humans are concerned, – Salter, Michaud, and Larouche, 2010 differentiated interactions by their impact on humans and the "wilderness" of the interaction. Scholtz categorized human roles into: supervisor, operator, bystander, and teammate (Scholtz, 2003). Supervisory and teammate roles within this classificatory system imply the same relationships between humans and robots as when applied to human-human interactions (ibid.). Operators are those who work "inside" the robot, tweaking parameters in the robot's control mechanism, modifying the robot's behavior to a more appropriate one, or take control over and tele-operate the robot. Bystanders observe without direct interaction; however, they nevertheless still need a model of robot behavior to predict and understand consequences of the robot's actions. Relying on an example of robots deployed in care facilities, Scholtz highlights that the boundaries between roles and levels of interaction are often unclear, as users may assume multiple roles or facilitate others in carrying out theirs. Additionally, a single individual may perform several roles simultaneously (ibid.).

While pragmatically useful for systematic evaluations of HRI, such theoretical frameworks view people predominantly through the lens of interaction efficiency and leave out what Young et al. describe as "holistic HRI experience" (Young et al., 2010), or – to use J. Bardzell and S. Bardzell, 2015' term – subjectivity of information. Similar observation was also made by H. Lee et al., 2022 who relied on literature review to classify HRI studies into three groups based on how they frame people and their roles in HRI research. The first – most numerous group, – represents humans as generalizable human wherein all participants are considered interchangeable (ibid.). The second group of studies views humans as users in specific contexts, with scholars striving to incorporate at least one real-world aspect (e.g., intended users of the robot or elements of the actual environment). Lee and colleagues point out how within this group only two studies involved the actual users of the robot. Lastly, the third group of studies frames people as social actors generating social dynamics with others. Such studies incorporate social and power dynamics among stakeholders as an additional layer to including actual users and environment. According to the authors, since 2014 up to 2022, publications of this type make up approximately 10 per cent of the published HRI research (ibid.).

Importantly different understandings and conceptualizations of people in HRI research are commonly associated with specific epistemological and methodological approaches e.g., the studies within the first group are generally positivist lab studies leaning on quantitative methods. While, as also pointed out by Lee et al., laboratory and group one studies remain at the center of HRI research, there are nevertheless traditions of research leaning onto participatory design methods and qualitative approaches as these are better equipped to address complexity of the social life. Among notable examples, is a series of studies by Sung et al. (Sung, R. Grinter, et al., 2008) and Forlizzi et al. (Forlizzi, 2007) who explored the adoption, use, and social impact of vacuum cleaning robots in participants' homes. These studies highlighted how robot use was influenced by household routines and spatial arrangements, and emphasized the role of social dynamics, and people's roles in households, for the process of adoption. These studies also gave rise to the concept of "domestic ecologies" that I adopt and adapt for the theoretical work presented in Chapter 8. Also highlighting the need for a more comprehensive theoretical perspective informed by studies of robotic technologies in the context of their use, Hornecker et al., 2022 drew on their observations of care work with assistive technologies to propose the concept of *triadic interaction*. This conceptual framework incorporates the active cooperation of care facility residents and the mediating role of caregivers, challenging the common assumption in HRI of one person operating one system. It emphasizes that holistic interaction involves a complex interplay of human and non-human agents, encompassing not only task performance but also subtle social and emotional elements.

In the domain of robots in public spaces, as noted in the Introduction 1, Rosenthal-von der Pütten and colleagues pointed out how focusing on the traditional category of users as those directly interacting with the system leaves a broad category of people "forgotten" (Astrid Rosenthal-von der Pütten et al., 2020). The proposed term 'incidentally co-present persons' (InCoPs) is thus meant to include people who find themselves coincidentally co-present with robots in the contexts of their deployment (ibid.).

2.3 HRI Studies on Sidewalk Delivery Robots

This subsection provides a general overview of research questions, objectives, and methods in HRI related to research on sidewalk robots as a broad research context of my thesis project. The overview is not exhaustive, given the field's rapid growth in recent years, particularly with technologies like Starship expanding into new markets. Acknowledging that some relevant studies appeared outside traditional HRI venues (e.g., Transportation Planning and Technology), I focus here on studies published in HRI-related outlets before, or coinciding with, the first phase of my project in December 2021 (see Section 3.2). Many studies with commercial robots and prototypes have since emerged as part of the wave discussed in Chapter1. Reflections on how these studies relate to my work are reserved for Chapter 9.

One of the earlier HRI-related works in the recent wave of studies of sidewalk delivery robots is a master thesis by Groot, 2019 addressing how appearance, interaction and intelligence design of delivery robots shape pedestrian acceptance. Pursuing the goal of developing a design concept that maximizes acceptance by pedestrians for a DHL delivery robot, the author relied on literature research, interviews and user experience tests in virtual reality to identify design cues to ensure the robot is intuitively understandable to pedestrians and is capable of integrating smoothly into pedestrian traffic.

Emphasizing the importance of context and situated interactions for rich insights on HRI, Vroon and colleagues (2020) outlined a method for user observations aiming to elicit and explore types of social conflict that transpire between robots and pedestrians. Pointing out that current approaches to social navigation of sidewalk robots commonly rely on implementing established social norms such as proxemics, the authors argue their proposed methodology allows to explore a novel family of conflicts that had remained outside the scope of existing solutions (Vroon, Rusák, and Kortuem, 2020). At the center of the proposed method – titled context-confrontation – is a combination of user observations with a robotic prototype that deliberately does not exhibit any adaptive "social" behaviors.

An important series of works on sidewalk delivery robots were conducted by the team of HRI scholars in Aachen University. Abrams and colleagues relied on a robot mock-up and Wizard of Oz design to conduct a pilot study of interactions in the wild (Abrams, Platte, and Astird Rosenthal-von der Pütten, 2020). While the primary aim of the pilot was to outline and discuss an approach for field observations, the study also resulted in exemplary cases of people's reactions to and interactions with the robot. These interactions included children being interested in the robot, but also some people expressing being opposed to the robot's presence. In related work, Astrid Rosenthal-von der Pütten et al., 2020 argued HRI studies should widen the scope to include people who do not deliberately seek an interaction with a robot (users). Already mentioned above, the term incidentally copresent persons (InCoPs) was proposed by the authors to conceptually anchor this gap in HRI search. The concept is intended to capture people who happen to be incidentally collocated with sidewalk delivery robots in the contexts of their deployment. Drawing on the concept of InCoPs, Abrams, Dautzenberg, et al., 2021 offered critique to existing technology acceptance models with respect to these falling short when it comes to explaining spontaneous and unsolicited encounters between humans and delivery robots on the streets. In response to this gap, the authors propose the concept of *existence acceptance* of autonomous systems, and explore a new model for acceptance in an online study with a robotic prototype.

Last but not least, Moesgaard, Hulgaard, and M. Bødker, 2022 relied on ethnomethodology inspired approach and the concept of InCoPs to investigate how people interacted and made sense of robots in urban environment. Researchers used the Wizard of Oz (WoZ) technique with an outdoor mobile robot developed by Capra Robotics to create and observe disruptions in familiar public settings. Observations were paired with brief onsite interviews with passersby who encountered the robot unexpectedly. Through interpretive analysis, the study identified six types of InCoPs: Children, Adults, Senior Citizens, Caregivers, and Dogs. Additionally, seven evolving categories of robot membership were noted during encounters: Robot with Unknown Purpose, Pet, Threat, Entertainment, Working Robot, "Dead" Object, and Experiment.

2.4 Summary

This chapter provided an overview of the key theoretical assumptions and concepts underpinning this monograph. Grounded in Science and Technology Studies (STS), I first addressed the dialogic relationship between technology and society, emphasizing how diverse social groups influence technology – not only through the social, cultural and political assumptions technologies embody (Winner, 1993) – but also via direct interactions, with people interpreting and adapting technical devices in ways that inevitably exceed the intentions of designs and engineers. Building on this, I argued for the understanding of robots as inherently socio-technical systems i.e., non-deterministic and open to interpretation and co-shaping through use. I proceeded to offer a more detailed overview of how people are conceptualized in HCI and HRI. This discussion highlighted varying interpretations of "users" in these fields, how the term itself has been criticized. Based on the classification proposed by H. Lee et al., 2022, I highlighted how different interpretations of human in HRI come hand-in-hand with distinct methodological approaches. Referring to the example of household studies with vacuum cleaning robots, viewing "users" as social actors generating dynamic social interactions necessitates researchers addressing at least some aspects of the "real world" – the socio-material context where the robot is to be deployed – and allowing people to interact with the systems as they would in their everyday life. With respect to research on sidewalk delivery robots as the broader context of my work, I wish to emphasize a significant gap in existing HRI studies. While several works have stressed the importance of situational factors and the need to examine technology within its deployment context, none have specifically addressed fully deployed technologies (as opposed to prototypes) or studied participant groups native to the context of deployment. My thesis aims to address this gap in HRI research.

CHAPTER 3

Epistemological and Methodological Positioning of the Thesis Project

Parts of the work relevant to this chapter have been published in Dobrosovestnova, Pagter, and Weiss, 2023 and in Dobrosovestnova, H. Lee, et al., 2024. For Dobrosovestnova et al. (2023), as the first author, I drove the publication, my co-author Jesse de Pagter contributed to shaping selected sections of the paper and provided general feedback. Astrid Weiss provided general feedback.

This chapter presents the context of the Inconsequential Encounters thesis project, including how my work is situated disciplinary, epistemologically, and methodologically; it provides a detailed overview of the thesis phases. Given that the project relied predominantly on qualitative methods, but also integrated two quantitative studies conducted in collaboration with Astrid Weiss and Ralf Vetter, I touch upon respective criteria of quality and address the choices related to the author's voice. In addition, the chapter includes a section on the ethical considerations.

3.1 Epistemological Stance and Disciplinary Commitments

I situate my work in the field of Human-Robot Interaction (HRI). HRI is still a relatively young field of research, with its roots associated with the inauguration of the IEEE RO-MAN conference series in Japan in 1992. Like the field of Human-Computer Interaction, HRI is not homogeneous – disciplines such as engineering, computer science, cognitive psychology, sociology, and others, bring with them diverse ways of knowing i.e. epistemological paradigms. These paradigms shape methodological approaches, goals, and interpretations of HRI studies (Bartneck, Belpaeme, et al., 2024; Weiss, 2012).

Despite the acknowledged pluri-disciplinary foundations of the field and accompanying epistemological diversity, (post-)positivism assuming the reality is objective and can be measured with scientific tools nevertheless still dominates much of the research approaches in HRI. HRI studies rooted in (post-)positivism commonly aim to develop observable, measurable data; and are generally focused on problems where control, prediction, and quantification are key.

Constructivism and interpretivism- oriented studies too have their place. Constructivist epistemology in general terms posits that: (i) knowledge does not exist independently from a knowing subject, and (ii) coming to know is an active and adaptive process that organizes one's experiential world rather than discovers an independent world "out there" (Olssen, 1995). Similarly to epistemological constructivism, interpretivism assumes our knowledge of reality is socially constructed, culturally and historically situated, and our understanding arises from the subjective interpretation of experience. In HRI, scholars situated in these paradigms tend to focus on how humans make sense of their interactions with robots, investigating subjective experiences, engagement, and social relationships that scaffold, or arise from these interactions. Qualitative methods such as interviews, case studies, and ethnographic research commonly accompany constructivist and interpretivist research.

While many have argued that *all* scientific undertaking – including that associated with the positivist tradition – is situated at the intersection of paradigm, methods, tools, people, and ideology (hence, it is **constructed** and not "found" or "discovered") cf. (Felt et al., 2016; Latour, 2010), if this assumption is not widely shared across a research community, constructivist and intepretivist research remains considered as inferior, and is misunderstood at best and discarded at worst. To make matters worse, many forms of constructivism exist in the literature today (Dobrosovestnova, 2019), which results in even more misunderstandings between epistemological camps, and all constructivism being dismissed as a form of "anything goes" relativism (Bickhard, 1997). To anticipate such potential misunderstandings, I wish to emphasize that the kind of constructivism I espouse is rooted in pragmatist philosophy (Chang, 2022; Peirce, 1997) coupled with realist ontology. Simply put, pragmatist realism re-instates commitment to the world(s) independent of the human mind (i.e. there is a reality that exists outside of our mind), but affirms that our knowing of this reality remains framed by our concepts, procedures, tools (Chang, 2022). In this onto-epistemological package, scientific research thus is viewed as a production of **operationally coherent knowledge** as opposed to discovering some sort of universal truths (ibid.). Following from this, being what (Onwuegbuzie and Leech, 2005) define as a *pragmatic researcher*, allows for epistemological and methodological pluralism – the choice of methods remains determined by the specific research goal and research questions at hand. In the case of my thesis project, though the overall methodological orientation I take is an insights-driven qualitative interpretativist research (Veling and McGinn, 2021), or what Braun and V. Clarke, 2021b term "Big Q", as a means to deepen understanding on the multiple dimensions of sociality of (functional service) robots (more on this follows below), I draw on more standard in HRI quantitative studies.

3.1.1 Disciplinary Affinities

Though I see my work targeting primarily the HRI community, disciplines and fields of research outside of HRI have contributed to me becoming a researcher. I believe it is my training, first and foremost, as a semiotician and culture scholar that made me attuned to *meaning-making* and *relations*, as opposed to *interactions* understood through the lens of signaling paradigm (Jung, 2017). Nearing the completion of my master studies in cognitive science at the University of Vienna, I took interest in affective and social dimensions of human-technology relations which at the time culminated in a master thesis on constructivism in educational robotics. To satisfy the newly discovered curiosity about the complex nature of human-technology relations, I attended seminars on robot and AI ethics. Though philosophy of technology is not what I consider myself doing, engaging with the related literature, and the community of philosophers of technology at the University of Vienna and those attending the bi-annual Robophilosophy conference, no doubt enriched and informed my work. At the start of my PhD journey, I discovered the field of Science and Technology studies (STS), and it has since then offered a foundation of theoretical concepts, and informed my methodological approach in more ways I can account for. From STS, I also borrow the theory-method package approach – denying the division between reality and interpretation of it, the combination of what C. Thompson, 2007 calls "theoretical ambition and empirical predilection" remains a hallmark of the STS as a field. Last but not least, HCI as an "older sister" of HRI too played its role offering guidance with respect to theoretical developments, specifically as these concern how people have been construed differently in different paradigms in HCI (the so called "waves" (S. Bødker, 2006)).

To conclude, the multitude of disciplinary inspirations and affinities has ultimately resulted in this monograph being what in STS is known as a "boundary object."[1] Introduced by Star and Griesemer (Star and Griesemer, 1989), the term refers to an entity that facilitates collaboration and communication between different social worlds, or communities of practice despite their varying perspectives, goals, and knowledge systems. I outline some of the related considerations in the publication resulting from the process of me trying to negotiate and reconcile my academic identity (Dobrosovestnova, Pagter, and Weiss, 2023).

3.1.2 Methodological Commitments

In what follows below, I introduce ethnography as an overarching methodological orientation of my work, though I remain cautious in labeling my work as "ethnography" for the reasons I also detail below. I reserve more detailed overview of the individual studies and

[1] I thank David Lamas for seeing it so clearly and pointing it out to me at the peak of my scholarly identity crisis.

choices made with respect to study design, participants' recruitment, analysis process, and so forth, for respective chapters.

Introducing Ethnography

As a methodological practice, ethnography dates back to the discipline of anthropology and its origins in the Western expansionism of the nineteenth century (Dourish, 2006). In the beginning of the twentieth century, ethnography spread through the work of Bronislaw Malinowski about the communities of the Trobriand Islands (Malinowski, 2017). At the time, ethnography advocated long-term, immersive field work that combined observations with participation in community life. From anthropology, ethnographic method spread into other social sciences and took on new forms and research commitments. The work of the Chicago School sociologists is one emblematic example of ethnography turning its eye toward communities close to home by investigating aspects of American urban life (Jacobsen, 2017). Ethnography as practiced by Chicago school sociologists retained a sense of ethnographic distance between subject and object of inquiry investigating subcultures and "outsider" groups (prostitutes, gamblers, homeless) (Dourish, 2006).

Clifford Geetz is considered one of the main developers of contemporary ethnography, as well as interpretive research more broadly (Soden, Toombs, and Thomas, 2024). Shifting away from earlier practices of ethnography that sought out to produce systematic and universal accounts of culture, Geetz argued for a vision of ethnography that served as an "enlargement of the universe of human discourse" (Geertz, 2008). His concept of "thick description" (ibid.) captures what lays at the heart of contemporary ethnographic research: rather than seeking out universal truths, ethnographies aim to produce detailed, context-specific accounts that invite new understanding of communities of practice. These accounts are recognized as inherently incomplete, resisting generalizations and claims of totality that would strip them of their thickness (Soden, Toombs, and Thomas, 2024). "Being there" remains one of the hallmarks of ethnographic methodological orientation because it allows for a direct, embodied experience of the field (Hine, 2015). To this aim, the focus is usually on a few cases, sometimes a single setting or a group of people (Hammersley and Atkinson, 2019).

More recently, calls for a "kinder and gentler" way to do ethnographic research have been made. In their "patchwork ethnography" manifesto, Günel, Varma, and Watanabe, 2020 reflect on the expectation of (long-term) immersion in the field as one of the principles of ethnography through the lens of feminist epistemologies in STS and HCI. Pointing out how immersion for many contemporary scholars is a practical impossibility because of the financial, institutional, and personal commitments, they call for re-combinations of "home" and "field" – what they coin as "patchwork ethnography" – as a way to attend to the changing living and working conditions in academia. Patchwork ethnography is designed around short-term visits, use of fragmentary yet rigorous data while maintaining long-term commitments, language proficiency, contextual knowledge, and slow thinking that characterizes traditional ethnography.

Practicing Ethnography. Unlike more positivism-leaning methods that rely on predefined categories and controlled environments, ethnographic research as it is understood today is unstructured and flexible. Again, not to suggest ethnography is equal to "anything goes", ethnographic data collection is unstructured in two senses. First, conducting an ethnographic study does not assume following through a fixed research plan specified at the start – research questions and research design are adapted and re-negotiated as new insights emerge (Forsythe, 1999; Hammersley and Atkinson, 2019; Hine, 2015). By refusing to decide in advance what will be most interesting and valuable to explore in a setting, the ethnographer remains open to new insights and to "prospects that activities may make sense in surprising ways" (Hine, 2015, p.25). Crucially, this means that the capabilities and limitations of methodological choices are revealed in practice and evaluated in retrospect. For example, one cannot decide in advance what and how many interviews might be needed, which form of presence is appropriate, or whether a particular line of investigation is "enough" (ibid.). Second, ethnography is unstructured in a sense that the categories used for interpreting the data are not built into strict observation schedules or questionnaires. Rather, they are developed in the process of data analysis (ibid.). Data collection, analysis and theory development often occur simultaneously (Walsh, 2012).

Further, ethnography is more than just a data collection method – it is closely connected to the practice of constructing an interpretation and reporting (Emerson, Fretz, and Shaw, 2011). Ethnographic accounts are never understood as neutral – they are shaped by the ethnographers' theoretical commitments, subjectivity, identity, and the relationships they build with participants. **Reflexivity** is thus essential in ethnography, as researchers must acknowledge their role in producing the knowledge and remain open about the complexities and uncertainties involved in their work. An ethnographer will often write reports in a way that clarifies their involvement in the production of knowledge, detailing the active steps that they took to generate the insights and openly examining the contingencies of the decisions that were made, the difficulties and frustrations that were encountered (Berger, 2015; Hill and Dao, 2021; Hine, 2015).

Ethnography in HCI and HRI

In HCI, ethnography was initially brought in through two movements: Computer-Supported Cooperative Work (CSCW) and Participatory Design (PD). Focused on understanding the social organization of work, CSCW necessitated a method like ethnography to study work practices "in the wild". Arising in Scandinavia, PD emphasizes workplace democracy and empowering users through participatory involvement. Scholars practicing PD also saw ethnography as a way to understand perspectives of system users (Blomberg and Karasti, 2012; Randall, Harper, and Rouncefield, 2007). Since then, ethnography is known in HCI as a methodological stance equipped to capture the complexity of the real-world environments and technology use and as a technique for studying technology-human relations in the wild (Dourish, 2006).

Though still existing somewhat at the margins of the field (Dobrosovestnova, H. Lee, et al., 2024), ethnography has made its way into HRI too. As reported by Jacobs, Elprama, and Jewell, 2020 in 2020, only 8 papers at the time claimed to have relied on an ethnographic approach in an HRI study. The earlier examples of these studies date back to the series of household studies with Roomba vacuum cleaners conducted by Forlizzi, Sung, and colleagues (Forlizzi, 2007; Sung, Christensen, and R. E. Grinter, 2009; Sung, R. Grinter, et al., 2008). Ethnographic approaches have also been deployed in the studies of robots in healthcare e.g., (Bodenhagen et al., 2019; Sabelli, Kanda, and Hagita, 2011; Wright, 2023). The recent proliferation of functional service robots in public areas invited more studies relying on ethnographic and ethnomethodological approaches. For instance, Pelikan, S. Reeves, and Cantarutti, 2024 relied on interaction analysis approach as a part of ethnomethodological toolkit to examine how delivery robots are materially and socially embedded in everyday life in urban spaces. Other scholars also explored video and digital ethnography as a means to study situated interactions with robots e.g., (Nielsen et al., 2023). Not contending this brief overview is in any way exhaustive, an important thing to consider when it comes to studies of situated HRI in naturalistic settings is that not all studies that rely on naturalistic observations are in fact an ethnography. As also pointed out by Nielsen and colleagues, while the number of "in the wild" studies in HRI is increasing, in many of these studies interactions with robots are still staged or imposed on participants, and the way the studies are designed still relies on positivism-leaning assumptions e.g., strive to produce generalizable outcomes, reliance on pre-established protocols, with the nuances of social live discarded or considered as noise (ibid.).

Critically Reflecting Ethnography in HCI and in the Context of my Project

While still at its very nascent stage in HRI, in HCI much critical reflection has already been done examining what it means to practice ethnography in and for HCI. As early as 1999, Diana Forsythe pointed out how appropriation of ethnographic approaches to support design and evaluation of software has resulted in many misconceptions scientists have about the method, and how (quasi-)ethnographic studies performed by untrained ethnographers are likely to be superficial and unreliable (Forsythe, 1999). Crabtree and colleagues critically examined the "return to culture" as a new way to think about technologies as cultural artifacts in and for systems design (Crabtree et al., 2009). According to the authors, while the use of ethnography for critical purpose is not necessarily problematic, the concern is that – in turning to new domains and inadvertently reinventing ethnographic practice, – HCI scholars and system designers may end up displacing detailed ways of accounting about how people organize action and interaction in situ e.g., (Lucy Suchman, 2006) with broad generalizations and generic interpretations. Last but not least, in his widely known series of publications on "implications for design", Paul Dourish pointed out how calls from reviewers to enumerate specific design considerations derived from an ethnographic study as a marker of quality of the work result in misconstruction of ethnographic work and a failure of HCI scholars to derive more benefit from ethnographic studies than they could (Dourish, 2006, 2007). To be sure, the argument Dourish advances is not that ethnography is not relevant for design – to the contrary, ethnographic accounts in his view remain deeply relevant for

HCI scholars and designers alike. However, the relevancy is to be obtained not through the foreclosure of design spaces and operalization of parameters specific to a design case. Rather, the value of ethnographic studies in HCI resides in opening up design spaces and inviting more conversations about the role of technology in people's lives (Dourish, 2007).

Aware of the critique outlined above, I approach describing this project cautiously, refraining from labeling it an "ethnography". Although I decided early on not to pursue the generation of direct "implications for design", my work remains grounded in concepts relevant to HRI and motivated by the goal of offering insights valuable to the HRI community. While theoretical and disciplinary commitments are not inherently problematic (Forsythe, 1999), I recognize that both during data collection and analysis, I prioritized themes I perceived as HRI-relevant. In doing so, I acknowledge enacting a form of methodological technological determinism (Wyatt, 2008), which could be seen as conflicting with the goal of ethnography to capture complexities of social life and situated practices.

Nevertheless, in both analysis and reporting, I maintained a commitment to several core ethnographic principles, as detailed in Section 3.1.2. Regarding (qualitative) data collection, I focused on how people "native" to specific communities (as opposed to naive participants encountering robots for the first time) experienced sidewalk delivery robots as new actors in the urban landscape. In alignment with the flexible and adaptive process typical of ethnographic studies, I allowed my research questions to evolve. New directions, such as an in-depth exploration of the notion of (experienced) sociality, emerged organically through engagement with the field and data (more on this in section 3.2).

In terms of data analysis and reporting, I strove for transparency regarding the (often difficult and imperfect) decisions made about research sites, participant recruitment, and stages of analysis. In Chapters 5 and 6, I prioritized "thick descriptions" over summaries or generalizations, aiming to capture the nuanced texture of the field. Lastly, I was aware not to obscure or remove my presence as both researcher and author of this text. Accordingly, except in Chapter 7 (due to its highly collaborative nature), I use the first-person singular pronoun to reflect my active role throughout the project.

3.1.3 Reflexive Thematic Analysis as Approach to Qualitative Data Analysis

As I further elaborate in Section 3.2, throughout the thesis project different methods were used to collect and analyze data. When it comes to qualitative data analysis, in line with the overall interpretive and exploratory nature of the project, Reflexive Thematic Analysis (RTA) was the approach that shaped the qualitative studies I report on in Chapters 5 and 6. In various publications spanning throughout their career, Braun and Clarke, who are recognized as the key developers of the RTA, emphasized the distinction between three types of thematic analysis that differ not only in terms of the procedures they rely on, but in the very epistemological assumptions underpinning the method

(Braun and V. Clarke, 2013, 2022; Braun, V. Clarke, and Rance, 2014). Braun and Clarke term the three approaches: i) coding reliability, ii) codebook, and iii) reflexive thematic analysis, respectively. In contrast to the coding reliability and (some) codebook approaches, which are widely perceived as belonging to qualitative research while they are in fact rooted in positivist epistemology (Braun and V. Clarke, 2021a), in RTA the focus remains on the rich meaning generation of contextualized and situated knowledge (Braun and V. Clarke, 2021b) – what Braun and Clarke coin as "Big Q" qualitative research. Aligned with an ethnographic stance, in RTA codes developed in the process of analysis are never finally fixed – they can evolve, expand, contract, be renamed, split apart, or abandoned. Such refinements reflect the researcher's deepening engagement with their data and the evolving, situated, reflexive, interpretation of the data (Braun and V. Clarke, 2022). The codes are thus treated as conceptual tools supporting the development of analysis, and not as ontologically real things.

Another important distinction between RTA and other forms of TA is related to how **themes** are defined. If topic summaries report on the different responses people had around a specific topic, themes in RTA are actively developed by the researcher around a distinct "central organizing concept" (Braun and V. Clarke, 2021b, p.77). Themes represent patterns of meaning across a dataset that capture something significant in relation to the research question(s). Aligned with interpretive research, themes are actively constructed (and not "emerge" or are "found" in the data) by the researcher; themes development happens iteratively, as researcher moves between the data and analysis, refining the themes through multiple phases of engagement. A strong theme is characterized by its capacity to offer insight into the dataset and a nuanced understanding of the phenomenon under investigation.

For the qualitative data collected during the first exploratory study (Phase 1 of the project presented in Chapter 4 of the monograph), I relied on the template approach to qualitative analysis by Brooks and King, 2014. While this approach shares some procedural similarity with RTA, it deviates from the latter in terms of how themes are conceptualized. I detail the method and the procedure in the respective chapter.

3.1.4 Criteria of Quality

Because interpretive qualitative research in HCI and HRI remains often misunderstood, resulting in demands placed on the studies and respective publications that do not align with the epistemological paradigm underpinning the method (Soden, Toombs, and Thomas, 2024), in this section I briefly overview criteria of quality one is invited to consider when engaging with Chapters 4, 5, 6 of the monograph.

Sample Size vs. Saturation vs. Information power. "How many data inputs are enough?" was a question I kept hearing from my more advanced peers, from reviewers, and it has remained a nagging question I kept asking myself throughout the thesis project. While it is common for reviewers situated within positivist tradition to inquire about sample size because to them it remains one of the criteria of generalizability of results

(Boddy, 2016), little agreement and guidance exists related to sample size in qualitative research. The concept of *data saturation* referring commonly to the point at which no new information can be observed in the data (Lincoln, Guba, and Pilotta, 1985) has become a form of panacea, or a magic rhetorical device, qualitative researchers engage to pacify reviewers situated within positivist paradigm.

There are, however, several forms saturation can take. Specific to the grounded theory approach, saturation is related to the form of iterative data collection, analysis, and sampling decisions converging at a point where no additional data are found that would allow to further develop the properties of the phenomenon (Douglass, Harel, and Trakhtenbrot, 1998). More generally, researchers achieve saturation when more time spent conducting participant observations, additional interviews, or other forms of data do not yield further insights (Soden, Toombs, and Thomas, 2024). How much time, and how many interviews these may be depends on the specific field site, phenomena in question, and so forth. This is why, saturation should not be thought of as a kind of quantifiable metric instantiated through e.g., strict requirement on the number of interviews or other data inputs as a criteria of evaluation of the quality of the project (ibid.).

Furthermore, in qualitative research literature, saturation, too, has been problematized. Braun and Clarke pointed out how the concept remains coherent with the neo-positivist epistemological stance where findings are assumed to be hidden in the data waiting to be "discovered" (Braun and V. Clarke, 2021c). Assuming that knowledge and meaning is something that is generated through interpretation, they argue that for approaches such as RTA, how many data items are enough to stop data collection is a decision that is situated and cannot be determined wholly in advance of analysis (ibid.). Instead, they suggest **information power** may offer better guidance to making decisions about sample size in qualitative research. Information power refers to the concept also used to determine the appropriate sample size of a qualitative study. Introduced by Malterud and colleagues, instead of relying on fixed rules about sample size (an aspect that information power concept shares with saturation), information power focuses on the quality and richness of the data – the more relevant information the sample holds for the research question, the fewer participants are needed to achieve meaningful results (Malterud, Siersma, and Guassora, 2016). Malterud et al. suggest to consider sample specificity, use of established theory, quality of dialogues, and analysis strategy as a guiding model to achieve relevant, high quality analysis and theoretical interpretations. Simply put, information power shifts attention from quantity of input of participants to the contribution of new knowledge from the analysis: the more information the sample holds relevant to the study at hand, the lower number of participants needed.

Generalizability vs. Transferability. As opposed to post-positivist research, striving for generalizability i.e. the extent to which the findings represent a broader population, interpretive research does not prioritize nor seeks generalizability (Soden, Toombs, and Thomas, 2024). Instead, *transferability* of findings is deemed more appropriate as a criteria of quality, and can be reflected in statements explicating to which other contexts, case studies, types of technical systems, and so forth, the presented findings might further apply or translate.

To summarize the section on criteria for rigor: since the interpretative qualitative work I conducted relies on small sample sizes (with the reasons and limitations discussed in detail in the respective chapters), I encourage an evaluation of the output's quality that considers both its limitations – framed within the context of the appropriate epistemology – and the informational power and transferability of the resulting knowledge.

3.2 Project Phases

Before outlining how the project developed, I want to clarify that the phases described below, while overlapping with certain research activities, do not represent a strictly linear temporal progression. Rather, each phase reflects a distinct research focus, encompassing specific goals, methods, and theoretical outputs. As noted in the preceding sections, the selection of goals and methods was not determined a priori – before the project began – but instead emerged in a situated and contextualized manner as I engaged with data collection and analysis, with each phase informing the others.

3.2.1 Phase 1: Dipping the Toes

My entry point into the project was observing instances of people voluntarily assisting Starship delivery robots on the streets of Tallinn, Estonia. At the time, few studies had investigated situated behaviors of helping commercially deployed robots in naturalistic environments, as opposed to controlled studies with robotic prototypes or Wizard of Oz techniques. My initial observations, conducted in December 2021, were therefore open-ended and exploratory. The broader goal was to determine whether these behaviors were common or simply amplified by social media, to explore when and how robots were perceived as needing help, and to examine other types of interactions occurring between robots and people beyond offering assistance.

To this end, I spent several days walking through or stationed on the streets of central Tallinn, capturing observations in handwritten notes and, when possible, in images or videos, while occasionally engaging in informal conversations with people. Early on, it became clear that instances of help were neither mere anecdotes nor staged for social media. Moreover, these seemingly minor encounters revealed layers of complexity I had not anticipated. This realization prompted me to incorporate an analysis of social media content (e.g., posts on Twitter, Facebook, and Instagram) to further investigate what might drive people's decisions to assist commercial robots voluntarily.

This initial round of observations and online content analysis became what I call Phase 1: Dipping the Toes of the project. Despite its limitations (discussed further in the respective chapter), Phase 1 was a crucial starting point that shaped my decision to delve deeper into the themes that emerged during this brief exploration. It also established why Starship robots remained the focus of my work for the following two and a half years.

Beyond providing empirical insights into Starship robots as (cute) but asymmetric social actors and the factors underlying people's willingness to help them, Phase 1 also led to a theoretical reflection exploring whether instances of robot assistance could be viewed as unpaid labor or acts of care. I detail these contributions in Chapter 4.

3.2.2 Phase 2: Deepening Perspectives

Phase 1 fueled my motivation to explore what Starship robots mean to the local community beyond the narrow focus on voluntary assistance. During a subsequent visit to Tallinn in August 2022, I conducted interviews (n=17) with passersby and vendors to understand their experiences with and attitudes toward the robots. In January 2023, I had the opportunity to interview three participants in Cambridge, UK, where Starship robots had been introduced just two months earlier. To clarify, conducting a comprehensive comparative cultural analysis was never my goal. While fascinating, such an undertaking was beyond the scope of my thesis for practical reasons (e.g., the cost of traveling to the UK) and research constraints (the project already provided ample material for exploration without incorporating comparative studies). Instead, these additional interviews served as a way to gain further insights into how the phenomena I observed in Tallinn might manifest in a different socio-material and cultural context.

For the analysis, I treated the interviews with passersby from both Tallinn and Cambridge as a single dataset. I detail the rationale for this choice, the analysis process, and the main outcomes in Chapter 5. One significant outcome of these interviews was discovering how multiple constructs of identity were evoked as people interpreted and made sense of the robots as new actors in their communities. This and other findings from Phase 2. informed key lessons about (existence) acceptance (Abrams, Dautzenberg, et al., 2021), which I consider the main conceptual contribution of this phase. These insights are further elaborated in Chapter 5.

3.2.3 Phase 3: Comparing Perspectives

In August 2022, after some persistence and a series of fortunate coincidences, I had the opportunity to interview three Starship Technologies representatives directly involved in decision-making about the design of Starship robots. I saw these interviews as a chance to delve deeper into the significance of the "inconsequential" encounters I had thus far been exploring through the perspectives of passersby and vendors. Of course, "consequential" can be framed in many ways. In this case, my aim was to understand what these situated interactions on the street, such as voluntary help, meant for design iterations and how developers themselves interpreted the role and importance of these interactions. Despite being limited to three interviews, the conversations proved highly enriching, covering several themes I outline in Chapter 6. Importantly, these discussions also sparked conceptual work on mapping subject positions beyond the traditional notion of ‘users’ (Baumer and Brubaker, 2017), a project I developed collaboratively with Hannah Pelikan and Franziska Babel. This work, detailed in Chapter 8, represents one of the key theoretical contributions of this PhD thesis.

3.2.4 Phase 4: Capturing and Articulating Everyday Scenes

In parallel with the research activities described in Phases 1-3, during my visits to Tallinn in August 2022 and February 2023, I continued observing and occasionally recording situated interactions on the streets. These repeated observations served as a way to triangulate the data collected through interviews (Phases 2 and 3). Additionally, returning to the field at different times allowed me to examine whether and how the phenomena were evolving across seasons and as part of broader socio-technical changes, such as design iterations or people’s habituation to the robots.

It took considerable time and reflection to determine how to approach these observational data. For the December 2021 observations, I had reduced my findings into generalized patterns of behavior and situational factors that scaffolded them and I report on these in Chapter 4. However, for observations collected later in the project, I opted to preserved the data as descriptive vignettes, interspersing them throughout this monograph alongside the reporting of interview outcomes (Chapters 5 and 6). These ethnographic vignettes aim to capture everyday scenes involving the robots on Tallinn’s streets, as well as the humans and non-humans they interact with. By doing so, I hope they provide additional nuance and situated context to complement the interview data. The vignettes were developed from my field notes and video recordings made while following robots from vendors to delivery sites. To clarify, these vignettes are not raw field notes (the latter are typically reserved for researchers alone (Emerson, Fretz, and Shaw, 2011)) but edited accounts written from these notes or re-watching videos. Unlike field notes, the vignettes are grammatically structured, use complete sentences, and offer a more detailed narrative.

3.2.5 Phase 5: Deep Dive into Robot Sociality

A key outcome of analyzing the observational, online, and interview data was understanding how Starship robots were perceived and experienced as social actors. Both interviews and online commentaries revealed heavy use of anthropomorphic language to describe interactions with the robots. However, closer analysis showed that the dimensions of sociality attributed to these robots extended beyond anthropomorphic attributions of human-like mental or psychological states. Since Starship robots are functional service robots without anthropomorphic design, Phase 5 focused on further empirical, methodological, and conceptual exploration of the dimensions of sociality attributed to such robots. To address the tension between anthropomorphic language and the more layered situated experiences of sociality, I drew on the Ontology of Asymmetric Social Interactions (OASIS) framework and its central concept of sociomorphing, proposed by Johanna Seibt and colleagues (Seibt, Vestergaard, and Damholdt, 2020).

As part of this phase, in collaboration with Ralf Vetter, Silke Buchberger, and Astrid Weiss, I conducted two online studies deploying the Attitudes Towards Social Robots scale (ASOR) (Damholdt, Vestergaard, et al., 2020) to examine dimensions of attributed sociality across four different robots, including Starship. Although this work initially aimed to investigate sociality, closer examination of the ASOR scale revealed limitations that prompted us to spend the final year of my PhD evaluating and refining the scale, providing data-driven evidence for its shortcomings and proposing iterative improvements. This methodological contribution, as well as other outcomes of the two studies conducted, are detailed in Chapter 7.

3.2.6 Phase 6: Theory

Phase 6 represents theoretical work conducted in collaboration with Hannah Pelikan and Franziska Babel during my two-month research stay at the COIN Unit, Linköping University in May-June 2024. Drawing on our collective experience studying autonomous robots in public spaces, we used the concept of subject positions from HCI (Baumer and Brubaker, 2017) to map the diverse roles people can assume in relation to each other and the robot in a public space, beyond the traditional role of "robot user". In the context of this monograph, this work synthesizes the empirical findings from earlier phases to develop a descriptive theoretical framework. The framework aims to address the diversity of people and the variety of interactions and relationships they can have with the robot, contributing to Aims 1 and 2 of the project. I detail how we approached developing the framework, and the framework itself in Chapter 8.

3.3 Positionality

Researcher's positioning can include personal characteristics, such as gender, race, affiliation, age, sexual orientation, personal experiences and preferences, linguistic traditions, political and ideological stances, and so forth. These characteristics can impact research through: affecting access to the field, shaping nature of researcher and participants relationship, shaping the way they construct research through the choice of language, questions, lenses applied to sense-making of the data (Kacen and Chaitin, 2006). With respect to my thesis project, I believe characteristics such as gender and age – though not insignificant – are less consequential than my personal background, linguistic competences. This is why my positionality statement focuses on these.

I was born in Estonia, in a Russian-speaking family. Even though Russian is my mother tongue, I converse freely in Estonian, with English being the language I rely the most on in my current professional and personal life. Having completed my bachelor degree in Estonia, I moved away from Estonia and have since returned only for visits ranging from one week to one month twice a year. This is why, I experience myself both as an insider and as outsider in Tallinn where I conducted parts of my data collection. Being an insider in this case means I know the city well, including the character of each district and how it has changed throughout the years. Knowing the city was helpful in choosing observation sites and navigating the streets during observations that included following the robots. Ability to converse with participants in their mother tongue, or language they felt more comfortable with, I believe impacted (some) participants' willingness to engage in a conversation with me. Being an insider certainly played a critical role in getting access to the interviewees from Starship Technologies. Not living in Estonia permanently, hence being an outsider in some way, have made me more attuned to urban, cultural and, not in the least, technological changes the city and different communities in the city have been undergoing. Being an outsider i.e. affiliated with a university abroad and not part of a company or a university in Estonia, might have shaped how my participants perceived me as well. It also helped me to maintain a certain (analytical) distance and, to the best of my abilities, to take things less for granted (Forsythe, 1999).

Throughout the duration of the project, I tried to remain agnostic to the success (or lack of thereof) of Starship Technologies as a commercial enterprise. I acknowledge a degree of ambivalence I felt because, as an Estonian (someone coming from Estonia and wishing for a good future for the country and its citizens), I could relate to the feeling of pride passersby and vendors from Estonia expressed about belonging to a culture recognized for its expertise in the technological realm (see Chapter 5). At the same time, my academic interests in labour and how technology reconfigure work, also as reflected in the two publications preceding my PhD journey (Dobrosovestnova and Hannibal, 2021; Dobrosovestnova, Hannibal, and Reinboth, 2021), came into tension with the emotion of pride. Despite the popular narratives hailing last-mile delivery robots as a more sustainable and efficient form of last-mile delivery, I believe it is yet to be seen the impact these technologies will have on different communities. On a personal level, however, the passion my participants from Starship Technologies shared for their craft was nothing but inspiring, and their in-depth knowledge and lived experiences contributed to this monograph substantially.

3.4 Ethics and Data Protection

At TU Wien, there is no formal procedure for granting scholars approval to conduct studies involving human participants. However, the university has a consultative Research Ethics Committee (TUW REC[2]) that provides ethics peer reviews through collegial feedback from researchers across disciplines. Given the in situ nature of my data collection, I presented my project proposal to the TUW REC at the outset to discuss ethical approaches to conducting observations and (video) recordings in public spaces. The committee advised that while keeping hand-written notes of observations was ethically acceptable, recording people in public without their awareness raised more complex ethical concerns. In instances where I did take images or videos, I made efforts to avoid capturing identifiable faces to maintain anonymity. If faces were visible in an image used

[2]https://www.tuwien.at/en/research/rti-support/responsible-research-practices/research-ethics-committee

with an ethnographic vignette, I blurred them. Outside this monograph, I excluded any images or frames showing people in my scientific publications and presentations.

For each form of data collection, including observations (Chapter 4), interviews (Chapters 4, 5 and 6) and online survey (Chapter 7), I prepared an information sheet, consent form, and data protection form outlining how the data would be stored, processed, and analyzed. For pre-scheduled interviews, these documents were sent to participants in advance. For situationally recruited participants, I provided the information sheet, including my and my supervisor's contact details. While not all participants signed the consent form (depending on the situation), all gave oral consent after understanding who I am, the institution I represent, and the study's purpose.

For interviews with Starship developers, the standard consent form I had prepared in advance was not applicable. Upon entering the company, I signed a non-disclosure agreement. Instead of a pre-interview consent form, participants requested the opportunity to review any texts resulting from the interviews before publication and to redact any sensitive information. This requirement did not extend to data collected outside the company.

Regarding Starship vendors, the anonymization process may be challenged due to the small scale of Starship's operations in Tallinn. Although I do not name specific enterprises, locals familiar with the area could make an educated guess about the businesses involved. However, identifying specific interviewees is unlikely due to the time passed since the interviews and changes in the structure of Starship's partners in Tallinn which aids in anonymization.

CHAPTER 4

Dipping the Toes

Parts of the work presented in this chapter have been published in Dobrosovestnova, Schwaninger, and Weiss, 2022 and Dobrosovestnova and Reinboth, 2023. In both case, the publications were driven by me as the first author. For Dobrosovestnova et al. (2022), my co-author Isabel Schwaninger participated in writing of the related work section and contributed to the development of the discussion while Astrid Weiss provided overall feedback to the manuscript. For Dobrosovestnova and Reinboth (2023), the choice of the theoretical lenses was mine, and I was responsible for the decision-making about the main content points. The development of the manuscript happened collaboratively, with Tim Reinboth's active participation in concept development and writing.

This chapter introduces the first exploratory study I conducted in December 2021 combining naturalistic observations, autoethnography and an online content analysis (Phase 1). The chapter elaborates on the motivation to conduct this study, outlines data collection and analysis procedures, and key insights from the study. The Chapter concludes with a Discussion and Reflections related to the methodological choices and challenges encountered when conducting this study.

4.1 Motivation

As mentioned in Section 1.1, I first discovered Starship delivery robots through the videos circulating in the social media. One of the videos depicted a supposed "robot traffic jam" with several Starship robots stationary in heavy snow; another video showed a policeman attempting to help a robot across a street of Kalamaja district in Tallinn (see Figure 4.1).

Stirred by the curiosity that arose in me after seeing these videos, and motivated by the calls for more studies of situated HRI including people who are not necessarily users of the robots (Astrid Rosenthal-von der Pütten et al., 2020), I shifted my family

Christmas plans to accommodate an exploratory study of situated interactions with Starship robots deployed in Tallinn. In this study, my aims were to investigate: i) How people reacted to encountering Starship robots on the streets, and which (patterns of) behaviors they exhibited with and toward robots; ii) In which situations the robots were perceived as requiring help, and which forms help took. Outside of these two broader aims, I remained open to whatever insights engaging in the fieldwork would bring.

Figure 4.1: On a snowy day, a man wearing police uniform is inviting with a gesture a Starship robot to cross the street. Picture taken from inside a car. December 2021. Taken from: `https://shorturl.at/nz90L`

4.2 Methodological Scaffolding

To meet the aims of the study, I relied on naturalistic observations, coupled with autoethnographic vignettes and an online content analysis as a way to achieve a complementary triangulation (Farquhar, Michels, and Robson, 2020). In what follows, I describe the data collection and analysis procedures.

4.2.1 Observations in the Wild

The observations were conducted in the course of four days and lasted in between 1 to 2 hours per day. Because it was my first encounter with the field, choosing observation sites and strategy was a process of trial-and-error. At the time, I did not know what location to pick as a "good" observation point (a point where robot traffic could be found). A hint was offered by an acquaintance who happened to be a developer at Starship Technologies. Remaining reluctant with respect to how much they could share about the backstage processes, they nevertheless pointed out that one of the largest fleets in Tallinn at the time was stationed near a supermarket in the Telliskivi street area (see Figure 4.2).

Throughout the duration of the project, Telliskivi (particularly Telliskivi street and the area surrounding it), Kalamaja, and Uus Maailm districts in Tallinn remained the main sites where I conducted most of the observations (see Figure 4.3).

During my first visits to Kalamaja and Telliskivi, I tried several strategies including remaining stationary at one spot, or moving around the district. Ultimately, a combination of both strategies proved to be the most productive i.e. yielding more data. When

Figure 4.2: Fleet of approximately ten Starship robots parked at the pavement in front of a supermarket in Telliskivi. One of the robots is either on its path to deliver or has just completed a delivery.

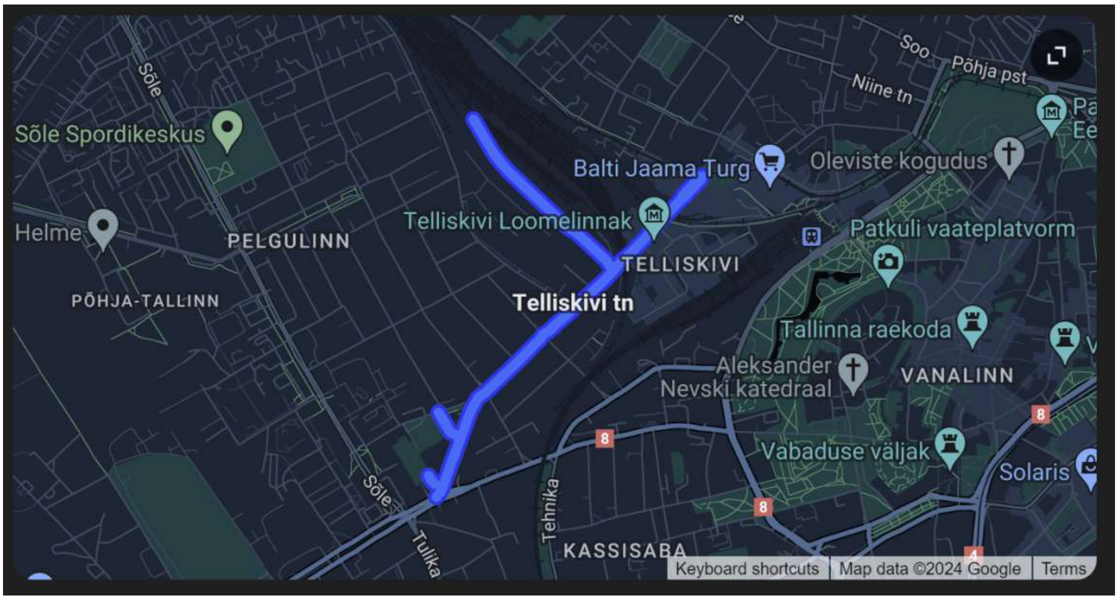

Figure 4.3: Telliskivi area map with Telliskivi street highlighted. Image taken from Google Maps.

stationary, I would situate myself near a vendor with a larger fleet and watch the robots return after completing a delivery; or, when an order was placed and a sales staff loaded a robot, I would follow the robot, in some cases (depending on the robot's speed and distance) to the point of delivery. To document my observations, I kept a field diary and took more extended notes upon returning back home. For observations at some distance, I took photos or made video recordings on my phone. The decision to record or not depended on the specifics of the situation: how intrusive it felt, whether it was possible to record in a way that would not depict the person(s)' face (see Section 3.4).

There were instances when I would spot a robot and an interesting situation outside of the dedicated observation times. In these cases, I generally halted whatever everyday activity I was carrying out to take notes or make a recording. Even though when in the field I relied predominantly on observations, in some cases I also engaged in casual conversations with people. In such cases, I introduced myself and what my role was, and probed their general opinions about the robots and what stood behind the choices they were making in terms of how to behave in relation to them.

Given how vastly unexplored situated interactions with commercially deployed sidewalk robots were at the time, in observations, I did not rely on a pre-defined protocol. My strategy for note-taking was to document all aspects of the interactions, and situations scaffolding these, that stood out. This meant, however, being a sole researcher in the field, observing and keeping notes simultaneously meant I inevitably missed out on something. I reflect on this and other choices related to observations in Section 4.4.2.

4.2.2 Online Content Analysis

From the first day of observations, it became clear that instances of people assisting the robots were not rare occurrences that happened to be amplified in the social media. Furthermore, these were just one aspect of an otherwise much larger phenomenon of human-robot *relationship building* unfolding in front of my eyes during that first trip to Tallinn. Recognizing this, I decided to deepen the first insights I was getting when conducting observations by investigating how people themselves articulated their interactions and encounters with Starship robots. To this aim, I introduced online content analysis into the study as another method complementary to the observations. Social media posts can be a rich source of data for qualitative researchers (Giles, 2017). According to Giles (ibid.), social media can provide "naturalistic data" in a sense that these data production is not influenced by the researcher (though one should not neglect the effect of the medium itself on the process and content of data production). If my aim with the observations was to establish *what happens*, the analysis of online content was motivated by the intention to gather some insights relating to the *why-s* behind it.

The data for the online content analysis were collected from three social media platforms: Instagram, Facebook, and Twitter (presently known as X). To narrow down the scope, I limited the search to the posts posted in the period October - December 2021. Given that at the time Starship robots had also been introduced in some areas in the UK and

USA, I primarily focused on the content that was generated within Estonia incorporating, however, posts in English, Estonian and Russian languages (geographic situatedness was the main criteria for selection as opposed to the ethic origin of the person posting). For Instagram, I used hashtag *#starshiprobots* to search for content related to Starship robots. In total, 75 comments were collected. For Facebook, I focused on the Tallinn Starship delivery page (`https://www.facebook.com/groups/starshipmustamae`) as this is where most of the user-generated content was found; in total, 60 content units were collected. From Twitter, 59 tweets were collected. Overall, I collected 194 content units (individual posts) across the three platforms. I archived these data in an Excel document stored on my hard drive. I anonymized the dataset removing social media names. Given it remains a muddy area whether it is ethically permissible – and how – to collect data publicly available on the social media (Ford et al., 2021), I refrained from collecting any indicators of identity such as gendered names, images, assumed age.

The analysis was conducted in two phases. First, I relied on the template analysis method as described in Brooks and King, 2014. I chose template analysis primarily as a means to get a systematic overview of the types of content people were posting online about Starship robots. The template analysis procedure involves the development of a coding template based on a subset of data which can then be applied to other instances of data and revised. Diverging from the RTA in its definition of theme subsection 3.1.3, in template analysis, themes are synonymous to codes (they capture the patterns in the data at the same level as codes) and are defined as "participants' accounts characterising particular perceptions and/or experiences that the researcher sees as relevant to their research question" (ibid.). Such themes can be developed inductively – from the data, – or in a top down manner (as informed by e.g. theoretical concerns) which means they can be defined a priori. In my case, the coding procedure was informed by the guiding research foci, with one a priori theme being Help. In total, the following 8 themes were developed. These themes were not mutually exclusive – one data unit could be coded with several themes. For instance, "helping" and "reaction" frequently coincided.

- Encounter: posts where the authors shared that they came across Starship robots, often accompanied by a picture of the robot.
- Experience: content describing people's experience of placing an order with Starship robots.
- Reactions: content that reflected people's emotional reactions to Starship robots.
- Art: artistic content depicting Starship robots.
- Help: content related to situations where Starship robots were perceived as needing help.
- Asking: questions about some features of the Starship robots and their behaviors e.g., how they navigate, whether they are tele-operated etc.

- Descriptions: content providing general explanations about Starship robots.
- Humor: humorous responses to Starship robots.

To capture the patterns in the data with more nuance, for the themes “Reactions” and “Help”, I used thematic analysis approach as put forth in an earlier publication by (Braun and V. Clarke, 2006). It should be noted that this earlier version of thematic analysis differs from Reflection Thematic Analysis as it was developed by Braun and Clarke later on (Braun and V. Clarke, 2021b). The stages of analysis included: generation of initial codes and collating data to each code, identifying themes – collecting codes into potential themes, reviewing themes and defining and naming themes (Braun and V. Clarke, 2006).

4.2.3 Autoethnographic Vignettes

In the HCI, autoethnography is a form of ethnographic practices that relies on the fieldworker’s own experiences of socio-technical artefacts (Rapp, 2018). In my case, the autoethnographic element of the study was enacted through keeping reflexive notes documenting my own experiences and reactions to encountering Starship robots and seeing other people encounter them. As part of the autoethnographic practice, I placed three orders through Starship application with three different vendors (two cafes and one supermarket). I then followed the robots from the vendors to the destination (my address in Tallinn). Depending on the location of the vendor, the journeys ranged from 20 minutes to 1 hour. For mnemonic purposes, I recorded each of the journeys on my mobile phone. As with observations, after each journey I documented the main impressions and thoughts in the field notes, this time focusing more on the first-person perspective, including my emotional reactions. At a later stage, for publication purposes including this monograph, these notes were developed into a retrospective account (Lucero, 2018) in the form of autoethnographic vignettes. I integrate selected vignettes in reporting of the study insights to highlight and expand on the key findings of the observations and online content analysis.

4.3 Results

For reporting, I grouped the key insights into two broader sections corresponding to the two main research questions. The first section addresses passerby interactions with Starship robots. In this section, I discuss the kinds of behaviors people exhibited, and factors that were associated with these based on the analysis of observations and online posts. The second section touches upon factors that may have contributed to people’s decision to help as one particular instance of interaction beyond use.

4.3.1 Passersby engagement with Starship robots

At the time the study was conducted, Starship robots attracted a lot of attention from passersby. Although still a rather novel phenomenon, few people ignored the robots completely. Passersby frequently stopped when they noticed the robot, some of them approaching to take a closer look or take pictures of the robot on their phone (see Figure 4.4). In one instance, I observed a person with a professional photo camera who slightly pushed the robot of its path while continuing to take pictures of it (see Figure 4.4).

Figure 4.4: Left: A couple, a woman and a man, dressed in winter clothes, are standing on the side of the sidewalk near a Starship robot. The woman is recording the robot on the phone. Right: A man with a photo camera, dressed in winter clothes, is kneeling down in front of a Starship robot to take a picture of it.

People in groups were more prone to point the robot to each other and to engage in brief conversations about it. Many of these social exchanges were accompanied by displays of positive emotions, such as smiles or laughter. Dogs and children were especially curious about the robots. Children followed the robot along its path and engaged in conversations about it with accompanying adults (see Figure 4.5). Animals and children interacting with Starship robots were also a common theme on social media, especially on Instagram, where many parents and pet owners posted pictures of their children and pets with the robots. Despite reports of people bullying robots in the wild in existing studies (e.g., (Bršćić et al., 2015; Oravec, 2023; Salvini et al., 2010), in the duration of the field study, I did not observe instances of bullying behavior beyond people's generally not ill-intended exploratory behaviors such as standing in front of the robot or slightly pushing it to see how the robot will react. Similarly, bullying was not mentioned in the data collected online.

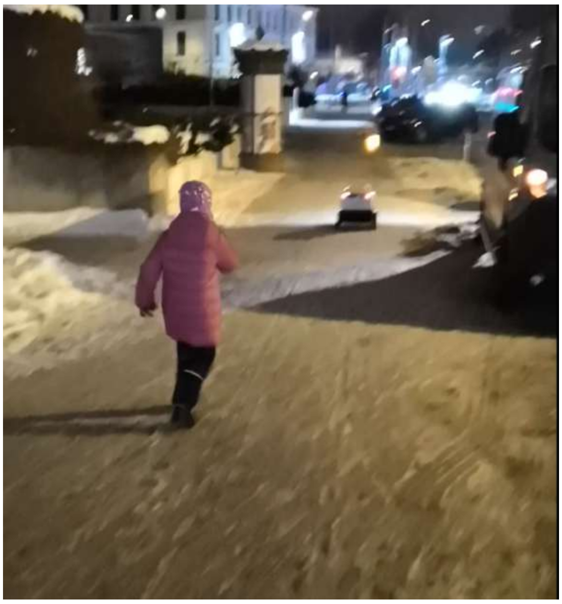

Figure 4.5: On a winter evening, a girl dressed in a pink winter coat is running after a Starship. December 2021.

4.3.2 Manifestations of help

In total, in duration of the four days, I observed five instances of people assisting the robots. Three instances were in response to the robot being stuck in snow. In these cases, passersby who happened to be nearby and witnessed the situation cleared the snow in front of the robot with their foot (see Figure 4.6), or gave it a gentle push to help it return to the cleared path. Another instance of help involved removing a physical obstacle (an e-scooter) on the robot's path (see Figure 4.6). Lastly, another instance of help was pressing a traffic light button at a cross-road.

The online data analysis provided more evidence in support of the insight that helping behaviors were not extremely rare occurrences. Many online commentators referred to their experiences of having helped a robot (e.g., "Modern times in Estonia. A robot which had become stuck in the snow, saw me coming, and asked with a synthesised voice whether I could help out. So I did, and both of us carried on with our day."; "Yesterday rescued 3 reindeer robots who were eagerly asking for help"), or shared their reactions to other people helping the robots. Online commentaries also included more general discussions about whether it was in fact appropriate or desirable to help the robots. Some commentators mentioned that instances of failures could be useful for the developers as this is how the robots learn and improve ("IT people know that 'helping' is the last thing to do. Product developers need to be aware of all kinds of bottlenecks so that they can fix them", "I wonder what the etiquette should be, always want to help when they get stuck. But is it like animals and you should leave them alone as the mummy robot will come to the rescue."). One commentator shared they were inclined to help the robot but

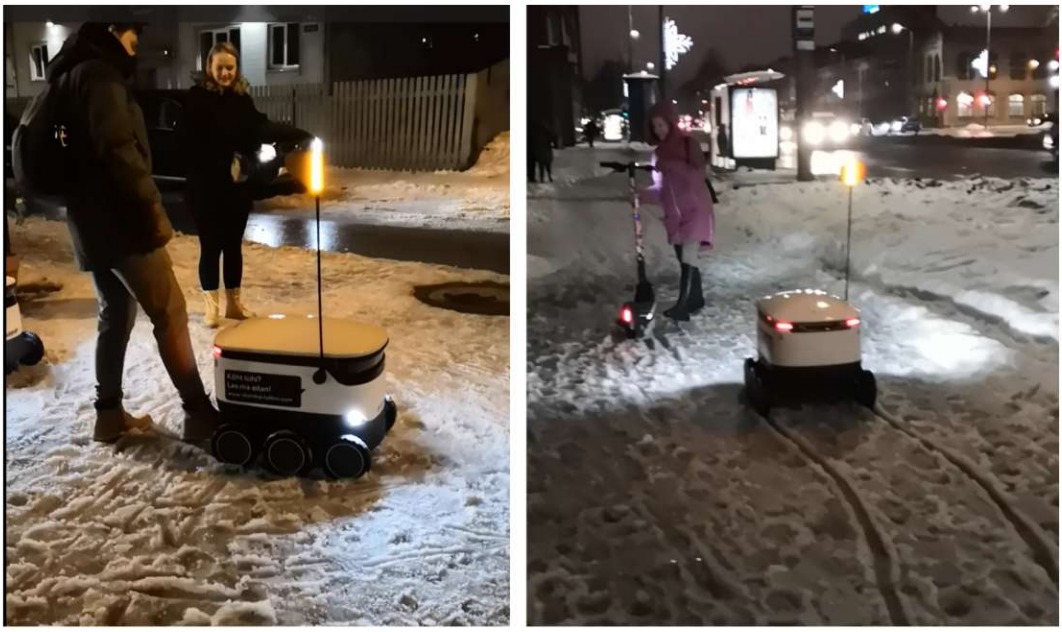

Figure 4.6: Left: A man is stretching out his foot to give Starship robot a push in order to free it from being stuck in snow. Right: A woman is lifting an electric scooter from the sidewalk to clear the path for a Starship robot. December 2021.

were not sure whether they were allowed to do so. This aligns with other more recent studies of situated HRI with sidewalk robots suggesting that lack of information was one of the main reasons for people's reluctance to engage with the robot when it was proactively seeking help e.g., (Weinberg et al., 2023).

Situational Factors Scaffolding Help

Weather conditions played an important role in eliciting helping behaviors. During two of the four days of the field study, Tallinn streets were covered in heavy snow and robots got stuck frequently (see Figure 4.7).

This attracted the attention of people and led to more situations in which the robots were perceived as needing help. Snow as an important factor associated with instances of people helping was also confirmed in the online content analysis.

The instances of robots trying to plough through the snow were one of the most common themes people discussed on Twitter and Facebook in relation to Starship robots in Estonia. This suggested that people noticed the robots getting stuck in the snow and found it a phenomenon worth sharing. Apart from snow, physical objects in the robots' path (e.g., electrical scooters) also contributed to instances where robots were perceived as needing help. Traffic lights that do not switch on unless a button is pressed posed

Figure 4.7: Three images depicting different angles on the same scene – a Starship robot is trying to free itself out of heavy snow by lifting its wheels. December 2021.

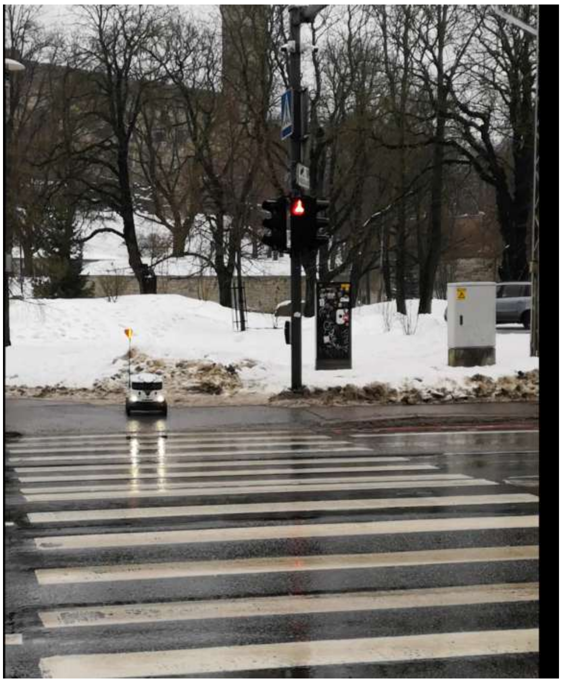

Figure 4.8: A robot parked at red traffic light in front of a wide pedestrian crossing. December 2021.

another challenge for the robots (see Figure 4.8). While not something I observed on the streets, one online post with multiple comments on the Estonian Starship delivery Facebook page also depicted a robot that had one side fallen off the pavement.

4.3.3 Robot-centered and Human-centered Factors that Contribute to Human Helping

Perceptions and Attitudes Towards Starship Robots

Cuteness factor. One clear insight emerging from the analysis of the online posts was that many people perceived Starship robots, and encounters with them, rather favorably and found the robots likable. In other words, qualitative and observational data suggested high levels of *existence acceptance* (Abrams, Dautzenberg, et al., 2021). The robots were commonly described as "cute" and "adorable" ("With a little help of humans, a little cute delivery robot crossing a snowy street in Estonia"). The adjective "little" or diminutive nouns (e.g., "little guy", "buddy") were also frequently used. Such diminutives may suggest that the robots are perceived by people as harmless, potentially further contributing to their acceptance (Niemelä et al., 2019) and people's willingness to help. The impression of the robot as being "cute" is also echoed in the autoethnographic account (see Autoethnographic vignette 4.9)

> I found the robots *cute*, and there was no way around it. There was something about their design and goal-oriented behavior that invited attributing some form of agency and, for what it's worth, character and personality to them.

Figure 4.9: Autoethnographic vignette: Robots are Cute and there is no Way around it. December 2021.

Affective Responses. In the online commentaries, people mentioned positive emotions they experienced towards Starship robots aligning with the observational data. People shared they felt excitement when encountering the robots on the streets, or when (in the role of users) they interacted with the robots upon having their order delivered ("When you are more excited to see the robot more than the order itself"). Some commentators mentioned that their mood improved when they saw a robot on the streets ("It's really cool to come across these little characters when walking outside. It improves the mood at an instant!"). This is again supported by the autoethnographic account (See Autoethnographic vignette 4.10):

I smiled spontaneously when I noticed one of them passing by our windows on the ground floor on Tehnika street where I was staying. I experienced empathy, and even some form of pity, towards the robots when I saw them standing in the rain in front of a cafe, waiting diligently for an order to be placed. This empathy was reminiscent of the empathy we feel towards animated characters – both fictional (in terms of their ontological status as a "true" social agent) but also very real in terms of the reaction they provoke in spectators.

Figure 4.10: Autoethnographic vignette: Affective Responses to Robots. December 2021.

Sociality Attributions. Even though Starship robots are best classified as mechanoid autonomous service robots with functional design (Yanco and Drury, 2004), both autoethnography and online content analysis suggested that it was common to attribute social attributes to these robots and treat them as quasi-social agents (Breazeal, 2004). Anthropomorphic language was used online to describe robots' behaviors (e.g., "A reindeer is resting at a parking lot").[1] Some commentators even extended moral rights to the robots. For example, one person shared an opinion that it was a moral duty to help a robot and expressed anger at a person who recorded the robot in a challenging situation but did not provide help ("Might have been better to give the poor [robot] a hand instead of filming"). As quasi-social agents, these robots were considered by some as worthy of empathy (Capuccio, Peeters, and McDonald, 2020). This finding is also supported by the autoethnographic experience (See Autoethnographic vignette 4.11):

I could not help but cheer for them when they succeeded in crossing a busy road efficiently. "C'mon, you can do it", – I found myself saying whenever the robots seemed "hesitant" to cross a street.

Figure 4.11: Autoethnographic vignette: Cheering the Robots. December 2021.

Perceived Usefulness. The quasi-sociality and perceived cuteness were accentuated by people's perceptions of the robots as useful and goal-oriented. On the social media, the robots were described as helpful and working "tirelessly" to deliver orders to people (e.g., "helpful starship bots", "Never tired of these little troopers!", "Starship delivery robots busy and cute as always, trying not to get stuck in the snow."). Several people described them as "responsible", a quality that is usually reserved for humans.

[1] While Starship robots are functional robots i.e., they do not have human-like or animal-like design cues, for the Christmas season, some of the robots were decorated with stickers that imitated a cartoon reindeer.

Negative attitudes. While positive attitudes towards Starship robots prevailed, they were not unanimous. More critical comments on Twitter expressed concern over the real value of the robots and how them populating the streets obstructed pedestrians (e.g., "I'm fed up of walking the streets in the snow and having to avoid the obstacle course of these tech gadgets and scooters just lying by the wayside. 21st century litter as far as I'm concerned.", "Nothing with a cute face could ever be problematic, right?"). Some humorous comments highlighted the irony of people assisting machines when it is supposed to be the other way around (e.g., "Machines were supposed to help us not vice versa.", "Just doing our national duty - helping robots deliver goods! In the past I did think that robots will help us, but seems a lot has been turned on its head recently", "Hooray! we'll still be useful in the service of robots."). Jokes about the robots rewarding those who helped them when they finally "take over the world" were also common. More critical commentaries pointed to the aspect of unpaid work involved when people assist commercially deployed technology (e.g., "Don't give free labor to the company that owns the robots — if they get stuck, let them rust!", "Crowd-sourced free labor."). Some even wondered about the working conditions of the operators (e.g., "Was it the robot asking or a low-wage worker asking remotely?"). The autoethnographic reflections also point towards more ambivalent and critical aspects (See Autoethnographic vignette 4.12):

> Throughout the field study, I felt that I am enacting different – at times, conflicting – perspectives and roles (researcher, customer, former citizen of Tallinn visiting home and experiencing the city change etc.), and it is not always possible to say which of the perspectives colors my experience at a particular moment in time. It was surprising, but also fascinating for me, how a more critical awareness about the hidden aspects of labor that are involved in making these robots a commercial success co-existed with a genuine positive emotion toward the robots and the overall satisfactory experience as a Starship customer. My experience was reminiscent of that of Williams' (K. Williams, 2015): in his autoethnographic study, he makes a deeply personal case for the tension between his experience as an engaged and sustained user of calorie-tracking and diet apps in a personal pursuit of losing weight and regaining control over his health, and his role as a scholar who had been critical of the reductive logic behind popular diet control and tracking technologies.

Figure 4.12: Autoethnographic vignette: Ambivalence and Balancing Different Roles.

4.4 Discussion and Lessons Learned

In this section, I consider the insights of the study, specifically as these concern instances of people voluntarily helping robots, within the context of ongoing efforts in HRI on designing and evaluating strategies to solicit human help. By bringing in perspectives from STS and sociology of work, I question, on the one hand, the pragmatic utility of designing to solicit help. On the other hand, I explore what such help might mean and which ethical underpinnings it might have. Towards the aim of contributing to the (methodological) practice of qualitative research in HRI, this section integrates also reflections on methodological choices I made when conducting this study, the shortcomings of these choices as I see them today, and the challenges I encountered.

4.4.1 Helping Robots: Work, care, and the ambiguities of life

One of the key insights of the study was that people were prone not only to perceive Starship sidewalks robots in their community rather favorably, but were also willing to extend a helping hand to them in challenging situations. Despite their functional design for autonomous operations, situations where the robots seemed to struggle, e.g., being stuck, invoked empathy and a sense of responsibility in passersby, with some people even construing it as a moral or ethical duty to assist. This finding is consistent with existing work on help-seeking robots. For instance, in a semi-ethnographic study with the ChairBot robot at university campus cafes, Fallatah et al. also identified people were generally willing to assist a robot, with curiosity, willingness to help people behind the robot, and wish to be perceived as ethical by others among the main drivers behind the motivation to help (Fallatah et al., 2020). As part of general efforts towards establishing the most efficient strategies to solicit human help, scholars in HRI identified robot politeness (Westhoven, Grinten, and Mueller, 2019), the degree of autonomy, familiarity with the robots as factors influencing people's helping behaviors (Srinivasan and Takayama, 2016). Further, Weiss, Mirnig, et al., 2015 suggested designing a robot to "needy" , or exhibit cues for sadness (Backhaus et al., 2018; Daly, Leonards, and Bremner, 2020) is conducive to people helping the robots. Based on the study outcomes, for Starship robots, the overall positive stance towards these robots and willingness to help them were coupled with anthropomorphic perceptions (Duffy, 2003) and experiencing the robots as in some sense social. These experiences, however, were not associated with the robots having anthropomorphic or zoomorphic morphology – a similar phenomenon of anthropomorphizing functional robots is also evidenced in an ethnographic study of Amazon warehouse robots by Chun and Knight, 2020, and in the earlier series of studies of Roomba vaccuum cleaners by Forlizzi, Sung and colleagues (Forlizzi, 2007; Sung, Christensen, and R. E. Grinter, 2009). Rather, for Starship robots, the overall likeable – "*cute*" – design, coupled with the overall perceptions of the robots as *useful*, may have played an important role in shaping people prosocial attitudes and behaviors. At the backdrop of the earlier studies in HRI probing "needy" design strategies for soliciting human help (Backhaus et al., 2018; Weiss, Mirnig, et al., 2015), these findings invite the question about the additional value of expressive behaviors for seeking out human help. For this question, the distinction between what is intentionally designed ("needy" expression as a design choice) and the robot being perceived as needing help (without necessarily seeking out help by engaging different design affordances) might be helpful.

For, this distinction not only underpins what is pragmatically sensible to design for[2], but, especially in the case of commercial technologies such as Starship, emphasizes ethical dimensions implicated in proactively soliciting human help. As underscored by some online commentators, it is unclear whether such help can be construed as a form of (unpaid) work, or hidden labor (Mateescu and Elish, 2019; Meissner et al., 2022) provided by people in support of ensuring the functioning of a seemingly autonomous system.

This reading of help to robots as work is not implausible. In philosophy and social sciences, work and labor remain an ongoing topic of conceptual and empirical investigations. These disciplines have explored multiple definitions of work, by whom and how work is done, and diverse implications of particular work-related configurations. While the concept of work as such resists a unified and straightforward definitions (Cholbi, 2023), many scholars have come to agree that employment does not exhaust all forms work can take. One of the proposed conceptualizations interprets work as a commodity (Budd, 2011). Within this view, work is understood as a source of economic value: Like any material resource, it can be deployed, sold, and exchanged (ibid.). From this perspective, people's help to commercial robots can indeed be interpreted as a form of work because these behaviors contribute, however marginally (more on this in Chapter 6), to the robots succeeding in their everyday tasks and, consequently, to generating value for the actors developing and deploying the robots. Casting voluntary help as work further underscores the tensions that arise when we consider how to intentionally design the robot to nudge people to help them. Even if such strategies take the form of playful solicitations, or rely on gamification cf. (Robinson et al., 2020) as a means to ensure that enacting help is also enjoyable and fun for the passersby, these apparently innocent nudges remain a convenient euphemism obscuring an act of manipulation, or an exercise of control, via the robot design (Vivrekar, 2018). Within big tech, various analyses have shown how the addition of the limited understanding of acting ethically through nudges and gamification further stabilize existing, unequal power dynamics between companies and customers, rather than transform problematic practices (Phan et al., 2022).

However, the act of help, though embedded and enacted within the given (neoliberal) socio-economic paradigm, is not exhausted by it. For, even the most precarious work remains entangled with affective and relational processes that the reading of voluntary help only as a form of commodity does not allow one to capture. This is why scholars like David Graeber (Graeber, 2001) and Michael Hard (Hardt, 2015) argue against the myopic focus on manipulation and power structures – as important as it may be to critically examine them – when discussing work and labor production. In the words of Graeber: "Too much uncritical enthusiasm, one ends up with a naive relativism utterly blind to power. But if one is too rigorous and single-minded about one's critical project, one can easily slip into a view of social reality so cynical, of a world so utterly creased with power and domination, that it becomes impossible to imagine how anything could really change" (Graeber, 2001, p.xiii). Against such a myopic reading, understanding of help such as

[2] I return to this point again in Chapter 6 when I discuss how relying on human help comes into tension with the developer's principle of reduction in dependency.

care can offer another productive lens for analysis. DeFalco, 2020 describes care as "inevitably personal, frequently amorphous, anomalous, leaky and curious" (p.33, ibid.). Framing instances of assisting robots as a form of care thus marks a shift from seeing such situations as two independent actors interacting with each other to the understanding of human and nonhuman agents as embedded and relationally entangled, cf. (Frauenberger, 2020). Casting help as care brings forth another dimension implicit to people helping the robots that is also evidenced in existing HRI studies (Fallatah et al., 2020) and I elaborate on further in Chapter 5 – by helping the robots, people enact different forms of care for other people. In this view, the robot functions primarily as a kind of proxy in non-dyadic relationship between people populating one community. However, given the persistence of the human tendency to relate and care for nonhuman agents (to construct the robot itself as the subject of care) despite – or in spite of – the ontological divide (Coeckelbergh, 2010), it is hard to condone or dismiss such acts as mere frivolity. This tendency does, however, re-iterate the tension arising when we design robots as "needy", or even as "cute" captured poignantly by deFalco in her question "What happens when we treat machines like people?" (DeFalco, 2020). This question ultimately concern the virtue of empathy towards robotic bodies (Sparrow, 2016), and their perceived or project vulnerabilities, at the foreground of vulnerability of the human bodies, for example, the bodies of human delivery workers sharing the streets, and nowadays, work with sidewalk robots.[3]

To conclude, there is no straightforward resolution, nor prescription appropriate to all situations, to how to define our responsibility as designers and researchers. Not fully exhausted by the reading of help-as-work nor help-as-care, people voluntarily assisting commercial technologies remains a fundamentally ambiguous and ambivalent phenomenon. In her reading of Lefebre's "Critique of Everyday Life", Brigitte Bargetz defines *ambiguity* as a plurality of possible meanings and interpretations co-existing (Bargetz, 2014). *Ambivalence*, on the other hand, concerns a personal inner conflict of attitudes and affective states one experiences when making decisions in the condition of ambiguity (ibid.). Approaching ambiguity in everyday life thus allows to "theorize individual beings caught in particular situations" (ibid.) and articulate the modes and mechanisms of their bindings and entanglements. For the task of understanding help extended to robots, accepting the inherent ambiguity allows to discuss the tensions without the pressure to resolve them cf. (Odell, 2019).

4.4.2 Methodological Reflections: Can a qualitative study be not qualitative enough?

When I conducted the first study, I lacked in training and experience in conducting ethnographic research. To be sure, at the time – outside of the autoethnographic vignettes – I did not even conceive of my field work as a form of ethnography. Today, I recognize

[3] I am completing this monograph at the backdrop of the recent news announcing Starship Technologies partnership with Bolt (Adams, 2024). Less relevant here, this development is quite consequential for my thesis project overall, and I return to this in Section 10.2 of the Discussion.

how the lack in expertise and awareness resulted in an approach to observations that was not nuanced enough for an ethnographic study, while also lacking in systematicity and reliability required for an observational study leaning toward positivist epistemology. Lacking in training and experience, one challenge I had when conducting my first observations concerned delineating what I should even consider as an instance of an interaction (does a smile when noticing the robot count as an interaction?), and what exactly and how to document in the field notes (should I describe how a person looked? Or should I only describe what the person did?). Having decided that every form of reaction to the robot – be it an emotion display or a behavior – is meaningful in the context of my study, I opted for keeping notes of every such reaction I witnessed. At the same time, I had to set aside the initial (misinformed) idea I had to also count such instances – given the frequency of reactions and that I was the only researcher in the field, any attempt at counting would have led to a number that would reflect more my ability to notice and document than the actual number of instances when people reacted to the robot in some way. I recognize now how, should I have chosen to proceed with more positivism leaning form of observation, a detailed observations protocol would be required. Constructing such protocol though, would still necessitate some (unstructured) time in the field to delineate the scope of the phenomenon under investigation – which my first observational studies ended up providing. That said, looking back at the evolution of the thesis project, I don't think a more positivism leaning study would necessarily be a good match to my research aims and questions. What I could have done better, though, is enacting qualitative work in a more in-depth and informed manner. As trivial as it may sound now, the first step towards to this would need to accommodate better notes taking. At the later stages in the project, the textbook by Emerson, Fretz, and Shaw, 2011 offered an excellent guide to this.

In the context of my project, one practical challenge, however, remained: how to reconcile being one person in the field (with limited possibilities to observe and take notes simultaneously) with ethically informed advise to withhold from recording interactions involving people who could not give their consent. As I also learned from experience, having a recording is extremely helpful because the amount of details that emerge in re-watching the same situation repeatedly far supersedes what one, or even several, researchers could realistically capture when observing and documenting simultaneously.

A certain 'under-performing' of the method (or missing out on the opportunity for the Big Q qualitative research (Braun and V. Clarke, 2022) concerned the choices I made when conducting the online content analysis. First, the very framing of this part of the study as an an 'online content analysis' as opposed to, for example, online or digital ethnography (Hine, 2015), today feels like an opportunity missed for a more rich and nuanced insights into how people construe their encounters with robots in daily life, also in the online spaces. Digital and online ethnography, though already an established approach within HCI, in HRI remains vastly under-explored (with few exceptions e.g., (Nielsen et al., 2023).[4]) As more robots proliferate in public spaces, it is inevitable that

[4]For the present purposes, I bracket out the question whether these studies are in fact ethnographies.

the amount of data generated about them online will offer new opportunities for research, and I wish I had recognized that earlier.

Further, above I mentioned how the chosen approach to analysis was an earlier version of the thematic analysis as opposed to the Reflexive Thematic Analysis I rely on in Phases 2 and 3 of the project. The original thematic analysis paper by Braun and Clarke was published in 2006 (Braun and V. Clarke, 2006), and has since to a certain dismay of its authors' (Braun and V. Clarke, 2019) become a widely cited but also a widely misunderstood methods paper resulting in a lot of poor practice (ibid.). Since then, the authors have both developed the method further leading up to the RTA, and written multiple publications explicating the misunderstandings stemming from the confusion of different forms of TA and their epistemological underpinnings e.g., (Braun and V. Clarke, 2019, 2021a,b). While the earlier version of the TA as put forth by Braun and Clarke does share some similarities with the RTA, there are however crucial difference that shape the outcomes of the analysis. Among these, RTA moves away from the idea of a structured codebook (thematic map), emphasizing themes, and their reporting, as the main outcome. In both forms of analysis, however, themes represents some level of patterned response or meaning within the data set, though RTA related publications articulate in much more depth the difference between themes and topic summaries, and the role of researcher in developing the themes (as opposed to "finding" them in the data). Not recognizing the (systematic and careful) work one needs to invest in developing a themes has resulted in examples of qualitative analysis presenting a form of topic summary as a theme while citing the original 2006 paper. Looking back at the way I conducted analysis in the Phase 1, I recognize how my own engagement with the data lacked in depth.

4.5 Summary

To conclude, what do these reflections mean for the outcomes presented in this chapter? As methodologically imperfect and, at times, as the process might have been, the insights resulting from the exploratory study have provided me with enough material to develop on in the subsequent phases of the project, as well as stimulated conceptual work on the topic on the pragmatics and ethics of designing robots to solicit human help in public spaces. As for the (methodological) imperfections themselves, I take them as an opportunity to improve my own research practice and offer some guidance to young career scholars seeking to conduct a qualitative study.

CHAPTER 5

Deepening Perspectives

Parts of the work presented in this chapter were published in Dobrosovestnova, Vetter, and Weiss, 2024b. As the first author, I drove the study and the development of the concept of the paper. Ralf Vetter contributed to the writing of the related work section and participated in the development of discussion; Astrid Weiss provided general feedback to the manuscript.

Motivated to investigate deeper what situated encounters with the robots in their daily lives meant for different people, I conducted interviews with passersby and vendors based in Tallinn, and passersby based in Cambridge, UK. This chapter reports on the recruiting process of participants, the data analysis steps, and key insights. The discussion reflects on these findings through the lens of technology acceptance.

5.1 Participants Recruitment and Ethical Considerations

The interviews were conducted at different times throughout the period ranging from August 2022 to October 2023. The first series of the interviews coincided with the second round of observations conducted in Tallinn, in August 2022. This was when I situationally approached people whom I had observed in some way interacting with Starship robots on the streets. The interviews conducted on the street (n = 7) lasted between 10 and 20 minutes. These interviews were not recorded; instead, handwritten notes were taken immediately following the interviews. In the notes, I tried to capture as accurately as I could the topics covered in the conversations, as well as the phrasings people used to describe their experiences with the robots. Apart from the interviewees recruited on the spot during observations, additional interviewees (n = 5) were recruited through shared contacts in Tallinn. These interviews were scheduled, recorded, and lasted between 25-45 minutes. In February 2023, two months after Starship robots had taken to the streets in Cambridge, through a shared contact, I recruited additional interviewees from the area (n = 3). The interviews with UK participants were all conducted online through the

Zoom Video Communications platform and were recorded with the permission of the interviewees. For all participants, irrespective of their geographical situatedness, the one condition for participation was that they had lived experiences with the robots, i.e., they had encountered them on the streets and possibly interacted with them in some manner (as opposed to only seeing a video online or hearing about the robots from other people).

In August 2022, I also interviewed vendors (n = 6) in Tallinn. I used the Starship app to identify stores and cafes that offered Starship robots as a form of delivery. To inquire about the possibility of an interview, I went to the enterprises identified through the app, introduced myself and my research project to the staff present, and asked if they were willing to be interviewed. In several cases, the staff would refer me to the management. I could not fail to notice that in these cases, the staff, who were in the role of serving customers at the cash register and were also the people who received the orders through the app and loaded the robots, seemed quite hesitant. Their assumption was that they knew very little about the robots and did not have much to say on the topic. I suspect this hesitation about their level of knowledge and the perceived necessity to continue working (instead of chatting with a stranger) was why they referred me to management as someone who was, in their view, definitely more competent to provide opinions and could make a decision to disrupt their work routine to accommodate a walk-in researcher.

Representatives of all but one company I approached agreed to be interviewed and were welcoming and friendly, though initially a bit unsure about what they could tell me about the robots. In one case when I did not succeed in getting an interview, the person in the shop was working alone, and my inquiry found them in the middle of placing goods on the shelves. In response to my request, they suggested that I use the shop's email to contact the management, which I did; however, I never received a reply. A similar situation occurred when I contacted two bigger supermarket chains also present at the time in the Starship app.

The vendors I did succeed in interviewing were rather small-size local businesses, including several cafes and specialized shops. Depending on their availability, the interviews with the vendors lasted between 15 and 40 minutes. The interviews were recorded or handwritten notes were taken immediately after the interview. The decision whether to record or not depended on the situation: in some cases, interviewees agreed to answer my questions while they continued their work. In these cases, recording felt pragmatically challenging and intrusive, as people were moving around the workspace and occasionally talking to other people.

5.1.1 Ethical Considerations

As mentioned previously in Chapter 3, at TU Wien there is no formal requirement to acquire ethics approval to conduct a study. Instead, the Research Ethics Committee, as an advisory body, provides guidance with respect to studies involving human participants as well as ethics more broadly. Prior to conducting my study, I used the opportunity to consult the committee and obtain their informal approval for my recruitment approach and the consent forms I developed.

5.2 Interview Guide and Process

The questionnaire guide I had prepared in advance of the interviews included the following topical blocks[1]:

- First experiences of encountering Starship robots on the streets and how these have changed over time.
- Experienced sociality: Perceptions of Starship robots when compared to other technologies, e.g., electric scooters.
- Helping robots: experiences and attitudes.
- Imaginaries of futures with robots.
- For vendors, an additional block of questions included questions about whether/how robots reshaped work routines, what responses of customers were, perceived advantages and disadvantages, or robot as a means of last-mile delivery.

My approach throughout the interviews remained flexible. Depending on the direction each interview was taking, I allowed myself to ask new questions or explore some themes in more depth. Each interview ended with an invitation to the interviewee to share other experiences, thoughts, or opinions that we had not covered but that they found worth mentioning. The interviewees were also invited to ask any questions about the study. Depending on the mother tongue of the participants (Estonian, Russian) and how comfortable they felt speaking English, the interviews were conducted in any of these three languages.

5.3 Process of Analysis

Preceding the analysis, I had to make several decisions that deserve mention. The first concerned how to treat data from differently situated participants, both in terms of their roles vis-à-vis the robots (i.e., people encountering robots in their daily work vs. on the streets) and geographical location. Firstly, it was not self-evident whether I should analyze interviews with passersby as a different dataset from interviews with vendors. A similar question extended to analyzing interviews with participants from Estonia versus the UK. After reading the data several times and considering the methodological implications, I decided to treat all interviews as one dataset. This decision was partly motivated by my experience of thematic saturation and similarities in response patterns

[1]For the questionnaire guide, please see Appendix 10.2

observed across multiple readings of notes and transcripts. In relation to their roles vis-à-vis the robots, for participants in Estonia (vendors and passersby), these similarities are understandable given that people occupy multiple roles, sometimes simultaneously: even though experiencing Starship robots as part of daily work may be unique to vendors, they nevertheless encounter robots as drivers, passersby, cyclists, etc. It therefore seemed sensible to treat passersby and vendors' responses as one dataset. That said, when analysis revealed that professional situatedness shaped certain experiences with robots, I indicated this accordingly.

Similarly, unless explicitly captured in the data (for example, in Section 5.4.1 when I discuss how identity shapes attitudes to Starship robots), I do seek to make comparisons between participants' geographic situatedness and their responses. This decision was motivated by the substantial similarities in response patterns between Estonian and UK participants. I speculate these similarities stem from participants' education levels, shared sociocultural environments, and overall positive attitudes toward technological development. As mentioned in Chapter 4, in Estonia the interviewees were predominantly recruited from the Telliskivi and Kalamaja areas, which are associated with young creative classes and vibrant urban life. Participants from Cambridge were highly educated professionals working in research and design; they also characterized Cambridge as youthful and technology-oriented due to it being a university town. To anticipate Chapter 6, Starship company developers similarly observed that the urban environment where robots are deployed and the socioeconomic background of local residents mattered more for robot perception than national culture.

It is worth reiterating that the interviews with UK participants were conducted at a different stage of familiarity with the robots. While in the Cambridge area Starship robots were launched in November 2022 (approximately three months prior to the interviews), in Estonia it had been possible to place orders with the app since the launch of Starship robots in September 2021. That is, participants in Estonia had had the chance to experience the robots for at least six months prior to being interviewed.[2] Prior work in HRI has discussed how the so-called novelty effect – following first encounters with robots – may give rise to curiosity and exploitative behaviors manifested in testing the robots' capabilities, as well as anxiety and avoidance behaviors (e.g., (Reimann et al., 2024)). Indeed, as I discuss in Section 5.4, getting to know Starship robots and forming expectations about what they can and cannot do — and what can and cannot be done to and with them — characterizes initial encounters for both the UK and Estonia-based participants. Outside of this discussion, primarily presented in the *Getting to Know Each Other Takes Time*, I did not set out to draw connections between the degree of familiarity with the robots and participants' experiences unless it was evident from the data that such a relationship shaped a given pattern in response.[3]

[2]For some interviewees, this period was even longer, as they had seen the robots in different parts of Tallinn during the testing phase preceding the service launch.

[3]An in-depth comparative analysis would require a dedicated research question, a larger sample, and potentially a different methodology. Such analysis would also need to be supported by a shared framework

For the purpose of analysis, all recorded interviews were anonymized by assigning a number (e.g., P1 or V6, with P standing for "passerby" and V for "vendor") and transcribed using Otter.ai. I then listened to the recordings and manually edited the transcripts to correct mistakes and add contextual information – for example, marking moments when people were laughing. During this process, I also took notes on first impressions and highlighted notable sections. The transcripts were then uploaded into the MAXQDA 2022 qualitative analysis software (Version 2022.0.0, `https://www.maxqda.com/products/maxqda`). The handwritten notes were digitized and uploaded to MAXQDA as well. During analysis, I preserved the original language of the interviews (Russian, Estonian, or English). For publication purposes, participants were pseudonymized: for participants from Estonia, I chose common Slavic or Estonian names; for UK participants, common UK names. Vendor pseudonyms were prefixed with "vendor." Direct citations used to illustrate and support insights developed during analysis were translated into English.

5.3.1 Reflexive Thematic Analysis

For the analysis of the interview data, I chose to work with the Reflexive Thematic Analysis (RTA) approach, as detailed in Section 3.1.3. In line with the approach outlined by Braun and Clarke (Braun and V. Clarke, 2021b), the analysis included the following phases: (1) familiarizing myself with the dataset, (2) coding, (3) generating initial themes, (4) developing and reviewing themes, and (5) writing up.

Though this differentiation between phases may suggest a linear process, the reality was far from linear. Coding and theme development occurred in several rounds: the first round of familiarization with the data took place in January 2023, a round of coding in October 2023, and another round followed by theme development in January 2024. Thus, the analysis was conducted at different points throughout the thesis work, with breaks during which I was involved in other research activities, such as the work presented in Chapter 7 and work on accompanying publications. In practice, each break required me to re-familiarize myself with the data, to make it 'come to life' again. These re-immersions were often accompanied by anxiety – the fear that there might be nothing of interest in the data, and that anything I could draw from it would be trivial – a fear I had to overcome each time I returned to the analysis. At the same time, every return offered new perspectives and new ways of interpreting the data. While some theoretical influences are harder to trace, the work on experienced sociality (see Chapter 7) and reading related literature undoubtedly shaped how I engaged in interpreting the data, especially regarding experiences of sociality.

When it came to coding, it took considerable effort to develop codes that were neither too specific nor too broad and that would allow me to quickly understand what each code referred to. In line with Braun and Clarke (Braun and V. Clarke, 2022), I treated codes

of novelty effect in HRI, informed by a range of interdisciplinary perspectives (cf. (Smedegaard, 2022)), which the field has yet to establish and which remains outside the scope of this thesis.

as intermediary steps and mnemonic tools that helped me maintain an overview of the data's breadth and assisted in making sense of it. Theme development, on the other hand, allowed for deeper exploration of the data through crafting interpretations – informed by research questions and theoretical commitments – of semantic cores captured in the codes and how they related. As with coding, theme development was far from straightforward. Since the interviews covered a wide range of topics, it was challenging to avoid merely summarizing what participants had said around specific topics. Resisting that urge was essential to uphold the methodological principles of RTA (Braun and V. Clarke, 2021b).

Another challenge was avoiding premature themes. Initially, I explored potential themes and their relations using pen and paper (see Figure 5.1).

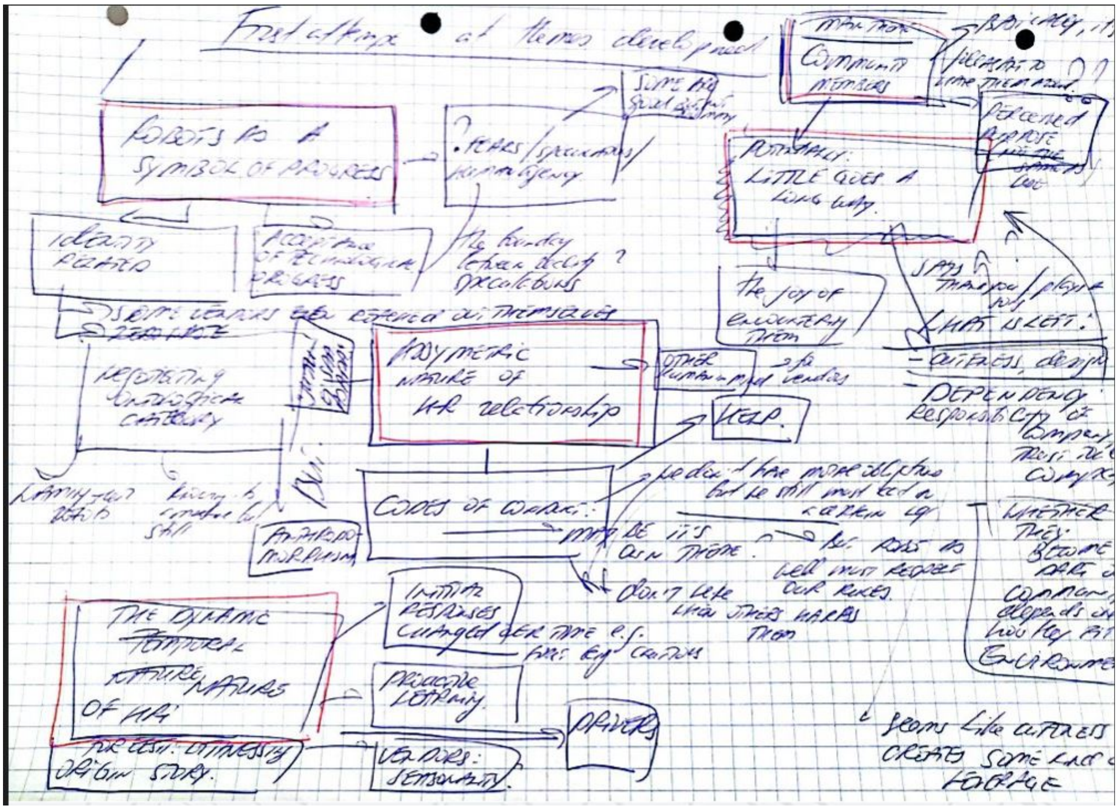

Figure 5.1: Clusters of codes around potential themes prepared with pen on paper.

I then printed out code labels and experimented with theme development by physically rearranging clusters of codes on a table. Although time-consuming, this process allowed me to consider all codes at the same level and engage with the data in new ways. Figure 5.2 captures some of these early clusters.

Throughout clustering and theme development, I dropped some codes and renamed others to more precisely reflect the semantic content of the data. In some cases, I had to return to the data to remind myself what a specific code referred to. Moving back and

Figure 5.2: Printed code labels arranged on the table around sticky notes representing potential themes.

forth between the physical clusters and data extracts in MAXQDA helped me understand what works for RTA coding. I found that some codes were merely topic summaries – for instance, *Trustworthiness* or *Bicyclist* – that did not convey why I had coded that data extract in the first place. At best, these codes pointed to a specific topic and allowed for retrieving extracts, but they were unhelpful for in-depth analysis. For such codes, I either re-coded extracts with other more specific codes or adjusted labels to better reflect the semantic content.

I also recognized that some codes were in fact premature themes I had imposed on the data. For example, the code *socio-practical* encompassed diverse aspects such as trust in companies, recognition of dependency on developers, and perceptions of robots following rules — all of which required separate consideration. I therefore dropped that code for being too broad and unspecific, and I did the same with *trustworthiness and reliability*.

In developing themes, I constructed several code clusters. One cluster formed around the notion of technological progress, capturing participants' reflections on automation as a sign of our times and linking personal, professional, or national identity (for example, being Estonian) to ideas of progress. These clusters ultimately formed the theme *Robots as a Symbol of Progress*. Another cluster focused on mutual responsibilities, grouping codes about how interviewees negotiated acceptable behaviors toward robots and expressed expectations of developers. This became a core part of the *Robots are Community Members too* theme. A further cluster concerned the dynamic, evolving experience of encountering robots, with codes addressing first impressions and changing attitudes over time. For vendors, this included the perceived seasonality of orders. This cluster developed into the *Getting to Know Each Other Takes Time* theme. Another cluster focused on robots as actors in communities, with codes capturing affective responses (such as joy) and how robots were framed as community members. This cluster contributed to both the *Robots are Community Members too* and *Robots are Social but not in the Same Way as People* themes. There was also a cluster on perceived and experienced utility, including practical limitations (such as robot size) and the broader sense of purpose participants attributed to robots. This became the *Not Using Does Not Mean Useless* theme. Finally, codes related to helping robots formed another cluster. Initially, this was at risk of remaining a topic summary. However, during theme development and writing, these codes were integrated across the themes *Robots are Community Members too*, *Robots are Social but not in the Same Way as People*, and *Getting to Know Each Other Takes Time*. This integration reflected my observation that helping robots was experienced as dynamic and evolving, linked to perceptions of robots as quasi-social actors and as community members.

In the end, as a result of this iterative process, I ended with five qualitative themes:

- Robots as a Symbol of Technological and Historical Progress
- Getting to Know Each Other Takes Time
- Not Using Does Not Mean Useless
- Robots are Community Members Too
- Robots are Social but Not in the Same Way as People

In the section that follows, I elaborate on each of the themes and their sub-themes, highlighting analytical insights with examples from participants' statements.[4] As specified in Chapter 1, when reporting the themes, I also include observational vignettes as a way to bridge the interviews with insights from the observational data.

5.4 Reporting the Themes

When presenting the themes, I first present the semantic core of the theme. I then proceed to elaborate on it.

5.4.1 Theme 1: Robots as a Symbol of Technological and Historical Progress

This theme centers on a core assumption shared by most participants: robots, as emerging technology, symbolize technological progress. When relating to their own identity or the identity of places where robots are deployed, participants framed technological progress—and consequently, the robots themselves—in a positive light.

[4]For publication purposes, I preserved participants' phrasing but redacted markers of spoken speech, such as filler words and excessive repetitions. When redacting, I ensured that the content of the statements remained unchanged.

When discussing their experiences of and attitudes to witnessing autonomous delivery robots in public spaces, many participants appealed to the notions of *technological progress*, with the delivery robots consequently being framed as instantiations, or symbols, of technological progress and contemporaneity. The implicit assumption that many of my interlocutors seemed to espouse was that technological progress in itself is *good* as it is presumed to improve people's lives. Equating progress with "good" meant that some interviewees viewed the robots as something that is "cool" because they are in line with their times: "In general I appreciate it. Because it is something new, it keeps with the time" (Jelena); "In general, for me, just making advances in technology or automating things is cool. So that, you know, coming from that thought I was thinking, because for the first time, I feel like, although a car is also technically like a robot, but for the first time I'm seeing this thing, you know, go by itself on the street. So in that way I thought it was cool" (Anika, UK). Vendor Nina even framed technological development in normative terms as something that is "ought to be": "In general, I understand that it would be great if [the robots] were developed and were used to help to deliver different goods, for many people [who] need help. And I think this holds a big potential. And I believe that there should be [technological] development."

Technological progress was thus construed by the respondents in idealistic, almost romanticized terms, with desire to improve human lives being an assumed main driver behind it. In this context, technologies such as Starship robots were also viewed as embodying human creativity and potential of the human mind: "Yes, this is why with robots it's like this, the attitude to them is slightly different than to household appliances. My initial idea is that behind the idea there is a person who inscribed their ideas, vision, and their wish to make people's lives easier" (Vendor Nina).

When situating themselves in relation to technological progress, various constructs of *identity* were evoked. For participants living in Estonia, *national identity* in particular was a construct they referred to when explaining how they perceived encountering Starship robots in their daily lives. Irrespective of their mother tongue and ethnic origins (Estonian or Russian), it was common for the interviewees to frame Estonia as a country that has established its competence in the IT and digital services spheres globally. Starship robots were thus considered not as a disruptive technological intrusion, but as an almost "natural" occurrence in the line of technological developments originating in Estonia. Participants welcomed such occurrences, and shared pride for being an Estonian citizen: "Well, we are Estonians, so to say. I mean, of course we are proud that there are many inventions in our country. For example, the elections, the ones that are conducted online – we were also some of the first ones in this. Of course, there is pride for that. And the robots are one of it all" (Jelena).

The pride and the feeling of co-participating in the technological progress happening in Estonia were further propelled by situated experiences of interactions with Starship robots in daily lives. Interviewees relied on their embodied and experience-based knowledge of observing and learning how the robots work (more on this in subsection 5.4.2) to inform their understanding of the robots not as mere technological curiosity, but as artifacts that are safe, functionally reliable and “well coordinated”: “ [...] It proves that we are [a] digital country, we have this E-Tiger and everything what we are talking about. If we see that it works really, there is no accompanying assistance somewhere, somebody’s safely coordinating all these many machines which are at streets, then I enjoy this. I’m proud of it” (Sofia).

The association of Starship robots with Estonia as a digital/IT brand, strengthened by the overall positive experiences of witnessing the robots work as they should, thus meant that Starship robots, though surprising at first, were quickly normalized. The interviewees based in Estonia considered the sight of the robots on the streets as “normal” – in Tallinn, the robots had by the time of the interviews become a part of the cityscape: “Yes, I’m from this side of Tallinn where these Starships were created and started to move over in central Tallinn. Everybody, I don’t know, especially tourists, they are so fascinated. [They] don’t know what they are... I’m quite used to this, but in the beginning of course, I was a little bit surprised. But of course media very quickly, like spread this information that this is our new technology. And I think in Estonia we are like used to it, it’s not so surprising that something has been tested” (Sofia).

The sense of pride invoked by witnessing the robots on the streets may have been further reinforced not only by the association with the technological and entrepreneurial environment of Estonia, but by the broader political and historical context. The rapid socioeconomic development that followed the restoration of independence of Estonia in 1991 by many is seen as a part of the process of Estonians reclaiming their unique identity in opposition to the lack of ideological (and economic) support for entrepreneurship characterizing the Soviet rule. From this perspective, Starship robots take on a role that exceeds being a mere functional artifact, or a part of the last-mile delivery offer. They function as a semiotic device, with extended role accommodating being symbols of a different, forward-looking historical path for the Estonian people. At the background of (architectural) reminiscences of the Soviet past (there are still a lot of buildings in Estonia built in the Soviet era), the robots thus contribute to the unique character of Estonia and its urban landscapes: “Estonia is a post-soviet space. There are Soviet elements, but also new technologies and start-ups culture. This adds character to the place” (Vendor Oleg).

The feeling of being co-present in, or even contributing in some way, to technological development happening right in front of their eyes for the interviewees based in Estonia was further emphasized by the opportunity they had to witness and experience Starship robots at different stages of their development and testing from the first trial runs, accompanied by Starship employees, to seeing the robots as they are today navigating the streets (for the most part) autonomously. The proximity to Starship Technologies’ “origin story” thus may have contributed to Estonian participants’ predominantly positive attitudes towards the robots: “That’s how it was originally a training project, there were always students who studied at the Technical University and who walked with these robots as if they were babies. Now they are driving independently. I myself studied at the Technical University. Therefore, in principle, probably, since those times it was already clear what was behind each robot” (Vendor Nina). In the quote above, the narratives about the origin of the robots are seamlessly constructed, wherein bits of one's biography, narratives about start-up culture, and experiences of witnessing the robots at various test stages are intertwined into accounts that are only partially factually true.[5]

The *sociocultural identity* of the place also mattered for how the interviewees from the UK made sense of the robots following their deployment in Cambridge. The interviewees speculated that people in Cambridge, including themselves, were more open to embrace technologies such as Starship because many city inhabitants are closely involved in various spheres of research and development. Being a university town, Cambridge was thus seen as a *good fit* for Starship robots: "Especially in Cambridge, here, you have a lot more students, you have a lot of people who are kind of doing some sort of science, or are, you know, at the cutting edge of scientific research. So it feels natural to me that this is how we're going to go in the future. That is, you know, one day we're probably gonna see robots flying too. I mean, we have drones delivering goods, but then we're probably gonna see a lot more robots commonly around us. And I feel like, probably for a city like Cambridge, it might be easy to notice it or get used to it" (Anika, UK).

Similarly to the participants from Estonia, the UK interviewees were also prone to describe themselves as forward-looking and technology-affine which shaped their perceptions of the Starship robots as progressive and thus exciting. Lily (UK) further contrasted her attitude with those who are in critical opposition to any technological innovation. In her view, blunt denial of all technologically mediated change was narrow-minded, and characterized by the lack of ability to change one's mind: "So I think, generally, people have a good attitude towards it and are like, oh, it's just, you know, delivering someone's shopping. But obviously there are few people in the world, which will always have that hate [of] change. And they think that robots are going to take over the world and are just ignorant about it". For Anika too, the mere fact that the robots could be considered as part of technological development was sufficient to embrace them: "I definitely feel that we am supportive of robotics or automation, as long as it's providing us value, or things are more efficient, faster. But I'm actually yeah, for some reason, I'm not even thinking in terms of, you know, emotion, or the social impact or what people are going to feel. For me, it's more about if there's going to be development progress, I'd support it."

Framing Starship robots as a part of technological progress, supported by seeing oneself as a progress-oriented and open-minded person, for Starship *vendors* contributed to the motivation to collaborate with Starship. In their view, collaborating with Starship for last-mile delivery service contributed to strengthening of their brand: "[we agreed to collaborate with Starship] because we were the first here, who started the first with it, in Kalamaja, before they [robots] were not really seen here. So we discussed it – and indeed, it interested us" (Vendor Jaana). Not only were they open to such collaborations, some of the vendors I interviewed shared they were the ones who had reached out to Starship in the first place because they liked the idea and thought it aligned with their enterprise identity. For example, Vendor Nina explained how she thought the concept of the store

[5]To the best of my knowledge, Starship was not one of the students' project.

she managed (ecological and zero waste produce) aligned with the form of delivery offered by Starship: “And as we are, in principle, a zero waste store, we thought it would be really nice in our district. Because Starship was first in Mustamäe [a residential area in Tallinn where the engineering office is located hence the robots were first tested in the area], then they expanded their zone where they operate, yes. And we thought that this would be a very cool collaboration, you don’t need any resources, or many resources, to deliver our goods.”

When the staff I interviewed was not involved in decision-making about adoption of Starship as a form of delivery, the choice made by the management was still construed as something that was cool and worth trying out: “[...] Because one day they were here and our owners just told us that oh, it’s the new version of like, delivery. And it’s so cool, and we are like trying it” (Vendor Silvia).

While progress was viewed by the interviewees as overall a positive trend, there were, nevertheless, constraints with respect to how far the interviewees were willing to stretch the idea of technological evolution and automation. These constraints were rather speculative in nature and were likely shaped by the discussions in the media around the topics of automation, replacement and technology acceptance. One way how such constraints were instantiated in the data was through the “but not too much” logic. When asked about how they saw the future to come, it was common for the interviewees to say that, while overall they did not fear futures with robots, “too many” robots is nevertheless not what they wanted: “Robots are good, you know, but not too much. Like right now it’s good. I cant imagine world with like, only robots” (Vendor Silvia). Katerina was more specific comparing sidewalk robots with bikes and e-scooters: as the experience with the latter shows, there may come a point of over-saturation when the amount of robots on the streets may become hazardous, and this is something that she would like to avoid: “But if there will be a lot of bikes, and okay, we have a lot of scooters now growing, then they might become hazardous because they would stop on any action or any obstacle that is in their way. But the person cycling might not expect it and then stop and then run it over. So as long as they don’t like, how should I say, become an obstacle? Suddenly. Because of its robotic reactions, then I’m fine with it.”

In other words, the interviewees assumed there exists a critical threshold that, if reached, would hinder public safety and well-being, and then their welcoming attitudes might shift to more negative: “I have thought that if we would have more robots at streets, for example, big and small and different shape and so on. We have now only these Starships, and we are used to it. But there is some kind of critical line that how many robots can be at street because of safety. Already in Mustamäe we have these without driver busses. And already we have like two not coordinated machines at streets, and if we have more, then where is this critical line that we still feel safe?” (Sofia)

“But not too much” logic also extended onto vendors who shared that while the current amount of robot-supported deliveries was rather low and did not hinder work practices too much, should the amount of the robots increase drastically, it may become a challenge to service the robots without employing additional staff.

To summarize, participants viewed Starship delivery robots as symbols of technological progress, associating them with positively valenced connotations such as efficiency, creativity, and societal advancement. In Estonia, the robots were seen as a natural extension of the country's digital identity, evoking (national) pride, while in Cambridge, UK, the robots were welcomed as fitting within the city's research-driven culture.

5.4.2 Theme 2: Getting to Know Each Other Takes Time

This theme is developed around the aspects of dynamism and change involved in the process of the robots becoming more ingrained in public spaces and people's lives. By focusing on the first impressions participants had of the robots, how these shaped their proactive behaviors (or lack of thereof), and how these evolved in situated interactions through experimentation, observations and mutual adaptations, this theme contributes evidence to how situated interactions co-construct human-robot ecologies (Forlizzi, 2007).

Despite the overall positive stance towards technological innovation, with the latter considered almost as 'new normal' for Estonian socio-technical landscape (see section 5.4.1), many participants shared how during their first encounters with the robots they experienced a degree of uncertainty and doubt about what the robots were, and how one should/should not behave around them. For some of the interviewees, the initial lack of experiential knowledge and information about the robots resulted in feeling fearful. These experiences align with existing literature on the novelty effect where the initial period of interactions is associated with uncertainty (Reimann et al., 2024). Several interviewees shared they were cautious of, and sometimes avoiding the robots because they did not want to obstruct them, nor get hurt themselves: "I don't know, [fear] to ruin something, to do something wrong, to break something" (Jelena). Sofia also pointed out how her initial insecurity had to do with not knowing how capable the robots were to deal with the environment: "And maybe also in the beginning, I was a little bit afraid that they don't see the cars because I didn't know" (Sofia).

While people were generally willing to assist the robots when they perceived them as needing help – as also supported by the observations and online content analysis presented in Chapter 4 – some of the interviewees were hesitant to do it at the early stages of encountering the robots on the streets because of the similar fear of breaking something or getting hurt. For several interviewees, the fears extended as far as considering a possibility of receiving an electric shock should they touch the robot: "I saw a lot of situations when they just were trapped in snow and so on. And I thought "Okay, what happens", and you also had the question that if they have problems would I help them, then at the beginning I didn't dare. [...] because I didn't know in the beginning, it was like so new. Do they give some kind of electric shock for me? Or [if] something is wrong, not connected correctly, they are testing these, the person just disappeared for a moment, and then how I'm touching them and what happens, if some kind of alarm is starting – you are stealing the robot – that kind of things" (Sofia). With time, these initial concerns and hesitations dissolved as people grew more accustomed to the robots and had a chance to understand what one could expect.

The interviewees shared different strategies they engaged in on their path to getting to know the robots. One common strategy mentioned was simply observing the robot and how it interacted with its environment and other actors in it: “And I kind of saw how it was interacting with people. So when there were a lot of people walking on the footpath, then it would always stop to let people pass. So it felt like it’s always sensing its environment most of the time. There was a time when it [...] was funny, because it went on the side of the sidewalk, the wheel was on the road, like half on the road and half on the sidewalk. So it was trying to get out of that situation” (Anika, UK).

People casually took on the role of lay researchers by focusing on the robot’s perspective and trying to deduce the mechanisms underlying the robots’ behavioral outputs: “I observed it when I was on my bike. And I was crossing a double pedestrian red light. So you would have to cross one to the small island and then cross the second light. So I was observing it was kind of cute but hesitant. Because first of all, it stops when any human goes in... Like if there’s any barrier in between, like, on its way, so it will have to stop. Then it had to react to the red lights. So that’s when I was observing” (Katerina). In her attempt to make sense of the robot, Katerina thus drew on folk psychological concepts cf. (Thellman, Graaf, and Ziemke, 2022) as well as her prior knowledge of the practices that uphold social structures (such as traffic regulations).

In the role of lay researchers, some interviewees engaged in more proactive strategies to explore how the robot will respond in specific situations which also aligns with the observations insights presented in Chapter 4. Interviewees mentioned similar proactive strategies such as positioning oneself on the path of the robot to see how it will respond: “So I kind of stood in front of the robot, not directly in the front, but kind of close by but not so close by, not on its way. And I felt like the robot was sensing me or sensing somebody and it was just not moving. So you’re just staying there, waiting. And then when I moved a little bit, it went forward and said thank you very much” (Anika, UK).

Getting to know the robots as new actors on the streets, according to the interviewees, involved negotiations of shared spaces, mutual adaptations, and concessions made to the robots. For example, negotiating narrow sidewalks was one of the situations participants mentioned as requiring some concessions to be made to the robots: “Yeah, as soon as the pavement is quite narrow, the robot I think just stops and waits for pedestrians to move around it. But then people have to walk around the robot, and not the other way around. I can only speak for the Cambridge where the pavements are incredibly narrow. And sometimes you can’t fit two people on one pavement. So one has to step on the road anyway.” (Lily, UK) (see also Ethnographic vignette 5.3).

In response to my question about how she feels about the situation when she has to yield path to a robot, Lily shared for her personally there was no difference whether she had to negotiate path with a human or with a robot. In her opinion, such negotiations and mutual adaptations are a natural part of our daily lives – so why not extend them to robots: “When it’s going in front of me on a narrow pavement, and if there was a human I would behave exactly the same way. I can probably move a little bit, or step on the

As the robot approaches a crossroad, I see a woman, whom I estimate to be in her fifties, crossing the road from the opposite side. Having noticed the robot, she pauses somewhat. Though there is enough space for both her and the robot to pass, she looks somewhat insecure, with her body language —- small swings from one side to another —- suggesting she's not sure how, or from which side, she ought to overtake the robot, and what to expect from the robot in response. Instead of sticking to her course, she proceeds to swing even more until she has finally passed around the robot. She turns her head to cast one more look at it as she proceeds on her way.

Figure 5.3: Ethnographic vignette: Woman negotiating path with a robot on the street. August 2022.

Figure 5.4: Situated adaptations. Left: Person swirling to allow the robot to pass. Right: Two people breaking walking in couple to give path to a Starship robot. December 2021.

road in a safe space. And so this would... there's no different of me interacting with a human or with the robot" (Lily, UK) (see Figure 5.4).

Not all people, however, wished to be as accommodating. One person I spoke to shared how his initial reaction to seeing a Starship robot crossing the street was the wish to drive over it. When reflecting on this strong reaction, he recognized that it had to do less with the robot itself but more with the fact that a private company was contributing

Figure 5.5: A driver pauses at a turn to allow a Starship robot to pass. December 2021.

to pollution of public spaces. In that regard, sidewalk robots were not much different from e-scooters.

Regardless of how they chose to behave and whether they viewed concessions to the robots as a trivial thing to do or opposed to the idea, most of the participants pointed out that not for all people at all times making such concessions is possible. In particular, people with reduced mobility, or elderly people, were evoked to exemplify this point: "But at the end of the day, I don't think the robots should 100 per cent have priority, because obviously, there are people that will find it harder to get out of the way of the path like wheelchair users, etc" (Lily, UK).

Another common situation involving negotiation of the right of passage, and initial lack of clarity with regards to what an appropriate behavior should be concerned drivers and instances of robots crossing roads. At the time when the robots were first rolled out, it was common for the drivers to stop at the pedestrian crossings and wait for the robots to pass (see Figure 5.5 and Ethnographic vignette 5.6).

In 2017, Estonia was one of the first countries to amend traffic laws to incorporate regulations concerning partially or fully automated or remotely controlled vehicles (*Liiklusseadus–Riigi Teataja* 2017). Per these amendments, drivers were required to yield path

The robot has now approached a small side road. While there is no traffic at the moment, it nevertheless stops. A driver approaches from the opposite direction, his right indicator signaling his intention to turn right, onto the small side road the robot needs to cross. The driver notices the robot and pauses for a moment, suggesting he is waiting to see whether the robot will cross. The robot does not move. The driver takes the turn.

Figure 5.6: Ethnographic vignette: A driver yields path to a Starship robot. December 2021.

to the robots on the dedicated crossing points. The robots, however, are programmed to fair on the cautious side and not to move when their sensors detect headlights. This rendered the prescription to yield path to the robots in many instances useless because it led to the situations when both the driver and the robots were waiting. This situation was an occurring event in my early observations, and something that was also mentioned by the interviewees as based on their personal experience of either witnessing such situation or being in the role of a driver: "That's why there are no fears or terrible situations. They are very cautious. Before they cross the street, they stand for a very long time. Some people stand and wait for them: Look, the cars are letting you pass! Some cars signal at robots – pass! As if the robots understands that if I'm being honked at and they stopped, then I can pass. They will still wait for the stream of cars to pass and only then will cross the road" (Jelena).

Jelena's words point to another relevant aspect related to how (some) people formed models of the robots' behavior by implicitly assuming the same modalities of communication and interpretative schema that applied in instances of human-human interaction would translate to instances of human-robot interactions c.f. (Thellman, 2021; Thellman and Ziemke, 2021). In this case, Jelena's example points to the expectation she assumed people honking at the robot had that the robot will not only "hear" honking but will also interpret it correctly as a sign that the driver honking is eagerly awaiting for the robot to pass and granting it passage.

Social media and mass media played a significant role in shaping people's awareness and expectations as they became familiar with the robots. As discussed earlier in Chapter 4, the introduction of robots in Estonia sparked a lively response on social media and received considerable press coverage. Press releases and articles highlighting specific events, such as people helping robots or discussing related legislative aspects, contributed to the knowledge gained through real-life interactions on the streets. This helped people form an understanding of what was expected, acceptable, and the intended purpose of the robots: "I was not very eager to test them at first, when I saw them, but definitely this functionality was so very quickly spread out in media that it's possible to order different nice special food, but also other things" (Jelena). Concerning instances of voluntary

[...] The robot is now at a large and busy crossing. It succeeds in crossing the first two roads without incident. However, something goes wrong just as it is about to navigate onto the pavement —- it gets stuck, with one side hanging above the traffic road. There are no cars in sight yet, but the situation does not look good. The robot's wheels are rolling as it tries to get itself out of the situation. A minute passes, but things are not improving. Meanwhile, a young man on a bicycle, perhaps in his early twenties, is approaching the crossroad from the side where the robot is stuck. He crosses the street and pauses in the middle, on the area separating the two roads. He has clearly noticed the robot. One leg is now hanging off the bike —- it looks like he is uncertain about what he needs to do. The light switches to green for him, but he does not leave. His hesitation is evident. Rather than being curious about what is happening, he looks quite concerned. Finally, just as he is about to get off the bike, the robot manages to get onto the pavement, away from traffic and into safety. The situation is resolved. The young man gets back onto the bike and cycles away.

Figure 5.7: Ethnographic vignette: A cyclist uncertain about helping a robot. August 2022.

assistance, when asked whether she thought these instances decreased in time, Jelena responded that in her view, the opposite had happened: "It seems to me that it's the other way around. That is, when they first appeared, everyone was afraid. And no matter how afraid you are, you don't know, you don't know how he [the pronoun used by the interviewee] should... maybe he should be standing there in the snow, stuck. Well, you don't know. But then later when it started to appear in the media, that someone helped there, it became more common" (see also Ethnographic vignette 5.7).

With time and through increasing awareness and habituation, the robots have become a 'normal' part of the everyday city life. With habituation, a certain sense of routinizing, with new patterns of behaviors forming that accommodated the robots presence: "People probably began to pay less attention to them. Before, yes, you are driving a car, you look, that everyone seems to be paying more attention, just in case. Now everyone seems to know that it is safe, that they are doing their job. It's as if we are separate [doing our thing], they are separate [doing their thing]" (Jelena).

To conclude, this theme highlighted the dynamic process of how robots gradually integrated into public spaces and people's lives, focusing on participants' initial impressions, their evolving behaviors, and adaptations during interactions. Although people were generally open to technological innovation, early encounters with the robots often involved uncertainty, caution, and hesitation, which dissipated over time as people became more familiar and comfortable with the robots' and their perceived role.

5.4.3 Theme 3: Not Using Does not Mean Useless

This theme explores how interviewees interpreted the *purpose* and value of the robots, extending beyond their practical utility and the performance of their designated tasks.

The overall positive attitudes towards Starship robots – be it instantiated through connotations of progress or simply because the robots were experienced as "cute" – did not mean people were insensitive to the perceived *functional limitations*. The perceived limitations mentioned included: *relatively slow speed of delivery* ("I don't think at this stage, with their efficiency of speed of movement and crossing the roads, I don't think he can beat delivery couriers, [who] travel on the bike or on the car" (Arthur, UK)), and *limited ability to access* destinations and delivery points: "Here not everywhere it is possible to access the yards. I mean, there are certain places where one can come. In other words, not everywhere one can come and get the delivery, yes" (Svetlana). Another common functional limitations mentioned was *small volume* that the interviewees perceived as insufficient for, for example, weekly groceries shopping: "The one thing I think about is that the other day, I ordered quite a big delivery because I wasn't able to leave the house. Now, I was quite conscious about how much space obviously having used one before, I know that they're not massive, they do have a fair bit of space. But to someone who was trying to plan for at least a week's worth of food, I was very conscious of whether it would actually fit in the robot or not" (Lily, UK); "why they are so small, because maybe I need two bags for food for my home" (Sofia).

Vendors, too, saw functional limitations including speed of delivery ("I heard once that one robot went there, like, by walk it's five minutes. It delivered there [for] 45 minutes. I was like, Oh my God, it's too much" (Vendor Silvia)), and the robot not being able to park at all locations. The latter in some cases meant staff had to go outside and walk some distance to package the robot and send it off: "[...] Since the sidewalk here is too narrow and the journey to the yard is so difficult that they have to be loaded from there" (Vendor Eva) (see Figure 5.9 and Ethnographic vignette 5.8).

Acknowledging these limitations and not perceiving added value that robot-based delivery could bring to their lives, most interviewees – while supportive of the concept – *did not see themselves as potential Starship customers*: "I don't know even how it could be useful for me. Maybe it's useful for me to get some kind of delivery, but I've never found a way where it would resonate or pop out and be like, Oh, you need this solution. Because I know it's a delivery method, but I've never had even the impulse, need, interest to use it" (Katerina).

A key aspect of this theme, however, is that not seeing themselves as Starship customers didn't lead the interviewees to deem the robots generally *useless*. Some participants suggested that, even if they don't personally use the robots for delivery or plan to, they believed the robots must still be beneficial for "someone", be it elderly individuals or people with disabilities: "In Mustamäe they appeared before other districts, this is why Mustamäe inhabitants got used to them before other districts' residents. And I assume they are using them quite actively" (Vendor Nina). Sofia shared that she observed how

As I sit and watch around preparing to order, the women continue chatting behind the counter, while moving in and out of the kitchen area. They chat in Estonian, and from what I manage to catch, they are discussing who will leave before they switch to another topic that I cannot keep track of because I am now about to place my order. The order is now placed. The app notifies me that the order is indeed placed, and expected time of delivery is 10-20 minutes. Meanwhile, another customer enters, places an order and sits at the table in front of me. We are now facing each other. Still nothing happening, and the women continue chatting. Soon enough a rather loud "bling bling" sound is heard – must be the Starship app. Another woman, not the one that served me first, comes to a device that I notice is installed between the coffee machine and among the galore of old-fashioned pastries. She presses, while chewing on some snack my order has distracted her from, something on the device, and I get notification that my order is now being prepared. I watch her pack the donuts into a paper box and then wrap the box in a plastic film – probably to preserve the warmth as the donuts only make sense when they are warm. Not to miss the moment of departure, I rush to put the notebook into my backpack. As I put on my jacket, I see the man at the table in front of me taking a picture. As I turn my head in the direction, I realize he's taking a picture of the woman who is already out, putting the donuts in the robot. She sat down, with a phone (device?) in her hands directed at the robot. Most likely, she's pressing something to send the robot on its way. She's not wearing a jacket, and I am reminded of the conversation I had with [vendor] manager who told me that it may not always be convenient to walk to the robot…

Figure 5.8: Ethnographic vignette: Experience of ordering from a doughnut cafe and observing staff loading a Starship robot. February 2023.

this method of delivery was beneficial for some of her neighbors: "And for example, in our house, there were retired persons with problems, with moving, but I was even surprised how quickly they... probably the grandchildren, or somebody's showed what to do with apps and how to order food, and these robots were like friends for them, because we just visited once a week or so. And, and I really saw that this is useful, not only with somebody bringing, or something, is bringing food for you". Although not always perceived as practically or functionally useful, the interviewees generally felt that the robots served a purpose and were fulfilling their intended role—delivering something to someone: "And it's also doing like a function, it's doing something where it's transporting something for someone from point A to point B. So in that way, it's nice" (Anika, UK). The perception of the robots as having a *purpose* may have been reinforced by the assumption that technological advancements are ultimately meant to benefit people, as explored in subsection 5.4.1: "Of course they are useful, as a form of technology in principle. I don't know if we can still talk about it as a novelty. Probably

Figure 5.9: Restaurant staff, without winter coat, holding a paper bag she is about to load into a Starship robot. December 2021.

not anymore for quite some time already. But, in any case, as an idea, as an innovation, the introduction of automation of a process such as food delivery. It can in principle be an automation of anything else. With similar technologies" (Jelena).

An additional value of the robot-based last-mile delivery was also associated with the perceived *sustainability* of this method of delivery when compared to deliveries made by cars. Similarly to Vendor Nina, Lily (UK), speculated how robotization of the last-mile delivery may pay off in the future by reducing pollution: "I think it's going to be such a great thing to help with future because obviously, a lot of people, at the minute they get prescriptions and stuff delivered, but that still obviously contributing to pollution because it's usually driven by a human. And so if that could adapt into delivering prescriptions, and other things.. That I mean, could be so valuable to so many people."

Additionally, the perceived value of having these robots navigating city streets was influenced by the enjoyment they provided cf. (Ylirisku and Arvola, 2018). Many participants and online commentators expressed how encountering Starship robots often brought smiles to their faces. This further underscores the importance of considering other factors beyond the perceived utility and ease of use cf. (Davis, 1989) for understanding of acceptance of functional robots in public spaces. I substantiate this point in Section

Soon enough, two people (a couple, or two friends), are walking with quite high pace in the direction facing the robot. I hear them giggling. Without slowing down, the man leans down toward the robot, stretches his hand as if to give it a high-five and says "hey hey" in a cheerful manner. Quick as this interaction was, the couple proceeds on their way.

Figure 5.10: Ethnographic vignette: A couple imitating high-fiving a Starship robot. December 2021.

5.6.2.

This theme unpacked how interviewees perceived the purpose and value of Starship robots, emphasizing aspects beyond their practical utility and task performance. While participants acknowledged the robots' limitations, such as slow delivery speeds and limited capacity, they generally viewed the robots positively, recognizing their role in the community and the enjoyment they provided, which contributed to their overall acceptance of robot-based delivery systems.

5.4.4 Theme 4: Robots are Community Members too

This theme examines how Starship robots are perceived and experienced not just as technological tools providing services, but as new participants within local communities. It emphasizes the socio-material and relational fabric of the everyday interactions with these robots, highlighting their significance in seemingly inconsequential moments.

Firstly, viewing the robots as members of the community was linked with the interviewees' observations that the robots could integrate into the established norms and routines of using and sharing public spaces relatively well. For instance, several interviewees noted how well Starship robots adhered to traffic rules and regulations, thus remaining safe for pedestrians on the streets: "But I mean, it does follow all the other, I guess, usual road regulations, like pedestrians [are] doing. I think for a robot that I have no idea really how it works, it's very good" (Lily, UK) (see Figure 5.12 and Ethnographic vignette 5.11 for comparison).

Secondly, in addition to adhering to established protocols for navigating public spaces, the interviewees highlighted the robots' ability to *observe social etiquette* that humans typically rely on during everyday interactions. For example, interviewees appreciated how the robots thanked people when people assisted them following requests for help. These seemingly minor acts of courtesy prompted the interviewees to describe the robots as "polite", as was also evidenced in the outcomes of the online content analysis presented in Chapter 4. For instance, Anika reflects that it is not just "nice" for a robot to exhibit such behavior; it also makes the robot somewhat comparable to a human: "It's something like what we humans do, right? If you give somebody the way, then the person acknowledges

There are already two people waiting to cross. The robot approaches one of them, a woman, from behind and first pauses. The woman is not noticing the robot at this point. It then proceeds to squeeze itself from behind and in between this woman and another woman who has joined at the crossroad, moving closer to the road (see Figure 5.12). This is when the first woman also notices the robot being there. It makes me wonder about the proxemics in this situation – is it polite for a robot to try to squeeze itself closer to the road? Should it remain standing behind the people? Which decisions were involved in planning for this? Meanwhile, as they are waiting, it looks like the second woman has chosen to keep herself a bit further away from the robot, allowing it to occupy the 'front row' in front of the crossing where she initially stood.

Figure 5.11: Ethnographic vignette: Informal norms at a traffic light.

Figure 5.12: A woman allowing a Starship robot to take over the spot she occupied at a traffic light. December 2021.

it. So I felt in that way the robot is being nice that, you know, just like a human that hey, thanks for giving me way. So in that way, it was nice" (about the situation when the robot thanked her for yielding the path).

Thirdly, by recognizing robots as part of their local communities, the interviewees also reflected on how people, including themselves, should behave around and toward these robots. Most participants indicated that they anticipated others to follow standards of polite civic behavior when interacting with the robots. As a result, they condemned any acts of vandalism or harassment against the robots, whether they had personally witnessed such incidents or heard about them. Lily (UK) evoked the notion of "common sense" as a rationale she used to articulate informal guidelines for how people should behave toward robots. She even assumed that people not respecting norms of polite behavior towards the robots should be informed of unacceptability of such behaviors: "I mean, I think people that just stand there and refuse to move out of the way of the robots need a bit of a smack into reality. That sounds a bit aggressive. [...] But there are people that are just ignorant, and they will just stand in the way and I think those people need to grow up and accept that this is going to be part of our community now, and it's really helpful". Katerina echoed these thoughts when sharing how she considered that vandalism towards robots is not the way it should be: "Yes, I think it would upset me [if people harassed the robots]. I think it's, well, not that it's not that I would relate it to feeling hurt. But I would feel like this is not the right thing. It shouldn't be broken, hit. It's not the way it should be."

Importantly, many interviewees viewed acts of kindness, such as voluntarily assisting the robots, also as "commonsensical" or simply the right thing to do. As mentioned earlier, most participants indicated that they either had helped or would be willing to help if they encountered a robot in need. However, this doesn't imply that they felt a moral obligation to assist the robots, nor did it involve attributing mental states to them. Instead, offering help to the robots was seen as a means of maintaining the social and normative fabric of the community, with a refusal to assist being perceived as impolite: "It's very useful that, okay, it's not working, somebody just helps a little bit and it's working again.[...] And, and it's not hard. Or maybe it's even disrespectful or impolite that I'm just walking through and I am looking to the other side while I'm doing this" (Sofia). Vendor Eva expressed similar sentiments, stating that, in her opinion, it doesn't matter whether it is a robot or a person in need of assistance – helping others is simply what people do: "Ah, it's like it doesn't matter, someone falls down on the street, or someone's bag falls, it's like immediately you go, you're going to help." When discussing people's assistance to robots, Lily (UK) further noticed that helping robots is not that different from helping other people on the streets, and that there will always be people who will choose to help and others who will ignore and simply pass by: "But I mean, people will probably just see it and walk past it. It's like, where you've got someone who's hit a cap, for example, and they'll just drive past it, or someone's falling off their bike and they just drive past it. There are people that have the common sense to do the right thing. And people who will just walk past and just ignore it. So I think people

My first encounter with the robot today was in front of [cafe]. A family with two young boys came; the boys are around 3-4 years old. One of the boys approached the robot and petted it on its head – the way one would pet a familiar plush toy. There was no hesitation on his side that he could do it – it was clear it was not the first time he was seeing the robot. The boy then carefully placed his scooter next to the robot (see Figure 5.14). Later, he petted it again and tried to tell his parents that the flag is for people to know that the robot is coming.

Figure 5.13: Ethnographic vignette: A boy petting a robot. August 2022

should help if it gets stuck because they're a great part of the community." Building on the socio-relational motivation to help the robots, Sofia mentioned that assisting Starship robots was important to her because it would model appropriate behavior for her young children.: "Because I have to be like, I don't know, some kind of not an idol, some kind of an example, a role model. If I don't help a robot, then I don't [help] a lady who has fallen down. I have to do something."

Figure 5.14: A blue toy scooter parked next to a Starship robot.

The relational, intersubjective dimension of what appears to be a simple interaction between a person and a robot became apparent as many participants expressed their concern for others who might be impacted by their situated choice. A frequent rationale for helping the robots – shared by both passersby and vendors – was the consideration of potential customers waiting for their deliveries. This motivation held even for vendors who, while off duty, encountered the robots as passersby outside their workplaces.

At the same time, embracing the robots as new members of the community, evident in actions like assisting them, was connected to people finding these interactions enjoyable and fun experiences in themselves. While interviewees didn't generally view the robots as having mental or emotional states, the design of Starship robots influenced how they were perceived. Similar to the online comments discussed in Chapter 4, many participants described the robots as *cute*. As Vendor Nina put it: "Yes, yes. The robots, they are really cute, we like to encounter them" (Nina). For the interviewees, this perception of cuteness was often linked to positive emotions, or, as Vendor Silvia described it, "positive vibes" associated with the robots (see Chapter 4). Many interviewees shared that they enjoyed encountering the robots in public spaces: "I smile. They look cute" (Katerina). This sense of enjoyment added to the impression that the robots blended well into their surroundings, contributing positively to the cityscape, even if they weren't always seen as practically useful (see Section 5.4.3). Vendor Silvia noted similar reactions from the public, observing that "usually people love them. Even like tourists taking pictures. With those robots. It's usually mostly positive, positive vibes". From this perspective, pro-social behaviors toward robots, like assisting them, were seen as rewarding in themselves: "Yes. Like many, many times, yes [I helped them]. Like, even in the winter time, basically, in the winter time when they got stuck, then people always help them. Robot said, Thank you so much or something like that. It's so cute." (Vendor Silvia) Relying on her background in design, Anika (UK) also emphasized that design matters for how people perceive and behave towards robots: "I feel like, first of all, I'm in the field of design. So I'm always going to be supporting design because I think it unconsciously affects the viewers or how people interact with things. So definitely, I feel if it's cute, you know, it might generate feelings, like how I had, you know, I need to protect this if something goes wrong, or I shouldn't harm it or kick it or, you know, box it or do things to it."

Lastly, another facet of viewing robots as community members was the acknowledgment of their *dependency* on developers and other stakeholders, including regulators. Interviewees highlighted expectations for developers (Starship Technologies) to take responsibility for addressing malfunctions and other issues, which impacted their overall trust in robots. Some participants in Estonia were willing to extend trust to Starship as a company, citing the strong reputation of Estonia's tech sector (see Section 5.4.1). However, they also noted that if this trust were breached, the company would face challenges in restoring it: "And then it is quite hard to push it back. So responsibility of these developers is quite high. So maybe, for example, if something happens with a very sensitive group, like a child or something, then it changes a lot. Now everything has been safe, and nothing has happened. But also, I think that if something goes wrong, then it's really hard to win back this trust, and how to do [this] because this technological world, it seems to be like so new, so deep, so many aspects, right?" (Sofia) In essence, by recognizing Starship Technologies as a "local company" behind the robots, people were inclined to extend their trust to the developers associated with them while also acknowledging that the trust is not unconditional: "I think my way of thinking is that the precondition that Starship are at street, it means that everything has been tested, that this is based on rules like how we we think, how we expect that person or car or any object at street behaves or acts, and of course we are trusting enterprises who have developed this" (Sofia).

This theme explored the perceptions of Starship robots as not just service-providing technologies but as active participants within local communities, emphasizing their role in everyday interactions and adherence to social norms.

5.4.5 Theme 5: Robots are Social but Not in the Same Way as People

From existing research in HRI and social robotics, we know it is common for people to treat technologies as quasi-social actors. Starting from the canonical work of Reeves and Nass (B. Reeves and Nass, 1996), to a plethora of studies on anthropomorphism in HRI (Duffy, 2003), we can expect people to anthropomorphize technologies. Although a much more substantial discussion on this will follow in Chapter 7, under this theme I unpack some insights with regard to the experienced sociality with Starship robots as instantiated in the data. In that regard, this theme was the one that was developed in the most deductive manner – already prior to the analysis of the interviews, it was important for me to explore how people experienced the Starship robot socially and emotionally, hence the analysis of the data was driven in part by the respective research questions, and related theoretical concepts such as anthropomorphism and sociomorphing.

As expected based on the literature in HRI and further evidenced by the online content analysis I detailed in Chapter 4, the interviewees relied a lot on anthropomorphic language to describe their experiences with Starship robots. It was common for them to compare Starship robots with children or pets because of the robots' miniature size and the likelihood of ending up in situations where they are perceived as being helpless: "I think, in my opinion, I see it [like] little pet because they're little. Like, obviously I know it's a robot. And it's like, I guess automated like a car. But it's just because they talk and they [are] just cute, I just love them. They are so sweet. So I guess that's why I see them like a stuck sheep. If they get stuck, then it's in a situation it can't get out. And it's like, Please help. So it's just me, and my crazy, stupid imagination" (Lily, UK).

As demonstrated by the direct quotation above, participants generally expressed awareness that these are still robots (i.e., neither humans nor pets) and that projections like the one mentioned by Lily should not be interpreted literally. Furthermore, some interviewees explicitly reflected on the struggles they had to find the appropriate words to describe what the robots are – not humans but not quite like other devices – and how they experienced them: "Because I think that it's like a little bit strange, but of course with robot it's something like I don't know. You have to be more polite [laughs], not so cruel... With bicycle and I don't know, this roller [scooter] is quite equal for me. It's like, transportation vehicle and so. But robot is... I don't want to give some kind of words related to this robot, which is related to human, but I don't know what kind of word to use because I can't find the right word" (Sofia). Philosopher Johanna Seibt refers to the disconnect between the robot's ontology, people's experiences with them, and the language used by both laypeople and scholars to describe these interactions as the **description problem** (Seibt, 2016).

Importantly, although many participants were aware of the gap between using anthropomorphic language and truly believing that robots possess mental or psychological states similar to humans, they still perceived robots as relational and social actors in some sense. For instance, two of the vendors I interviewed shared that they had assigned names to the robots they serviced. Interestingly, the name and the robot identity it conveyed were not assigned to a unique robot but 'moved' effortlessly between different robots [6] cf. (Bransky et al., 2024; T. Williams et al., 2021).

The observation that vendors were more likely to assign names to the robots than those who only encountered them on the streets in the role of passersby suggested to me a form of (unilateral) connection, a kind of collegiality – albeit performative – established between the vendors and the robots, treating them as quasi-colleagues: "Well it is not a human, no. But it's a kind of cool character, we like it. [...] Rops [short from 'robot' in Estonian] is its name. [...] So among us we say: "Has Rops come?", "No, one Rops is coming, see, getting in front of the other one", because sometimes there are two of them who come here" (Vendor Helen). When I asked Arthur (UK) why he believed some vendors gave delivery robots names, he likened robots to animals, explaining that, similar to certain animals, they may not exhibit enough perceived individuality or personhood (from a human perspective) to warrant individual names, but still possess enough liveliness and character to be assigned a collective name: "Well, that's to me, that's no different to looking at birds. At least for the untrained eye, the birds of particular species all look the same. But we do assign some sort of emotion to a species of birds, either like they are singing, or you like the appearance; some are red, some are yellow – you enjoy it. Same thing, where I was living previously, there were many squirrels running around. And we were calling all squirrels Ralph. So if we're doing it for animals, well, it's pretty much alike. And why we're doing it? Well, because it moves, it clearly lives, it tries to fly, tries to do something. While this robot is doing its job, moving around, why not?". This quote further highlights the role that autonomous navigation, perception of having a goal/purpose and, in the Starship case, cuteness, play in shaping the perception of Starship robots as a kind of social actors.

As discussed in Section 5.4.4, the analysis of the data suggested that robot sociality differed from the sociality found in human-to-human interactions. For example, while vendors assigned names to the robots and, like passersby, often used anthropomorphic language to describe the robots, when it came to their daily practices, they shared they

[6] The robots are not assigned to specific vendors. Depending on factors such as order volume and other considerations that I, as an external observer, am not entirely aware of, different robots are rotated among various vendors

would prioritize humans over robots. For example, in situations when they had to choose between servicing a human – be it a client or a human delivery courier – or a robot, they would prioritize the human. Similarly, while appreciative of the robots behaving "politely", Anika (UK) pointed out it would not occur to her to respond to the robot with a pleasantry such as "You are welcome": "So for me when I first you know, when the robot told me "Thank you". It didn't occur to me that I should say "You're welcome". It didn't occur to me that I should talk to the robot. So it didn't feel instinctive for me to talk to it. Because somewhere, maybe unconsciously, I felt it's not a human." Perhaps, the words of Vendor Helen, pointing out that no matter how cute or anthropomorphic, robot will still remain a robot, offer a good conclusion to this sub-section: "What's there to say about this robot? (laughing) It's not like you can really have a conversation with it".

Under this theme, I explored how people often used anthropomorphic language to describe Starship robots, while also acknowledging their unique status as non-humans, but yet distinct from typical machines. Participants frequently expressed affection toward the robots, showing forms of sociality by assigning them names or regarding them as quasi-colleagues.

5.5 Limitations

Although the sample was relatively small, interviewing passersby and vendors who regularly encountered Starship robots provided valuable insights into factors that influence community acceptance of robots i.e. the information power of the study was sufficient (Malterud, Siersma, and Guassora, 2016) to formulate contributions both to the ongoing studies of robots in public spaces and to how we conceptualize and study (existence) acceptance. However, I acknowledge limitations in the diversity of the sample. All participants expressed positive attitudes towards delivery robots, which meant that views from individuals who may hold less favorable opinions were not captured. Additionally, the perspectives of people from broader socio-economic backgrounds, such as those from lower socio-economic classes or without higher education, were not included. As mentioned in Section 5.6.2, studies on the acceptance of robots in public spaces should integrate experiences from diverse stakeholders, including groups that are less visible in academic HRI discourse, such as human delivery couriers or low-level sales staff in supermarket chains. I revisit this discussion in Chapter 8.

5.6 Discussion and Lessons Learned

The insights from the interviews with passersby and vendors enriched the themes identified in the initial exploratory study (see Chapter 4) and introduced new perspectives. A key finding was that the integration of sidewalk robots into daily life is deeply woven into the socio-relational and cultural fabric of local communities. Revisiting the interpretation of assisting robots as a form of care (see Section 4.4.1 in the preceding chapter), what appeared as a simple interaction often reflected broader relational and intersubjective considerations for others beyond the robot itself. This included care for both an imagined other, such as customers waiting for their deliveries, and real individuals, like a participant's children, who a parent hoped to set a good example for, or elderly neighbors depending on the robots for essential deliveries during the pandemic. Additionally, participants' care for the robots was influenced by design-related qualities—being "small" and "cute" – combined with autonomous movement and perceived helpfulness, which led to seeing the robots as helpful, yet sometimes vulnerable actors in public spaces.

Whether people saw the robot as 'social' was related to how well the robots integrated into the cityscape. Importantly, the latter depended not only on the robot morphology and design (being small and cute), but also on how well it aligned with existing practices and formal and informal norms, such as adhering to traffic rules or expressing gratitude when helped. Altogether, these socio-relational and cultural dynamics underscore the community's acceptance of the robots. This section, therefore, explores what such processes reveal about (existence) acceptance (Abrams, Dautzenberg, et al., 2021). To further analyze this, I will briefly introduce existing models of acceptance in HRI and then outline five insights from the interviews to expand our understanding of how robot acceptance unfolds in public spaces.

5.6.1 Acceptance of robots in public spaces

As noted by Fink, 2014, when it comes to robots acceptance, the key question remains not only what acceptance means in HRI, both in short- and long-term, but also which aspects it includes. In the HRI community, several models have been adopted and adapted to measure the acceptance of robotic technologies. Historically, the TAM by Davis et al. (Davis, 1989) has been used to measure the acceptance of computers at a time when personal computers were introduced in white collar work. Building on the theory of planned behavior (TPB) (Ajzen, 1991), in TAM, perceived ease of use (PEU) and perceived usefulness (PU) are assumed as main determinants of intention to use, with the latter considered a determinant of the actual use behavior.

While the TAM has been useful in predicting the influence of work-related aspects for computer program acceptance, recognizing the model's limitations in reductionist operationalizations of determinants of acceptance led Venkatesh et al. (Venkatesh et al., 2003) to propose an expansion of the TAM. The resulting Unified Theory of Acceptance and Use of Technology (UTAUT) converged multiple iterations of the TAM and related models and incorporated two new determinants: social influence and facilitating conditions, as well as four moderating constructs (age, gender, experience, and voluntariness of use), again with the purpose to predict use intentions. In the UTAUT, social influence subsumes behaviors influenced by beliefs how other important actors (e.g., supervisors) will evaluate use, while facilitating conditions address organizational, technical, and personal infrastructures and resources.

In the decade that followed, scholars have recognized the limitations in applicability of established acceptance models to embodied agents, such as social robots. Consequently, Heerink et al. developed the Almere Model – a specialized framework aimed at evaluating the acceptance of assistive social robots and agents, particularly among elderly adults (Heerink et al., 2010). Given that social agents embody interactional capabilities, the authors added constructs reflecting social acceptance to measures of functional acceptance from the UTAUT. Based on the related work in HRI, agent related constructs influencing social acceptance, namely perceived enjoyment, social presence, perceived sociability, trust, and perceived adaptivity were integrated.

Despite being a first step in the direction of adapting the constructs of TAM and UTAUT for the fields of HRI and SR, the Almere Model has been criticized for the lack of theoretical grounding and shortcomings in empirical validation (Graaf, Ben Allouch, and Dijk, 2019). In response, De Graaf et al. returned to the psychological foundation of acceptance models, the TPB (Ajzen, 1991), aiming to adapt it for studying acceptance of social robots. Their proposed model differentiates beliefs into attitudinal – utilitarian and hedonic – social and personal normative beliefs, and control beliefs. Drawing from the established dimensions and measures for these constructs, De Graaf et al. proposed a scale for assessing the intention to use a robotic technology.

Following the diffusion of sidewalk service robots in public spaces, Abrams, Dautzenberg, et al., 2021 argued that these acceptance models are still limited when it comes to assessing acceptance of functional robots in public spaces because they do not capture situations when people interact with robots spontaneously and outside the context of intended use. Based on the case of autonomous delivery robots, Abrams et al. propose *existence acceptance* (EA) as a concept incorporating passive approval based on the encounters that they characterize as unintentional, partially socially interactive, functionally-embodied and non-use related. As EA differs from usage-related acceptance, Abrams et al. propose novel – socio-emotional, societal-functional, expected-interactional – determinants contributing to the EA.

Despite the advancements made by HRI scholars in developing acceptance models that are a better fit for autonomous functional robots in public spaces, these models are still limited with respect to their validity outside experimental set-ups. Furthermore, they commonly capture acceptance at a specific point in time, without considering the processual and long-term dimension of acceptance. Additionally, the integrated social and cultural dimensions mostly consider the limited scope of organizational contexts. While Abrams and colleagues introduced general perceived usefulness as a societal-functional determinant of acceptance, they nevertheless acknowledge the immaturity of the concept when it comes to gauging wider societal acceptance (ibid.). In view of these limitations, in what follows, I will articulate five lessons for existence acceptance I derived based on the outcomes of the studies presented in this and preceding chapters.

5.6.2 Five Lessons for Existence Acceptance and Directions for Future Work

Lesson 1: Identity as a sub-factor under social influence

The qualitative insights from the studies discussed in this and previous chapters demonstrate that the acceptance of robots in public spaces does not always correlate with intentions or behaviors related to technology use thereby reinforcing the conceptual foundation of existence acceptance, as laid out by Abrams and colleagues (Abrams, Dautzenberg, et al., 2021). Currently, the existing version of the existence acceptance model incorporates subjective norms (SN) as part of societal-functional elements, along with prior experience with robots and perceptions of usefulness (for others) (ibid.). At the same time, social influence is a complex yet under-explored phenomenon, especially regarding the acceptance of robots in public spaces. Research on acceptance models, such as UTAUT, indicates that SN plays a significant role in technology acceptance in *mandatory contexts* (Venkatesh et al., 2003); however, this influence tends to diminish over time and in non-mandatory environments. This underscores the need for researchers to further explore the connection between social influence and technology acceptance (Karahanna and Limayem, 2000). In the field of information technology, Y. Lee, J. Lee, and Z. Lee, 2006 have made significant contributions by incorporating (self-)identity as a factor of social influence in the context of *voluntary use* of technology. Given the role participants' (national, professional and personal) identity played in shaping their attitudes to Starship robots, my first suggestion would be to extend existence acceptance model by including identity as a factor in social influence.

Lesson 2: Technology acceptance is temporally extended

Currently, technology acceptance models account for temporality through constructs like prior experience (Abrams, Dautzenberg, et al., 2021; Graaf, Ben Allouch, and Dijk, 2019; Venkatesh et al., 2003). However, the dynamic and evolving nature of getting to know and accept the robots discussed under Section 5.4.2 suggests existence acceptance is also a dynamic outcome of – socially and culturally scaffolded – repeated encounters and interactions between people and robots. In this process, both people's prior experiences, as well as the history of repeated encounters with the robots play a role in shaping their attitudes. The findings presented in this chapter thus add evidence in support that prior experiences contribute to existence acceptance supporting assumption made by Abrams, Dautzenberg, et al., 2021. At the same time, the evolving nature of human-robot relations in public spaces highlights the need to assess existence acceptance at various points in time following technology deployment. Since traditional technology acceptance models typically provide precise but singular measurements, long-term studies that combine qualitative and quantitative methods can offer richer insights into the observable changes in existence acceptance.

Lesson 3: Existence acceptance is not passive

I wish to emphasize an *active*, agentive character to how people encounter and experience robots on the streets. In that, my argument resonates with Groot, 2019' who also points out that existence acceptance comprises a spectrum of behaviors, among which some may be more fleeting, such as embodied situated adaptations, for example, yielding path to a robot (refer to Section 5.4.4), while others may take form of intentional prosocial stance towards robots such as lending them a helping hand. This is why, future work on existence acceptance might consider extending/adapting the model to accommodate, beyond a passive attitude, behavioral outputs. At the same time, ongoing and future ethnographic/naturalistic studies will contribute to our knowledge about the diversity and nature of situated encounters underpinning acceptance.

Lesson 4: Depending on the perspective, multiple constructs of acceptance may be needed

Anticipating discussion in Chapter 6, when investigating sidewalk robots in public spaces, we must consider both a wide range of actors and stakeholders, and *whose perspective* we are taking (Pelikan, S. Reeves, and Cantarutti, 2024), especially when we consider that Starship robots are a part of a commercial offer developed by a commercial enterprise. This means, what might be considered as good enough from one perspective (perspective of a passersby or a vendor) will remain a necessary but insufficient precondition of success from another perspective (perspective of developers). In other words, considering business case driving technologies such as Starship, from the perspective of developers, usage-related acceptance must co-exist with existence acceptance such that robots are considered a success. On the one hand, this means recognizing and investigating different stakeholders, and which factors matter for acceptance from their perspective, is a productive avenue for future HRI research on acceptance. Future studies on acceptance of robots in public spaces could thus investigate underlying constructs and processes leading to existence and usage-related acceptance. On the other hand, it leaves open the question whose perspective – and why – in fact should we consider as "enough" from the perspective of the HRI community?

Lesson 5: Designing for acceptance is a community-based effort

In Sections 5.4.3 and 5.4.4, I highlighted the interpersonal and relational aspects involved in both negotiating the meaning, and defining the purpose of delivery robots in public spaces. This socio-relational foundation indicates the potential for exploring *community-oriented* and non-dyadic approaches (Hornecker et al., 2022) for the task of designing existentially and socially accepted robots. Participatory design (PD) is now a well-established method in HRI e.g., (Darriba Frederiks et al., 2019; Rogers, Kadylak, and Bayles, 2022; Selma Šabanović et al., 2015); it can further empower various community members to have a voice in decisions about robot behaviors and their deployment scenarios. Additionally, community engagement can take various forms, such as outreach events and media campaigns, which can help facilitate long-term acceptance.

Furthermore, it is essential to ensure that the design of robot-community interactions considers not only design concepts, features, and prototypes but also the enduring impact of robotic technologies on existing practices, norms, and relationships (Amigoni and Schiaffonati, 2018; Chijindu and Inyiama, 2012; Dobrosovestnova and Hannibal, 2021; Weiss, Bernhaupt, and Tscheligi, 2011) – I return to this point in Chapter 8.

5.6.3 Methodological Reflections and Main Take-outs

Conducting this study presented several methodological and practical challenges, particularly during its initial stages. One key difficulty, not often discussed in publications detailing studies in the real world, was the need to approach strangers on the street and initiate conversations. For me as an Estonian (where introversion and sparseness of words are practically a meme among expats), this was initially outside of my comfort zone. However, as I started approaching people, I learned that the task was less intimidating than it seemed. Most people I approached were not only willing to talk about their experiences with the robots, but were curious to learn more about my project. For young scholars facing similar challenges, my advice is to give it a chance and try to surpass the initial hesitation – most likely, you will also find out people are often more open than expected.

Another challenge was managing informed consent and data recording in spontaneous street interviews. Balancing ethical protocol with a natural flow of conversation also required some trial and error until I found what worked for me. Ultimately, I also gained confidence by preparing multiple recording options (phone, Livescribe audio recording pen) for less hectic environments, such as pre-scheduled interviews or interviews inside cafes.

Lastly, my experience reshaped my understanding of the concept of data saturation and made me recognize what stood behind Braun and Clarke's critique to the concept of saturation (refer to Section 3.1.4). By the tenth interview, I started to feel the patterns in responses were becoming more and more repetitive. This feeling that little can be gained from additional interviews was the reason why I decided to stop. However, during analysis, I realized that nuances and valuable insights could still emerge from seemingly similar interviews. The lesson here is not to rely solely on a sense of saturation but to continuously ask what additional insights might be relevant to the research questions and who might provide them. I return to this point again in Section 10.2 on the monograph.

5.7 Summary

This chapter focused on the perspectives of passersby and vendors in Tallinn and Cambridge. Within it, I described the recruitment, data collection, and analysis processes, where semi-structured interviews explored themes, such as first encounters with the robots, social perceptions, help behaviors, and how participants construed utility and purpose of the robots. A Reflexive Thematic Analysis approach led to five main themes, highlighting how people viewed Starship robots as symbols of technological progress and new members in local communities. In particular, although many interviewees did not personally use the robots, they still saw them as purposeful and useful for specific community members. The chapter concluded with five lessons for existence acceptance inspired by the themes that were developed during the analysis.

CHAPTER 6

Reflecting Perspectives

Parts of the work presented in this chapter were published in Dobrosovestnova and Weiss, 2024. As the first author, I conducted the study and wrote the publication draft. Astrid Weiss provided overall feedback and contributed to the discussion section of the publication.

In this chapter, I shift focus from people encountering Starship robots in the contexts of their deployment to perspectives of people who conceptualize and build the robots. As detailed in Section 3.2, in August 2022, motivated by the wish to better understand what role 'inconsequential' encounters play for the robot developers, I interviewed three people closely involved in Starship robot development. This chapter describes the recruitment, interviewing, and analysis processes, resulting in five qualitative themes. The discussion section explores how these insights might inform the relationship between academic HRI and industry-based HRI. The chapter concludes with methodological reflections on challenges related to access and (self-)censorship.

6.1 Participants Recruitment and Interview Process

Recruiting Starship developers was not a straightforward task. Based on what I later realized were my own assumptions (more on this follows) and an informal conversation with a person working at Starship Technologies, I expected there would be a dedicated person in the company responsible for "everything HRI". Reaching out to the suggested person through a publicly available contact email did not bring the desired result—my emails were not returned. Nearly ready to put the plan on hold or even abandon it, I mentioned to friends in Estonia that I was conducting a study on Starship robots and had unsuccessfully attempted to contact the company. Coincidentally, though not entirely surprisingly (Estonia can feel like a large village where everyone somehow knows everyone), my friends happened to be on friendly terms with one of the key persons in the company and kindly offered to make an introduction. This introduction allowed me

It is August 2nd, a sunny day in Tallinn. At 10:00 o'clock I am scheduled to meet CP1 at Starship offices in Mustamäe. Mustamäe is a residential district that hosts Tallinn Technical University, this is the area where – to my knowledge – the robots had been tested prior to the company coming out of stealth. It is also a district where my grandparents used to live. When I was growing up, the main residents of the area were people like my grandparents – the first post-soviet generation to retire in Estonia. Many of them were of Russian decent and primarily spoke Russian. Today, the generation has changed – there are many families with children; it is much more common than 20 years ago to meet students from all around the world who come to study at Tallinn Technical University. Many of these students earn their daily living as food delivery couriers, or doing similar precarious jobs. On the trolley, I catch myself thinking how this must be the first time when I return to the district not to visit my grandparents but for work. I am not sure what to make out of a mix of emotions this thought brings about – I just wave it away and try to go over the questions I had prepared for the interview in my head. As I approach a six stories gray building, I notice several robots parked in front of it, another one is rolling towards the building as I approach from the other side. I take elevator to ascend to the upper floor. To make sure I am on time and find my way, I had planned to arrive a bit ahead of the meeting. As I stand in front of a door hesitating whether I should call or just wait a bit longer, a man in what seems to me mid or late 30s is walking up the stairs. He is wearing a casual white t-shirt, and he is bare feet – as I notice during my subsequent tour around the office, it is common for people working here to prefer socks, slippers, or just bare feet to outside shoe-wear. I introduce myself and the reason for my visit; it seems like the man already knows what I am there for. As he welcomes me into the offices, he points out I need to register my visit on a device installed right at the entrance. Once I've filled in my contact details and signed what seems to be a non-disclosure agreement, I am guided to a small meeting room nearby. To my surprise, two other people join us. As I find out from the subsequent introduction rounds, one of them is the CP1, and the person who first greeted me and the other young man in the room are representatives of the autonomous navigation and localization teams. Our introductory meeting begins.

Figure 6.1: Autoethnographic vignette: First visit to the Starship Engineering Office in Tallinn.

to present myself and my research project to the person and request a meeting, which led to an invitation to visit the company's engineering office in Tallinn.

As detailed in an autoethnographic vignette (see Autoethnographic vignette 6.1), the introductory meeting involved, apart from myself, three people occupying roles closely related to Starship robot design and development. Having been with the company from

Figure 6.2: Left: Starship Engineering office in Tallinn. Right: Robots parked in front of Starship engineering office in Tallinn. September 2024.

its early days – for two of my participants from the foundation of the company – also meant these people were well positioned to talk not only about the matters that were of immediate concern for Starship robot development, but also of the overall trajectory of the development of the company. All three interviewees were male; in their 30s-40s. Our first meeting was not recorded; this meeting was a preliminary step for me to share more about the research project and some of the findings at the time. The people in the room introduced themselves to me and shared what kind of HRI-related studies had been done in the company already. In this meeting, it was further agreed that I will interview each of the people in the room in one-on-one interviews on separate occasions. Subsequent scheduling was handled over e-mails. All three interviews were conducted in August 2022.

Ahead of the interview, I prepared a questionnaire guide that included the following thematic blocks:

- Background: included questions situating an interviewee's responses e.g., questions about professional background, how the interviewee came to work at Starship, aspects of their work they enjoy and aspects that they find challenging.
- Starship robots: included diverse questions about the perceived milestones in development, experiences of 'real world' deployment; experiences with situated

encounters e.g., people helping robots from the perspective of what they meant for the company.

- Robot visions: questions about what kind of future the interviewees envision for Starship robots; expectations about how Starship robots might re-configure existing practices e.g., last-mile delivery.

- Concluding block where I invited interviewees to add/comment on what we had discussed and what had been left out but that they considered relevant to mention.

The block of questions about Starship robots was motivated by my main research goal to explore how the company experienced people engaging in various interactions, including help, with the robots on the streets. It was important for me to find out what role these interactions could play from the perspective of the company, and which implications – if any – these had for design-related decisions. Apart from this, I was interested in getting more contextual knowledge about how the interviewees experienced developing robots for the real world, what the main challenges were, and how the interviewees envisioned the future of Starship robots.

Similarly to the interviews with passersby and vendors detailed in Chapter 5, I intentionally kept the interview guide flexible, allowing myself to explore unexpected topics that arose if these seemed relevant to the research project. The initial questionnaire and the topics of relevance developed from one interview to another – I used the opportunity to probe some of the responses and the topics that were discussed in one interview in subsequent interviewees. Some of the questions I explored in the second and third interviews built up from responses in the first interview. As a result, though there was an overlap in broader topics discussed, the three interviews were quite different. Not in the least because each interviewee brought in their experience and their personality. Flexible interview style aligned with the general approach to non-structured and semi-structured interviews in interpretative research wherein predefined interview questions are commonly used as prompts to help the interviewee to keep track of the topics that they would like to cover, while at the same time these questions may – and do – often change as the study progresses (Soden, Toombs, and Thomas, 2024).

The interview style was in all three cases rather informal – I experienced the interviewees as open and friendly, though not over-sharing. It was clear from their responses that – while they were overall open to share details about their work – all of them remained aware that not everything could or should be shared. They were also very clear when they perceived that a question tapped into a domain that was outside of their knowledge/experience.

Each interview lasted approximately one hour; all interviews were conducted in English language.

6.1.1 Data Collection and Processing

All three interviews were recorded with the oral consent to recording acquired from the interviewees. While I had prepared the formal consent form and data protection sheets and had sent these out to the interviewees ahead of the interviews, a certain deviation from the standard protocol took place. The interviewees specified that they will not sign the consent form at the time of the interview. As I also detailed in Section 3.4, it was agreed that all scientific outputs resulting from the interviews will have to be forwarded to the interviewees prior to any publication for data sensitivity check. This was the process that I followed prior to the publication of (Dobrosovestnova and Weiss, 2024) and of this thesis chapter.[1] Regardless, the interviewees were informed how the data collected will be stored and processed.

For data storing and analysis, the interviews were anonymized, with each interviewee being assigned a code e.g., CP1.[2]

6.2 Reflexive Thematic Analysis

The three interviews were transcribed using otter.ai platform (2022 release). I went over each transcript manually to correct for mistakes made by the software and as a way to familiarize myself with the data. As with the interviews with passersby and vendors, for analysis, I chose reflexive thematic analysis (RTA) (Braun and V. Clarke, 2021b) because it aligned well with my epistemological positioning, the insights oriented interpretative research.

The first familiarization with the data took place in January 2023 when the edited transcripts were printed, and I went over them with pen highlighting instances that seemed particularly relevant or interesting in relation to the research project. The transcripts were then uploaded to MAXQDA software (Version 2022.0.0, `https://www.maxqda.com/products/maxqda`), and subsequent rounds of coding were performed in MAXQDA. I performed several rounds of coding at different times throughout the thesis project. Following the first round of coding in January-February 2023, I returned to the coding again in October-November 2023 when I refined the existing codes and began crafting the first iteration of themes. The themes were finalized in February 2024.

I used a mix of inductive and deductive coding. The deductive codes were primarily informed by the work on sociomorphing and experienced sociality I was conducting in

[1] The agreement for consent prior to publishing only extended onto the interviews with the company developers. All other data collection followed standard protocol.

[2] I am aware that how my participants are situated in the company makes it hard to obscure their identities. In an e-mail exchange preceding publication of (Dobrosovestnova and Weiss, 2024), participants agreed that their positions in the company and names could be revealed. In other words, it was possible to publish without anonymization of the interviewees. After weighting different options, I decided to disclose their positions in the company as these are important for contextualizing participants' responses. At the same time, I opted for maintaining the individual identities anonymized to preserve distance between patterns in responses and personal identity of my respondents as I consider it less relevant in the context of this research project and research questions I address in this chapter.

parallel. Prior to transitioning to themes development, I had approximately 100 codes developed in MAXQDA. It is worth re-iterating that in comparison to, for example, Grounded theory approach where coding should be performed until theoretical saturation is reached (i.e., no new information is found), in RTA, there is no definite point to stop coding, nor ideal number of codes to be reached. Rather, what is desired is a set of codes that richly captures analytically relevant aspects of the dataset (Braun and V. Clarke, 2021b, p.198). This is why, the codes in RTA are frequently not finalized.

Development of themes also happened in stages. The preliminary stage accompanied the rounds of coding — as I coded, I kept notes of thoughts and observations I had. These notes proved helpful when moving to themes development, as they suggested some of the narrative paths reporting could take. As an intermediary step, I worked with the Mural board (see Figure 6.3) where I tried to represent potential themes graphically.[3] The construction of the themes continued into the writing processes.

Figure 6.3: Work on themes

In total, I settled on five themes defined as follows:

Robot Design as a Site of Ongoing Negotiations. This theme elaborates on how design of a commercial robot – while appearing materially fixed – is a temporary assemblage shaped by various negotiations. Through four sub-themes (Starship is not just a robot, but a product; Starship is still a technological artifact; Design pipeline; Socio-relational processes underlying development), I elaborate on different forms of negotiations underpinning design, primarily focusing on the company's viewpoint and respective internal process of decision making.

[3]Please notice that the image represents only a preliminary stage in theme development.

People not users. This theme arises from the perceived limitations of the concept of 'user' to capture the diverse range of actors who interact with and experience Starship robots once they are deployed. In discussing this theme, I point to who some of the actors may be, and address why certain (social) groups merited special consideration and how that in turn shaped design decisions.

What we learn on the streets. This theme shifts focus to the feedback loop between real-world interactions with the robots on the streets and how these interactions influence ongoing design efforts. Here, I address how interviewees experienced designing a robot for the "real world", including how they perceived the differences between human-robot interaction in industry setting when compared to academic HRI. I also explore how the company understands and responds to various forms of street interactions with robots, ranging from assistive behaviors to intentional obstruction.

Different interpretations of acceptance. This theme explores varying interpretations of acceptance concerning Starship robots evoked in the interviewees, including acceptance as absence of rejection and acceptance as a form of positive hedonic experiences with/of robots. I also discuss how these varying interpretations shape design related decisions.

Robots are a different kind. centers around the notions of (robot) sociality as instantiated in the data. Among the themes, this stands in the most direct relation to the theoretical considerations at the core of the thesis, specifically as these concern the topics of anthropomorphism and sociomorphing. I discuss how participants negotiated the notion of sociality in the context of Starship robots but also recognized the asymmetric nature of the robot sociality.

6.3 Reporting the Themes

In this section, I report on the five themes entangling analytical points with direct quotations from the interviews.

6.3.1 Theme 1: Robot Design as a Site of Ongoing Negotiations

Starship is not just a robot, it is a product

As I advanced in analysis and themes construction, it became evident how challenging it would be to separate between the process of technological development of the robot and the business context scaffolding it. For, even when the interviewees tried to reduce the conversation about Starship robot design to decision making about the technical features and behaviors, the fact that it is not 'just a robot,' but a *product* developed by Starship Technologies as a business enterprise, considerably shaped how they articulated design trajectory and choices pertaining to it.

The fact that the robot was being developed as a product in an industry setting, on the one hand, meant pragmatic constraints with respect to the financial and human resources, and material infrastructure available at different points in time in the history of the company scaffolded all ongoing work. Though challenging and limiting, many pragmatic constraints (e.g., limited human and financial resources, lack of needed infrastructure) that existed at the early stages of the company preceding it coming out of stealth were nevertheless experienced by CP2 as an exciting time when the small team was driven by intrinsic motivation and passion for their craft: “When I went to visit, it was five people in one room. One guy was sitting on the floor because there wasn’t enough space. It was a stealth project with no name. Like no working robot. It was very early. And it was awesome. Fantastic” (CP2). I could not help but notice how this account echoed mythologized narratives about successful Silicon Valley companies once started by small groups of enthusiasts in their garages (Audia and Rider, 2005).

The fact that Starship robots were framed as more than ‘just a robot’ was instantiated in how the interviewees emphasized *scalability, safety, reliability, and energy efficiency* as something they considered seriously already at the very early stages of the company’s existence when no physically instantiated robot prototype yet existed: “And in order to make that work, and still achieve the safety levels that we need outdoors. For the robot, that was definitely something that wasn’t solved in the world before. And that was the thing we started to do at first. And that, I would say, dominated the development of the product for the first three years or four years. A lot of it was related to getting the robot drive while keeping the cost low, and have the safety at the level that is necessary” (CP3).

The words of CP3 underscore how the broader outlook towards successful deployment in the ‘real world’ as a necessary precondition of reaching the company’s business goals meant ensuring the robots are *safe and predictable to people*, alongside financial sustainability, was placed high on the priorities list. In other words, even at the very early stages of the processes of developing the robots – when the focus was on the fundamentals of the robotic technology (e.g., navigation, localization) – these efforts were entangled with considerations about how the robots will ultimately co-exist with multiple actors in the contexts of deployment.

Being acutely aware of the goals and constraints stemming from developing a ‘product’ meant the interviewees also experienced their work as fundamentally different from developing robots in an academic setting. CP3 emphasized how what may work in an academic environment, and be considered as success (i.e., lead to a publication), cannot in principle work in industry setting as it will conflict with the high demands on scalability, robustness, cost-efficiency, and, ultimately, profitability: “[..] If you put in the restrictions on the size, weight, and the cost to produce, and reliability, and some of these other things, which is just very different from an academic setting and the sort of high volume commercial setting, which needs to be totally different level in terms of how easy it is to do, and how reliable it is, and how low cost it is” (CP3).

And yet, Starship Robot is still a Technological Artifact

Remaining aware how any technological development in an industry setting is entangled with a host of business-related constraints and demands, one of the first steps towards what we now know as Starship robots, according to CP2, was to *mathematically model and program the logic* that would set the foundation for what would then be translated into a physically embodied prototype: “We obviously didn’t have anything like a lab to do that stuff. And then we kind of just worked for years on decoding logic of getting robots working, you know, like autonomy and more basic stuff. So we basically just sat around doing what amounts to math and programming for years. Quite, you know, quite difficult stuff, I had to remember math from long time ago” (CP2).

Not having a *physical prototype* to test with at the early stages of development was another challenge that the team had to overcome: “There were definitely moments where at the very start, we basically didn’t have a robot to test with. It’s a huge barrier to not actually have any robot that you can try things with. And it took a while for us to get something to the point where we could simultaneously actually use the cameras” (CP2). Once the first prototypes were available, a new set of problems and challenges needed to be addressed. These included figuring out how the robot will *navigate around physical obstacles in unconstrained environments*. For instance, climbing the curbs was something that the team invested a lot of efforts into: “And then there was huge amount of work to get the robot to be able to climb the curb, it wasn’t really a mechanical thing. And there were various designs going on to try and figure out how that might work reasonably quickly. First design, I think the planning process took a minute. So you’d be sitting on the edge of the road for a minute trying to climb the edge of the curb, right? Like, it works. But you know, this is probably not good enough. And then that was one of the milestone when we finally had a model that worked” (CP2).

With the transition toward deployment in the real world environments, the tasks and challenges to be addressed shifted yet another time. Now, beyond ensuring the robot navigates (for the most part) autonomously and in a safe and reliable manner, increased efforts were directed toward making the robot *predictable and understandable* to other actors in the environment. For example, the interviewees identified *intent signaling* as one of the key areas of development related to predictability: “So the primary goal is get the robot to work autonomously and safely in the environments we drive in. And then the secondary goal is, while keeping the same level of autonomy and safety, trying to communicate what the robot wants to do, and try to make sure that actors in the space are aware” (CP1).

Design Pipeline

To underscore the inter-dependency between priorities identified at different stages of development, and how the hierarchy of priorities is negotiated, as an analytical abstraction, I differentiated between the following three levels of design: i) *fundamentals* integrating hardware and software elements of the robot that fulfill the condition of it functioning as an autonomous vehicle equipped with capacities that support it ultimately functioning as a delivery robot (e.g., localization, obstacle avoidance, in some way constrained weight and size); importantly, in a manner that remains safe for other actors in the environment (e.g., availability of sensors required to perceive other actors in space, programming and actuators that ensure obstacle avoidance and/ timely halting; limitation on weight etc.); ii) *the first level of HRI* integrating elements of the robot behaviors further inscribing fundamental concerns for safety e.g., intent signaling; iii) *the second level of HRI* – the components of the robot behaviors that reflect more socially expressive dimension of interactions e.g., dialogue-based behaviors such as robot asking for help, or greeting passersby and customers.

Further, even though these were only touched upon marginally in the interviews, it is also possible to abstract the level of design that accommodates features that pertain what is traditionally considered under an umbrella of user experience (UX) – how the robot signals the lid is open, the accompanying app through which vendors and customers can interact with the robot, etc. To this, we can add the level of aesthetic in design: how the robot looks, what allows this robot to be perceived as 'cute' or aesthetically pleasing.

As pointed above, these levels is not something that exists in reality – they are an analytical abstraction, and it is entirely possible that the elements of design could be differentiated and classified differently. To me, this abstraction matters inasmuch as it allows to articulate how – despite the dynamic, distributed (more follows below) and iterative process of design – it is possible to establish certain continuity and directionality to it and to articulate how priorities are established and shifted. CP3 used a metaphor of a *pipeline* to ground how he experienced this directionality. When explaining how decisions are made with respect to which dialogue-based behaviors to introduce into the robot, CP3 emphasized that, from the point of view of how efforts and resources are distributed, it makes little sense to concern oneself with dialogue prior to having ensured the necessary hardware and software exists that makes such behaviors possible in the first place: "[...] For example, if you want to add our first voice command, we need to think through, to build software in the robot, to actually put the speakers in the robot, which is hardware; we need to build the software in the robot to play back whatever samples. To get these data into the robot, we would actually need to download them from somewhere in some central server location. How to get this server location? We'd need to build some sort of user interface for maybe our UX designers to add these things [...] Once we have built all this pipeline, it actually became super easy to add one more, one more, one more, one more" (CP3).

Where abstracting into levels is also helpful is for substantiating how even when the said pipeline is in place, it will still be a matter of negotiations which components and behaviors, how, and by whom, get implemented onto the robot. While all three interviewees agreed cost-efficiency, robustness and safety are some of the fundamentals that mattered and will most likely continue to matter in the future, when it comes to the second level of HRI (expressive behaviors), opinions varied quite substantially in terms of whether interviewees considered it was worth investing efforts into these. For example, when talking about the robots bringing joy to people encountering them on the street, CP3 assumed a more business-centered logic stating it was not their goal as a company to contribute to passersby' happiness: "We're not actually trying to, for example, improve the happiness of pedestrians around the world. That's not the business idea of Starship, right? If a robot actually does bring smiles to people... But that's not our goal, that's not something that we are actively necessarily working on" (CP3). Contrary to this more pragmatic outlook, CP2 and CP1 both shared excitement about the space of possibilities they perceived existed if they were to explore how expressive and social interactions can make experiences with the robots "delightful": "And if we actually started adding things, more things to the robot intentionally for expression and for communication, it gets crazy, what's possible. And we will, we are discussing these. I mean, obviously, different people have different enthusiasm levels in this area. I guess it's fair to say that, I'm quite enthusiastic about it. But even given that I haven't pushed super hard to push other projects out of the way just to do these things" (CP2).

The differences in how individual interviewees negotiated differently the importance of designing for expressive social interactions (second level of HRI) had to do with the overall challenge to predict and quantify the impact of such interactions for the company: "I would say, also, in the company, it's not trivial to make a decision how much to invest in these types of things? So I'm responsible for an engineering budget, for example, I could decide to put half a million into, you know, investigating more of voice interaction with the robot. Will I do that or not? I don't know... Actually, I don't know, what the impact is, it's hard to quantify what the impact is" (CP3). In other words, even though the interviewees shared they recognized such interactions in some way matter, the challenge of quantifying the effect meant designing for these would most likely land low on the priorities list, irrespective of the level of enthusiasm different people in the company may feel about these: "Especially because the horrible truth is that, as much as I would like to do it, it's really hard to predict, above the fact that it would be lovely, it makes some people happy. It's really hard to predict what the actual effects of that would be. So if you're trying to cross prioritize this work against, you know, making it possible to launch here, or like saving this much money or whatever, it's really difficult to make it win" (CP2).

At the same time, considering that many of the elements of the second level of HRI rely on existing pipeline, it makes them more malleable to change that is not costly and can be implemented by individual people in the company. CP2 compared such quick changes to weekend projects when he spoke about how some of the most well received robot behaviors were in fact an outcome of someone's spontaneous idea that was easy to implement: "We have spent very little time engineering it. But that's the signals we get about the moments we do have, things like just saying thank you, or, playing songs when they arrive at the delivery, or something like that – these are extremely, widely positive. These are some of these... almost afterthoughts that put in, someone's kind of weekend project. And these ended up being wildly popular, hugely popular things that have hugely positive reactions. So if after-thoughts and weekend projects can have that much benefit, then what if we actually systematically start designing this and building?"

Importantly, the aforementioned "pipeline" extends beyond the software and hardware, as these in turn require a network of other structurally integral components, including human (UX designers, remote assistance specialists, maintenance personnel etc.) and non-human actors (e.g., servers, data centers). That is, robot design is not only distributed in time and enacted by different people who at various levels negotiate constraints, priorities and goals, it is also more globally distributed cf. (Crawford and Joler, 2018).

Socio-relational Processes Underpinning Development

Relational processes within the company also contributed to coming together of Starship robots. One of the first things that became evident in the course of the interviews (and why I was in fact talking to three people, and not to one person from an assumed HRI department): even though there are certainly dedicated teams within the company focusing on different components of robotic technology, the reality of the robots coming together was much more distributed and fluid. Firstly, different aspects of the same problematics, for example, autonomous movement, can be addressed by people who are differently positioned within the company: "Movement would be determined by my team, or could be sort of pushed forward by marketing team, but my team would actually write how the robot moves and know about the constraints how robots can move. And the platform electronics team, I think on their own accord offered up this solution, they've designed how the flag looks like, they picked the colors and made this LED look like the flag, and then they got some okay [from a person in higher level management], and then they made it" (CP1).

Secondly, it was also possible that a feature was decided by one team, but how it will be instantiated materially will be decided by a different team. The following example given by CP1 shows how it happened in the case of the indicator light: "As an example, I mentioned that my team actually is the one that decides when to use the indicator light. My team is actually not the one that decides what the indicator light looks like. What the indicator light looks like was decided to some extent by the mechanical engineering team that built the pieces that go in to the robot, and to some extent, by the platform electronics team, which sits here and they have the power over LEDs, and how to use LED colors. And they have written an animation, but this animation of how the LEDs switch, this is not written by my team, this is actually written by lower level, like hardware engineers. So they have written what this looks like."

Such *distributed* and only partially transparent – especially for an outsider such as myself – decision making processes meant among other things that anyone in the company was welcome to pitch an idea. Whether this idea will get implemented and how, though, will depend on a whole host of factors: "And there is a public relations part and the marketing part where, as an engineer, I can come up with a solution like flashing headlights, but it is a big question when, where, and whether we will actually do this." Sometimes, suggestions and ideas can come from the teams that are further removed from the problem at hand: "But how the LEDs work is determined mostly by what was convenient to put in this flag and what the team here at the platform electronics team actually came up with how to individually switch LEDs. So there are animations in the robot LEDs that are mostly actually determined by a team that has nothing to do with the autonomy even of the robot. It's mostly like what they found most pleasing or what served the purpose at the time" (CP1). Notice how this citation suggests how, beyond fundamental concerns and attempts to rationalize the best course of action, chance, situational convenience, and individual tastes also play a role in how the robot looks like and behaves at a specific point in time.

Implementing an idea thus may rely on *interpersonal connections* and getting to know the people one works with. As explained by CP1: "And there is no barrier for them to showcase what this looks like. It means, if someone new were to come in as HRI person, they would actually have to learn who is doing what. So in that sense, it might make that a little bit difficult, but I think this would also be accommodated quite well. To some extent, it hides who gets to decide because to some extent our behavior is very global" (CP1).

Furthermore, without conducting observations in the company, the interviews data suggested how even the spatial arrangements of the offices mediated interactions between people: "So all of the engineering teams that work directly on the robot are located on this floor. So pathways are short, and like I walk here, knowing that it's very short pathways and, to change something for me is just a request for them to change something, or even I can write some of this code, or if one person on my team could write this code. And so there's clearly a lot of communication going on" (CP1).

To summarize, it is evident that the insights about considerations and processes scaffolding Starship robots design presented above merely scratch the surface of everything and everyone involved in making what Starship robots are today and will be tomorrow. I consider these insights valuable for the given project because they emphasize how robot design in an industry setting is an open process where careful, pragmatic and quantified estimations co-exist with sometimes almost haphazard individual decisions and situational factors not always traceable even to the people involved. Not aiming for an exhaustive account, the contribution of this theme is rather in how it showcases some of the logic involved in negotiating what is important, what is less important, and what is not important at all from the perspective of the company and individual developers.

6.3.2 Theme 2: People not Users

At the core of this theme is a shared contention by the interviewees that 'user' as a term falls short when it comes to mapping out and considering the plurality of people who – in different ways, in different roles, and to a different effect – come to interact with Starship robots in public spaces. The inadequacy of the term was not something that reflected exclusively the perspective of the three interviewees. According to CP2, it is an established and recognized practice within the company to avoid using the word 'user':

"We try not to use it the word. We have customers and then otherwise, we just talk about people. Because [it] doesn't seem like the right word" (CP2).

As suggested by the citation above, the company as represented by the interviewees differentiates between two broader classes of people: people who are Starship customers i.e., use Starship app to place and have their orders delivered by Starship robots; and people who come to experience and interact with the robots on the streets. The first class of people are thus those who, in the words of CP2, have some sort of *formal* relationship with the company. These are the people whom we could consider as 'end users' – the group of stakeholders that are primarily considered within the space that is conventionally delimited as User Experience (UX). When it comes to this group of relevant actors, the fundamental aspects of robotic technology (see Section 6.3.1) such as navigation matter inasmuch as they support the functioning of the robot as part of the overall service provision: "To talk about the experience, the other group is our customers, which also kind of experienced the robot to some extent. I would just say that about half of their experiences, architecture shows are the same as just the bystanders... But then the other half is related to actually not so much how the robot behaves, but how the overall service behaves, how the app is built. Then if I push the button in the app to open the robot, does the robot open immediately? Or is it 10 seconds from now? So this is a little bit more traditional UX type of things, which of course, you can improve indefinitely, you can make it more fluid" (CP3).

The reason for avoiding framing people in terms of 'use' and 'users' was twofold. Firstly, according to CP2, most people who interact with the robot in some way do not have a formal relationship with the company in the same way as customers do. However, their inhabiting the spaces where the robots are deployed means that they must be considered in the process of developing and designing: "[...] everyone that joins Starship and thinks about the space, or even like walks into it for a little while, hits this point. It takes some time to hit this point where you realize that it is almost impossible to demarcate the groups of people that interact with the robot just because 90 something percent of them have no formal relationship with us, and possibly never will. So, it makes very little sense to think about users or whatever, with the one exception of this single moment at the point of delivery, where the robot is interacting with someone accepting a delivery" (CP2).

Secondly, *people* are not a homogeneous group. People inhabit public spaces in different roles; only some of these roles will matter to the company (I return to this point in what follows), they will be differently affected by the robots, and will negotiate the public space with the robots on different terms: "For someone that we passed by on the street, or a driver. They're not using Starship, in the same way they're not using anyone else on the street that they passed by, or they're not using the pedestrians they stopped in front of on pedestrian crossing. So I think we basically just don't use the word. We use customers and people" (CP2) (I elaborate on this in what follows in Section 6.3.3).

As (informally) estimated by CP2, interactions with customers amount to around 1 percent of all the interactions people have with the robots. That is, the vast majority of the interactions happen outside of the space that is more conventionally demarcated as 'use'. The role of the people interacting with the robot outside the domain of use is considerable, as substantial effort in robot design is aimed at making robots capable of responding to various ways people's agency might be expressed – ranging from simply existing as a physical object in space to actively interacting with the robots, such as by assisting, hindering, or exploring them. The intriguing challenge lies in the fact that the identities, mental states, and methods of interaction of these people remain only partially visible and understood by the developers: "[...] And so you have these just one percent of interactions that we know anything about, the formal interaction, the relationship we have in the formal interaction. Every other time it's someone with some thought about what the robot is, and some intent towards it, some mental state, and we can't say much more about it, unless we figure it out. And it's a fascinating problem, because it means most of the work that we do on this affects people without relationships to us, and without feedback to us. Without a way to express their satisfaction with it, or any reason to do so" (CP2).

Within the diverse category that interviewees broadly defined as *people*, distinctions were made among various subgroups including *passersby*, *drivers*, *cyclists*, and *children*. The reason for the interviewees to differentiate between the first three subgroups of people had to do with them interacting with actors on the streets, now including the robots, on somewhat different terms. This means that, to keep the robot predictable and safe for everyone, designers must ensure that it is visible and understandable to individuals moving at varying speeds, using different sensory modalities, and relying on somewhat different formal and informal norms. In contrast, children were identified as a specific subgroup because they are generally more likely to notice the robot and interact with it in a more open and spontaneous way than adults.

Other groups mentioned included elderly individuals and people with disabilities. Crucially, the significance of these groups extends beyond the robot's need to navigate public spaces alongside them; they are central because they form the local *communities* and ultimately hold the power to determine whether the robots will be accepted: "We consider them as part of the environment we are in, more than just part of the environment, part of the community. And robots have to successfully integrate into this community of people. Otherwise, we have not reached our goal as a business" (CP1).

The way different subgroups of people influence the design process varies. For instance, some groups influence design by prompting designers to anticipate potential interaction scenarios and adjust the robot's behaviors to ensure safe navigation. A clear example of this type of 'design influence' involves elderly citizens, whom interviewees identified as a more vulnerable and less agile group compared to an average person. As explained by CP1: "With elderly people, generally, they are a little bit less agile on the sidewalk or on the road. So there might be more of a concern from our side [what] we actually want to behave like. Keep enough distance from them and not swerve in their path, and so forth. That is, if an elderly person falls because of a robot, this is a scenario which we've considered thoroughly: how dangerous is the scenario, and how often would [it] happen?

How can we prevent this from happening effectively? So far, there hasn't been any any major incident that I know of. But this is for sure something we consider."

A different manner to consider specific groups of people, who in this case were also construed as 'vulnerable', in design was through a participatory design initiatives. For example, *people with disabilities* were mentioned as one such class the company engaged as co-participants in design. The motivation for this collaboration stemmed from the perceived ability of people with disabilities as a social group to influence public opinion and acceptance of the robots, hence giving them a significant voice in the conversation: "I would say, people in wheelchairs or otherwise, disabled people, have been much more vocal as a group. And we have engaged with them in most places that we go to try and figure out how best to behave because, in this case, both the robot and the person in a wheelchair are somewhat limited as to what paths they can take. Whereas a person on their feet is less limited – they can step off the sidewalk much more easily or step onto the road, or in a curb – there's not a problem. But a robot can't easily go off a curb and back on. And a person in a wheelchair, obviously also. And so there I think is much more of engagement and trying to figure out how best to cooperate. And we have initiatives ongoing right now to improve detection of mobility devices, strollers and wheelchairs" (CP3).

What these examples indicate is that, despite the company's intention to create technology that respects diverse perspectives, not all individuals are regarded equally, or even at all. I substantiate this point further in Chapter 8.

6.3.3 Theme 3: What we Learn on the Streets

Theme 1 focused on robot design as a site of negotiation, emphasizing internal company processes. The 'What we learn on the streets' theme extended this argument by examining how real-world interactions with the robots influence the design process. Within Theme 3, I explore how participants understand and experience the task of designing for the 'real world', including the key perceived differences between academic and industry settings. I then strengthen the argument for the fluid boundary between design and interaction spaces by highlighting examples of reciprocal adjustments (Akrich, 1992) between types of situated encounters and design iterations, differentiating between proactive, obstructive, and assistive interactions, and consider examples of corresponding design adaptations.

Designing for the Real World

When discussing how they experienced developing a robot for the 'real world', CP1 shared that even when he tried to stay in touch with the academic community and the studies published in academic venues, not much of the overall information available in his experience applied to the challenges Starship developers face: "But we do then try to base it on on studies and on literature, and I try to keep up with this literature as well. But there is much of it. And not much of it actually applies to what we do" (CP1). Unsurprisingly, the perceived lack of transferability of academic knowledge resulting from controlled studies to real-world applications is largely due to the complexity and dynamic nature of public spaces where Starship robots operate. For instance, CP1 highlighted that – while certain strategies for signaling robot intent may be effective in a lab setting – they cannot be applied in real-world environments due to spatial limitations and safety concerns. As a result, *a less efficient communication strategy may be favored* because it better balances environmental constraints, safety priorities, and the need for predictability: "So we know that, or we expect, actually from various studies that the strongest indicator robot has to communicate its own intent is movement. But movement actually requires moving, and moving in some situations can be dangerous or [must be] highly controlled – we don't want the robot to move uncontrollably. We don't want the robot to speed up, we don't want the robot to hit things. If you come up with the greatest ever pattern to show that the robot wants to move left, then there is still a constraint that actually, first and foremost, the robot has to be safe and has to remain autonomous. And only then, if it has enough space, could it actually show some pattern that it wants to move left or something like this. That's why we have often used lesser methods such as lights to indicate what the robot might do, or wants to do. Because they're very safe and easy. They cannot break anything by flashing lights" (CP1). To reiterate, this example illustrates that the optimal strategy for a specific task or goal to be performed in the real world settings may not be the most efficient one, but rather the one that best accommodates a variety of constraints that must be considered.

Furthermore, real-world environments introduce *factors beyond immediate task performance* that are often overlooked in laboratory studies. For instance, variations in light throughout the day are rarely addressed in HRI literature regarding robots in public spaces. However, when deploying robots on the streets, considerations like weather and light conditions become crucial – robots need to be able to function as reliably in darkness or fog. This necessitates equipping the robot with headlights for navigation and visibility to others. However, as CP1 noted, activating the headlights can temporarily obstruct the robot's vision which yet again adds another level of complexity: "And the second problem is that if you flash the headlights at night, then the robot for some time doesn't see anything, at that [side], so there has been some, some trouble, or some investigation into that as well. And right now this is just on hold" (CP1).

Another factor that hinders academic HRI research largely non-transferable is the *diversity of actors sharing the streets* with the robots. As previously mentioned in Section 6.3.2, the pragmatic decision to differentiate among various groups, such as bicyclists, drivers, and pedestrians, relates to the need for different communication methods and behavior strategies that ensure the robots are detectable, understandable, and predictable for everyone: "And this is also a question like we have two distinct categories of people who interact with [it]: pedestrians and sidewalk users and cyclists. And then drivers. And drivers are special because they're in cars and they are in a structured road environment, and they follow rules. Whilst pedestrians, they just walk in, there's not really rules or structure to a sidewalk environment. [...] So a cyclist might not see the robot because it is hidden, but it's actually very attuned to hearing something that, oh, there is actually something around, there's maybe an E-scooter or something like this. Cyclists very much rely on hearing cars and they go by this, it is just based on intuition, and adding beeping to crossing a cycling road" (CP1).

Even if developers successfully establish a set of features and behaviors that allow the robots to operate reliably in one setting, *entering a new market and environment* will likely present a fresh set of challenges. For example, CP2 noted that moving from the relatively uncrowded streets of Tallinn to the bustling and dynamic environment of a university campus introduced a new class of issues: "But we did have a class issue, probably when we first started operating in pedestrian busy areas because that was rare. In Tallinn, here there's almost no one on the streets, you can get around quite easy. And in the areas of the UK [where] we first operated, they were also very suburban, which meant that there was reasonable amounts of car traffic and maybe an odd bicycle on the street. But, you know, it's not as dense of a pedestrian area. So when we first started operating in the US, in some university campuses where everyone walks right into university campus, suddenly, we had a new class of interaction we hadn't really programmed before" (CP2).

Crucially, when it comes to ensuring the robots operate reliably and (for the most part) autonomously in different environments, fundamental principle of *reduction in dependency* was brought forth by CP2. CP2 pointed out that even when a "shortcut" might be possible in a specific context, the company prefers to take what may initially seem like a longer and more difficult route to ensure the resulting solution can be applied in various situations. For instance, while robot localization could theoretically utilize locally available high-resolution maps, the company opted to develop a robust solution that does not rely on these maps, despite their availability in certain areas: "Including things in the past, there's been chances for us to get local, very high resolution local maps. This is just a philosophical point. [...] we could skip a bunch of work by using this for that city only. And we decided philosophically not to do that, just because we would basically just broadly solve the problems with almost the same logical solution and make... spend all of our effort iterating on that one solution to make it great" (CP2).

The principle of reduction in dependency also applies to interactions involving other actors on the streets, such as when the robot needs assistance. A notable tension arose as the interviewees discussed the significance of passersby voluntarily helping the robots when they become stuck or face navigation obstacles. While the interviewees were aware that people were helping robots (see Chapter 4) and seemed to enjoy it (see Chapter 5) – and it was something that the interviewees perceived as "nice to have," – they nevertheless emphasized how they did not rely, nor would choose to rely, on such help as that would increase robot dependency on external actors: "And the same way, if you can't rely on these things, if you can't rely on people always being there at all, let alone wanting to be helpful about it. So we just build system to not need it. And then in general, this means, for example, we intentionally route robots around, we will wrap robots around crossings that need the button to be pushed. We'd rather go a long way. Instead of going to a crossing that would be, you know, five minutes faster. If someone pushed the button, we would just spare these extra five minutes avoiding the crossing" (CP2).

Forms of Situated Interactions and Respective Reciprocal Adjustments

Overall, all three interviewees shared they were surprised at the overwhelmingly positive response to the robots after their deployment going as far as people not only not destroying the robots, but actually embracing and willing to lend a helping hand to them: "I was definitely surprised. [...] I would say that a large part of the reason why I was surprised came just from the fact that I never thought about it. And I never thought about it before we actually saw it, because we were preoccupied with the rejectio" (CP3). In other words, absence of certain negative behaviors towards robots was something interviewees could explain after the fact but, according to them, could not anticipate prior to the robots deployment.

Based on the examples shared by the interviewees and supported by my observations, I identified three broader categories of situated interactions[4]: i) Responsive but inconsequential (e.g., showing interest without directly intervening). Such behaviors have little direct impact on the robot, with examples including stopping nearby to observe the robot or to take a picture, ii) Obstructive: interactions that in some way negatively affect the robot's navigation (e.g., vandalism; forms of harassment of the robots; some forms of exploratory behaviors); iii) Assistive: interactions that in some way positively contribute to the robot's operations, or pursue the goal of facilitating/assisting.

As I also experienced when observing interactions on the streets (refer to Chapter 4), the interviewees were aware that while the most common behavior was simply ignoring the robots, some people would choose to pause and watch the robots at a distance. Interestingly, CP1 characterized even the most fleeting forms of encounters when nothing happens as a form of *social encounter* nevertheless: "It turns out, and right now with our robots, with what we've experienced, people in general are very accepting of robots and are fascinated by them, and are interested; and most people most of the time, walk past them, nothing actually happens, but still it is to some extent, a social encounter, and an interaction" (CP1).

Regarding obstructive interactions, particularly vandalism – which is acknowledged and studied in HRI and related fields e.g., (Bršćić et al., 2015; Oravec, 2023; Salvini et al., 2010) – the interviewees noted that such behaviors are relatively rare compared to the overall number of kilometers the robots travel daily around the world: Now, there have been some cases of vandalism towards robots. And there are some specific problematic areas where vandalism is more likely than in other areas. And there have been very specific types of vandalism. (CP1) Among the various forms of vandalism the company

[4]In this Section, I primarily focus on proactive *intentional* behaviors toward the robots, excluding encounters where no traditionally understood interaction occurs, such as a person simply passing by a robot. While I acknowledge that even these seemingly 'non-interactional' encounters involve mutual adaptations, I do not consider them in this Section. Rather, my focus is on instances where individuals clearly recognize the robot and intentionally choose to behave towards the robot in a specific way.

has encountered, the interviewees highlighted: lifting the robot, swerving towards it on the road (in case of drivers), and instances of physical destruction (e.g., breaking the LED flag). While generally considering such behaviors as obtrusive, interviewees nevertheless recognized that not all of them stem from malicious intent, but they may be motivated by a general curiosity and wish to explore how the robots will react: "People, sometimes, they are curious about how the robots works. And, you know, specifically – a basic thing of jumping in front of the robot and seeing does the robot stop. Actually, a lot of people want to do that. If [it was the case that] everybody does it all the time, then it would actually be a problem for us, because the robots would have difficulty moving. Luckily, it's not quite like that. But it does happen" (CP3).

Regarding pro-social and assistive behaviors toward robots, as pointed out above, the interviewees generally appreciated people's willingness to help. However, they noted that not all forms of pro-social behaviors are necessarily desirable or lead to positive outcomes from the perspective of the company. As previously mentioned, the company employs a reduction in dependency principle, meaning that while they might currently view external assistance, such as people pressing traffic buttons for the robots, as a viable strategy to overcome challenges, it is likely the company will seek to minimize reliance on such help in the future. Additionally, in some cases, external assistance could result in negative consequences. For instance, in Chapter 5 I discussed how it was common for the drivers to yield path to robots, which lead to both the robot and the driver waiting on the crossing. Another example involves people lifting the robot with the intention of placing it back on its path. While this action can be helpful for preventing a potentially dangerous situation, it may also have unintended consequence of impairing the robot's ability to localize itself because its wheels are off the ground.

When it comes to design iterations informed by lessons from situated interactions, deciding whether to take action – implying a commitment of systematic efforts and resources to address a specific issue – requires some form of ideally *quantified* assessment. Per interviewees, this assessment includes estimating the overall frequency of a particular type of interaction, its impact, the resources needed (such as skills, time, and finances) to develop and implement changes, and the anticipated positive effects of those changes.

Without implying these are the only available strategies, the two primary mechanisms through which situated interactions informed design identified in the analysis were: i) Prevention: adding a feature to reduce or prevent unwanted behaviors/interactions; and ii) Integration—introducing a (robot) behavior or feature that leverages a specific behavior, for example, by proactively encouraging it.

Prevention: According to examples shared by the interviewees, obstructive and *repeated* interactions were most likely to be addressed. For instance, systematic efforts have been made to prevent behaviors like people lifting the robots or tipping them over: "There's multiple types of things that people can do to harass our robots, one of them would be actually to take it, take a robot and turn it on the side. And then the robots' wheels don't touch the ground, the robot cant get back up by itself, which is an issue. There

I would say we have actually done systematic work in the sense that we actually done something, some change [to] how the robot behaves, and quantify what the effect of that would be" (CP3). As part of these systematic efforts, company looked into how people responded when a remote assistance specialist sounded a siren "But we learned, we looked at just a bunch of times where the operator sounded the siren, and we just looked at it from the videos. What do people do then? In this case, we actually found from the videos a number of times it seemed to be effective in preventing whatever abuse. So we went on to do this automatically" (CP3).

Another example of preventive adaptation involves efforts to reduce instances of people breaking the LED flags. As CP3 noted, since these actions may not always stem from malicious intent, it remains unclear how best to address such behaviors: "People can also touch our flag without the malicious intent, right? So I would say that it's not necessarily super obvious what we should do? Apart from making the flag cheaper, which we are going to do actually. But at least it's a clear, systematic, and actually quantifiable thing to work on. Significant enough to very systematically work on" (CP3). CP3 further explained how instances of people breaking the flag also led to iterations on the software such that it would make it possible for the robot to automatically detect when this happens: "Our systems do not immediately know that the flag has been broken. Just six months ago, we were at the level where we only learned about it once the robot came back in the evening, and then a technician or an on-site service person who just cleans our robots in the evening or oversees the robots, they actually see that one flag is broken. But this robot has been driving 30 kilometers during this day, nobody knew where it happened, when it happened. Did it happen in the morning or in the evening? Now, we have more of an – actually, a piece of software, which is detecting this. And we are now building a new iteration of the hardware that allows us to detect it more reliably and immediately when it happens. And ideally, we would like to detect it before it happens. We would actually like to detect somebody touching the flag before it breaks."

Integrative adaptations: As discussed above, whereas the company's interest in mitigating destructive behaviors towards robots seemed straightforward, considering assistive behaviors, as well as generally positively charged social encounters with the robots in design process was a subject of ongoing negotiations about how best to approach it (see Section 6.3.1). A pertinent example concerned people voluntarily helping robots. According to the interviewees, people voluntarily assisting the robots was not something the company imagined or anticipated would happen. The dialogue-based solicitation of help activated remotely by a remote assistance specialist was introduced retrospectively, following the robots roll-out and observing multiple instances of people behaving pro-socially towards robots: "It was afterwards. We did not think that, hey, maybe we can induce people to help robot this way. If the robot asks for help. But no, I will say this has been very much an afterthought or very much something that we have reacted to what we see in the world. And if anything, and I would say we have reacted very slowly, in this area" (CP3). The logic of designing based on quantified effort and effect, did however apply to soliciting pro-social behaviors as well. CP2 explained how – should the company choose to dedicate serious efforts toward developing strategies for soliciting human help – it would likely involve a systematic analysis of the factors involved: “In future, we may have more luxury on a couple of different axes. One of those is... we may actually have the time [to] understand trade-offs of them more. Like you could foresee things like that – we could actually understand what times of day there is enough people to press the button there. We could [understand] what times of the day when it actually would be reasonable for us to go there and ask help from passersby. And then we can build this behavior. That only [results] not in, you know, not sending in the morning when there’s no one around, and not right in the middle of the day when everyone’s pressing it every second anyway. But those times of the day, then we could build this interaction in” (CP2).

Returning to the design pipeline metaphor discussed in Section 6.3.1, this example highlights how adaptive changes to design in response to real-world interactions demand flexibility and a solid foundation in hardware, software, and supportive infrastructure (e.g., dedicated and skilled company staff). In this case, because the change was relatively easy to implement within the existing system, it was pursued even without concrete data proving its practical utility. At the same time, each new implementation may also require a period of adjustment, potentially disrupting established behaviors and reshaping expectations people have formed through their interactions with the robots. As explained by CP1: “I think also another challenge is: people get used to the behavior of the robot as it is. If we change the behavior, there is an expectation that the robot will behave in a certain way. And then it doesn’t. To some extent, this is good, because actually people pay more attention to robots, and they attribute more intelligence if they don’t always behave exactly the same. But to some extent, it could also break expectations. And in some cases, this could lead to negative interactions or collisions or something like this. So far, we haven’t had such a problem. But there are imaginable situations where we have a new type of behavior, which we can use in new areas, but in old areas, we have to slowly introduce it or something like this” (CP1).

6.3.4 Theme 4: Different Interpretations of Acceptance

During the data analysis, it stood out to me how different interpretations of acceptance were evoked by the interviewees. Firstly, acceptance was defined as the *absence of rejection*. The interviewees shared how prior to deploying the robots, they considered different worst-case scenarios including physical destruction of the robots. Given these possible drastic negative outcomes, achieving an absence of rejection appeared to be a favorable goal to aim for: “So our goal was to avoid rejection. And I think, overall, we had already immediately a fairly good head start on it, in that the people were not rejecting the robots from the get go” (CP3). The fact that the robots were not only “not rejected”, but many people embraced them, was a surprise to the interviewees: “I am still I amazed to see them, and to see them working very smoothly. And it is not obvious that people would be happy to share the sidewalk with robots” (CP1).

By viewing acceptance as the absence of rejection, CP3 characterized people’s possible reactions to the robots as a significant risk that the company needed to carefully consider before deployment: “And a big risk, or significant risk to this, we surely identified that, okay, how would the public react to robots on sidewalk, which then also gets to a little bit more like human-robot interaction topics, which we didn’t know anything about. But we also thought that, again, it’s a risk, maybe it doesn’t work from a perception standpoint, and from human interaction standpoint. But hey, you know, we’re willing to try” (CP3). In this context, for CP3, striving for acceptance meant focusing on minimizing the risk of proactive rejection, such as potential physical damage to the robots or intentionally obstructing their operations. By adopting this perspective, much of the work addressing the fundamentals and the first level of HRI (see Section 6.3.1), can be seen as contributing to the mitigation of risks associated with rejection.

At the same time, CP3 noted that on the journey toward achieving acceptance as absence of rejection, it is unrealistic to expect that everyone will accept the existence of robots cf. (Abrams, Dautzenberg, et al., 2021). Some individuals will always reject robotic technology, regardless of the robot’s appearance or behavior, due to a general resistance to technologies introduced into public spaces: “One group that is sort of more, let’s say, philosophically against cluttering the sidewalks. So it’s not about how our robot behaves, or how our robot looks, or, you know, they don’t care how it looks. There’s some people who essentially think that just philosophically, a robot, a cyborg, should be for people. And, of course, it’s kind of the same people who are arguing against scooters [....] But still this sort of philosophical [position]... which I think is not related to how the robot behaves at all. We cant improve that by robot behavior. Or we can maybe slightly, but not so much” (CP3).

Joyful experiences with robots were another way how participants interpreted acceptance. Both CP1 and CP2 emphasized how they wished for interactions with Starship robots to be “delightful”: “I would like them [people] to have a magical experience with robots, that seeing robots for people who are not directly in a situation where they are customer is delightful. That actually they recognize that we’re living in a somewhat of a futuristic world where robots roam the streets and are part of society. And it’s somewhat delightful to see them driving around and working” (CP1).

Returning to 6.3.1, distinguishing between these interpretations of acceptance is important because it is related to decisions regarding allocation of resources for design and development. To emphasize, for CP3, who primarily viewed acceptance through the prism of absence of rejection, prioritizing design of expressive social interactions to increase hedonic acceptance was not seen as a key focus for the company, at least at the time of the interviews: As long as there is no rejection, there’s actually not massive priority for the company to have even better interactions. It is important, it is beneficial. But we have other things, which are more important, I would say to get better (CP3). CP1 and CP2, on the other hand, considered (hedonic) acceptance not merely as a nice to have side-effect, but as a fascinating problem space to explore on its own terms: “Okay, me personally, I would actually like many interactions with the robot to be delightful, to delight people, just by its very existence in their shared space. And I believe that it’s actually quite possible to create" (CP2).

In summary, although interviewees differed on the importance of designing robots for expressive social interactions, they shared a sense that positive interactions, even when seemingly minor or inconsequential, add value to the company's public image. CP3 likened these positive encounters to "free marketing": the mere presence of robots often improves public perception of the service and product, something the company can further enhance: "The other angle that we certainly as a business have identified: is just a positive perception of our service and product in general. Like any company is interested in that, right? And overall, we definitely have seen that our robots are kind of free marketing, by itself, essentially just the presence of our robots. You know, people have more positive reaction to it. But then that is actually something that I think it is completely in our powers to improve further" (CP3). While positive hedonic experiences are not the company's main goal (from the perspective of a business case), viewing these interactions as contributing to marketing efforts and company promotion (potentially leading to usage-acceptance, for more on this see Section 5.6.2) enhances their perceived utility from a business perspective.

6.3.5 Theme 5: Robots are a Different Kind

Although interviewees acknowledged that Starship robots are not 'social' in the same way humanoid or anthropomorphic robots might be, they still considered them social due to their intended deployment in public spaces with the latter being viewed as inherently social spaces. The classification of Starship robots as social stemmed, first, from the understanding that robots operating in public must follow established legal and informal norms for coexistence in shared spaces – a perspective that aligned with the views expressed by passersby and vendors (see Section 5.4.5). Secondly, interviewees recognized that the robots would impact not only daily street life and interactions with various actors but also society as a whole. This is why, in the words of CP1, even though the intent of the company is not to build a social but a functional service robot, such robot will nevertheless be inevitably social as it will operate in a society and will contribute to shaping society: "Our robots' primary intent is as a form of moving things from one place to another in a city sidewalk environment. By acting in a public space, and this is the intent also, to act in a public space and move in a public space, they are inevitably social robots, and they will have an effect on society and shape society. And we are aware that even though our primary intent is mostly to be out of the way and not interact much with people, we realize that every meeting with a person is an interaction, even if nothing happens. So yes, absolutely. They're interactive. And they are social robots though their designed purpose is not being social robots, but they do have an effect on society" (CP1).

With respect to adhering to existing norms and regulations, interviewees emphasized how, in their view, Starship robots were in fact more compliant than some other technologies and actors on the streets such as, for example, people riding scooters recklessly: "We are, of course, arguing our robots are actually better than scooters. Depends on who is riding the scooter, they can do reckless driving. The robots don't really do reckless driving, right? Even if there's some issue with the robot, the robot behaves, I mean, in wrong way, it's way more rare than with the reckless driving done by person" (CP3).

Apart from the sociality understood through the socio-practical dimension, all interviewees were aware people were prone to have affective responses to the robots and treat them as social actors. The interviewees relied on the notion of anthropomorphism to articulate why they thought that was the case. Aligned with section 4.3, interviewees acknowledged they recognized people's tendency to use linguistic constructions generally reserved for humans or pets in relation to Starship robots. According to CP1, (linguistically) attributing states and human-like characteristics to robots leads to establishment of a bond: And we see that people say that when robots are standing somewhere that other robots today are on strike. They're obviously not on strike. But you know, that's what people say about them. Or the robots are sometimes, they say that the robots are feeling a certain way, that this robot is happy. And this robot is clumsy and sad. So we see that. Yeah, robots get attributed these characteristics. And it creates almost like a bond (CP1).

When discussing why he thought it was the case, CP1 emphasized the role of the robots design for it being experienced as cute and non-threatening which also aligns with the experiences vendors and passersby shared. In CP1's view, cuteness was supported by the relatively small size of the robots and the coupling with movement: "when you look at it, it looks non-threatening, it looks somewhat cute. It's like the size of a large dog or something like this. Smaller than a person, but larger than most animals. I think it is also the way that robots move. And the fact that they move. If a robot is displayed in a museum, I don't think people actually interact with it in the same way" (CP1). Furthermore, attribution of intent, and some form of agency that CP1 expressed through emphasizing the robots are "not yours" i.e. are experienced by people as somehow independent from their will and intentions, while serving some purpose: "I think a sidewalk faring robot actually has characteristics that we usually attribute to animals, if it finds its way around, it has these things, it comes TO YOU. And yes, you interface with an app. But then it opens FOR YOU to give you something and you can take it out and and and the robot will drive away on its own. And it is not YOURS" (CP1).

However, like vendors, the interviewees recognized the asymmetric nature of the robot sociality. That is, even when the robots are perceived or experienced as social, or as different from other technologies because of the socio-relational aspects entangled, in itself it is not enough to consider them in any way equal to humans. CP3, for instance, pointed out how he believed that in the situations when people e.g., vendors, have to make choices between robots and other people, they will prioritize the latter: "Always, or almost always, the person who is often the same person who is putting the stuff in the robot, the same person who is serving the people who are in the store or cafe. So in the cases of busy hours, they have a choice, they need to prioritize, which one do they prioritize. And overall, there's a tendency to prioritize the person who is there. Even if there is let's say, like a delivery guy, who also is a delivery service, not their customer, so they do not necessarily have the incentive to be really nice to them, or something like that, because they know that it's not their customer who is actually making the decision to buy something" (CP3).

6.4 Discussion and Lessons Learned

In the discussion, I highlight key insights gained from my analysis of the interviews with Starship Technologies developers. First, I consider the difficulties of designing robots iteratively within an academic context. Second, I discuss conceptual developments needed to account for stakeholders beyond direct technology 'users', as further evidenced by the analysis results. Lastly, the section touches upon what developers' perspectives contribute to the topic of (experienced) sociality. Alongside these theoretical insights, I integrate methodological reflections on my experience accessing industry participants, including challenges I faced and the open questions that emerged as a result. The section concludes with a few key limitations, particularly the difficulty of capturing participants' 'perspectives in action' through interviews.

6.4.1 The Challenge of Designing Iteratively in HRI

A key insight from the reflexive thematic analysis presented in this chapter is that commercial robot design is a distributed and iterative process shaped by a host of economic, structural, technical, and interpersonal processes. On top of these, for sustainable deployment, it is crucial that the design continues to be reciprocally and iteratively developed in response to learning about factors and situated instances of interactions that can never be fully determined or predicted prior to the robot deployment. In academic HRI, although there exists work proposing and evaluating models and tools to support iterative design processes, these efforts generally focus on specific selected features or aspects of the robotic system, such as locomotion and manipulation (Frutiger, Bongard, and Iida, 2002), or multimodal communication (Saad, Broekens, and Neerincx, 2020). Additionally, while valuable in their emphasis on the iterative process and strive to support it, these efforts incorporate the dialogic nature of design and interaction spaces inasmuch as responses to the system can be captured through an evaluation study based on predefined criteria determined in relation to the behavior or feature being designed. This quantification-leaning process of assessment is, on the one hand, pragmatically useful because it allows for systematicity and, ideally, robustness – in that, it also aligns with quantification-oriented decision-making processes within a commercial setting, as discussed in Section 6.3.1. On the other hand, such approaches do not allow to capture and integrate interpretative flexibility and emergent forms of interactions with the robot beyond those that are in the focus of a pre-defined evaluation criteria.

To be sure, the task of modeling and accounting for something that cannot be fully anticipated in advance is not easy. An example of a recent work that in some way tries to meet this challenge is the work by Hassan et al., 2024 who relied on the agent-based modeling approach to develop a 3D digital twin environment model to simulate human-robot and robot-cityscape interactions. Appreciative of these efforts, in the HRI community we are nevertheless still to fully embrace this challenge and explore it in a comprehensive and extended manner.

Furthermore, considering how crucial the iterative design process is for the development of socially sustainable, ethical, and responsible robots for deployment in urban public spaces (P. Salvini, 2018), with the exception of a few examples, such as Snackbot (M. K. Lee et al., 2009), UIRO (Weiss, Mirnig, et al., 2015) and CaBot (Nakanishi, Kimura, and Naitoh, 2023) where the iterative process was prioritized, documented, and reported, there is generally a scarcity of publications in HRI with a similar focus on reporting iterations on design and development. This is a regretful omission because much can be learned from such work. At the same time, this gap is understandable considering pragmatic constraints placed on research in academia, wherein, with increasing commercialization of science and demands on publications while the projects' lifespans are shrinking (Hackett, 2008), there is little room for long-term projects allowing for several cycles of development, integration and testing, and iteration on design (Gedenryd, 1998). These structural (and budgetary) constraints regretfully contribute to the issue of limited transferability of knowledge resulting in the academic HRI to industry settings, as also experienced by the interviewees.

Although my aim is not to suggest that the task of HRI scholars working in academia should necessarily be the production of knowledge that is pragmatically useful for the industry, this lack of transferability also means that the HRI community is less prepared to tackle the "wicked" problem of designing for sustainable and responsible real-world deployments where when one design problem is solved, another one appears (Weiss and Spiel, 2022). In addition, the example of how the interviewees negotiated the importance (or the lack of thereof) of voluntary assistance to robots – from, on the one hand, seeing it as something that is "nice to have" and integrating it in design through dialogue-based solicitation of help, but, on the other hand, seeking to reduce reliance on instances of external dependency – further highlights the pertinent need for the HRI community for continuous re-evaluation of the efforts directed at solving a problem that, in essence, may be a misconstrued problem altogether.

Above, I highlighted the importance of continuing efforts in investigating how the loop between design and situated encounters could be addressed more comprehensively in HRI. Apart from empirical work exploring situated encounters and how they shape design, another important step must include ongoing conceptual work questioning and refining how we frame and construe people (H. Lee et al., 2022) (see also: (Astrid Rosenthal-von der Pütten et al., 2020)) and phenomena in HRI. In that regard, an important insight from the analysis of the interviews was how keenly aware the interviewees were – based on their ongoing experiences – about how the term 'user' fails to represent not only the kind of relationships Starship *customers* have with the robot and the company, but also the kind of relations and interactions people on the streets have with the robots that, while not being 'use' remain at the forefront of the development process. This feedback from the case study of an (arguably) successful deployment[5] re-iterates the need not only conceptually reexamine how we construe people in HRI (H. Lee et al., 2022), but to systematically map out who these people are, if not users, and in which roles they stand to the robot. To this end, in Chapter 8.2 I rely on the cumulative insights from my empirical studies to propose one such conceptual descriptive framework.

Lastly, concerning the insight about Starship robots being perceived as in some form social actor (see also Chapters 4 and 5), the sub-themes I discussed under the *Robots are a different kind* theme generally aligned with how passersby and vendors articulated their socio-relational experiences with the robots. First, one such shared sub-theme was the recognition that sociality is not confined to how the robot looks or the kind of task it is intended to perform. Rather it also – or even primarily – resides within how the robot *behaves*, i.e., whether it is perceived as well-aligned with existing formal and informal norms and expected patters of behavior in specific situations. Second, another shared aspect in how experts and lay people articulated sociality concerned the recognition of the role that design and, importantly, autonomous movement, but also perception of the robot as having *some kind of* purpose, play in people perceiving and treating the robots differently as they would other machines. Taking a more meta- perspective, what stood out to me is how prone expert interviewees were to rationalize people treating Starship robots pro-socially as a form of *anthropomorphism*. Given that the interviewees shared they did strive to stay informed about the developments in the academic HRI literature, it is not surprising they would adopt the term, as it is also pervasive within HRI discourses when it comes to framing and investigating social and relational aspects of HRI (Damholdt, Quick, et al., 2023). At the backdrop of how (some of the) lay interviewees experienced the mismatch between the available words and the content of their experience (see Section 5.4.5), that is, anthropomorphism as expressed through language might be rather an outcome of the descriptive problem than an accurate reflection of the processes that are taking place (Seibt, 2016), to me suggested that when labeling every aspect of pro-social behaviors towards robots as an instantiation of anthropomorphism, we might be yet again missing out on the opportunity for a more nuanced understanding of sociality in HRI. Recognizing that is what motivated the following chapter of the monograph where I explore **sociomoprhing** as a concept that may pave path to closing this gap.

6.4.2 Methodological Reflections: On access and self-censorship

An aspect one has to consider when interviewing experts, especially situated in an industry setting, is that access to potential participants will depend significantly on the willingness of gatekeepers to grant or facilitate it. As follows from my account of how I succeeded to secure the interviews, my success hindered both on a chain of lucky coincidences, but also on the aspects related to my background (See Section 3.3), more precisely, being born in Estonia and having personal connections in Estonia. Aware of this and of the privilege of my position, I want to emphasize how challenging it remains for young

[5] In here, I define success as indicated by the sheer number of the kilometers Starship robots have driven in different communities around the world.

career researchers to solicit expert interviews with industry players.[6] This challenge is further underscored by the competitive nature of the commercial robots production, with companies generally striving to control the information and narratives that are made public about the company and the robots. This challenge underscores the inherent power imbalance and the tension between the academic push for open science and transparency, and the legal and economic imperatives that shape information-sharing practices within industry. While academics are increasingly encouraged to share research openly, industry partners often operate under different incentives and constraints, governed by proprietary concerns and legal frameworks (Gentemann, Erdmann, and Kroeger, 2022; Mirowski, 2018).

On a personal level, though I never experienced the company representatives as non-collaborative or unwilling to assist within the limits of their roles and respective constraints, this power disparity (Winkle et al., 2023) was still a salient part of my experience. For instance, I had to sign a non-disclosure agreement (NDA) before entering the company offices, and I committed to sharing this chapter – and any related publications – with the interviewees, without full understanding of how it might be received or interpreted. Importantly, being aware of this, also influenced the choices I myself made in analysis and reporting of this chapter, prompting me to adopt a continual process of distancing from the text to assess whether any information might be considered as "business sensitive" or otherwise potentially harmful to the company. While this introduced some unease – particularly due to the lack of clear criteria for what might constitute sensitive information – in its most direct way, the impact it had on my research was in me deciding to omit reporting on a theme related to interviewees' views on how Starship robots might reconfigure the last-mile delivery market. To be fair, this choice was also partly motivated by how I perceived the scope of my research: at the time of analysis, I considered this topic peripheral to the thesis and felt it would have required more targeted exploration in the interviews. However, I also acknowledge that this decision was a form of self-constraint (or self-censorship?) prompted by the sensitivity I perceived around the subject. I return to this topic below where I further illustrate this point with another example concerning my attempt to interview remote assistance specialists.

Another valuable learning moment in my collaboration with Starship was the realization that access to gatekeepers alone does not guarantee data collection success. In August 2022, when I interviewed company developers, I had plans to conduct an ethnographic study at the company's call center in Estonia, where the remote assistance specialists (RASs) (referred to as "operators" in HRI contexts) are based. To explore this idea, I asked one of the company executives about the possibility of observing or interviewing RASs. After a moment of hesitation, the executive indicated that, for the reasons left unspecified, it was not a good time for such a study. We agreed to revisit the question in January 2023. When I reached out again in January, I found myself again experiencing similar kind of self-restraint in how carefully I crafted the email to ensure that I presented

[6] From personal conversations with my peers, I know other young career researchers also tried to get in touch with the company but their attempts were not successful.

the research objectives in a way that reassured the recipient that I would avoid topics that might be deemed sensitive or problematic. Although I had no specific knowledge of which topics might be sensitive, I operated on the assumption that they might include workplace social dynamics, labor conditions, and technical details underlying the robots' operations. This careful phrasing, which I now understand as an effort to signal trustworthiness and goodwill, highlights the balance I tried to preserve between my research and the partners' interests when seeking industry access.

Returning to the point that having access is not a guarantee to successful data collection, ultimately, after a chain of correspondence, though I received an approval from the legal and HR departments to interview RASs (contingent on the sharing the interview guide in advance and notifying the company of any publications) my attempts were largely unsuccessful. Only a few RASs expressed interest, and several, who initially agreed to participate, did not attend the scheduled interviews nor responded to follow-up emails. While I can only speculate about the reasons behind this lack of engagement, I believe my experience is useful not merely as an anecdote, but as an entry point for examining the broader dynamics at play in academia-industry collaborations. I elaborate on some open questions raised by these experiences below, without presuming to offer definitive answers.

In reflecting on my experience, I am led to ask: what truly lies behind my (even mild) instances of (self-)constraint? Should these actions be framed as (self-)censorship, or could they be considered forms of care – if not directly for the participants, then at least for maintaining a positive and trustworthy relationship with them? Or perhaps, these acts could even be construed as an attempt at self-protection, particularly given the power imbalances I've discussed? These reflections prompt me to wonder how much the increasingly blurred boundaries between ethical and legal considerations shape our research when it concerns industry partners or participants. Put differently, under what circumstances do such actions represent care, and when do they become acts of self-censorship driven by concerns about potential legal repercussions? Such concerns are not entirely unfounded; to my knowledge, there has been at least one instance among colleagues at the TU Wien in which a company attempted legal action against a research team over the findings of a study.

Moreover, this raises the question with respect to which strategies might allow researchers to better navigate the sensitive terrain between corporate interests, participant protection (in this case, for lower-status employees like the RASs), and the researcher's right to critical knowledge. This question goes beyond streamlining research practices to ask how we might foster trust for more open, safe, and insightful exchanges. Alongside this, I continue to ask myself what obligations, if any, we academic researchers have toward industry partners who grant us their time and access. To what extent, if at all, should their cooperation influence our analysis and the dissemination of our findings?

While these reflections are drawn from my specific case, they resonate more broadly as industry-driven robot development grows, and as collaborations with industry increasingly become a necessity for studying these robots (Weiss, Wortmeier, and Kubicek, 2021). I believe such questions are crucial for the HRI community to consider in its ongoing work.

6.4.3 Limitations

To conclude, I would like to reflect on a few limitations of the research presented in this chapter. One notable limitation relates to the challenge inherent in (ethnographic) interviewing. Specifically, this challenge concerns the distinction between the perspective of action and perspective in action. When we ask individuals to explain their actions to us as external observers, their accounts often aim (consciously or not) to make the setting and practices meaningful *for an outsider.* This differs fundamentally from perspective in action, where meaning naturally unfolds within the interactions themselves. To mitigate this issue, it would have been desirable to complement interview data with observations (as I did for the data collection centering on situated experiences of people), or to spend an extended period embedded in the company context. However, given the practical constraints and the scope of this thesis project, this was not feasible. Does it render the outcomes of the analysis invaluable? Not necessarily. Such reflective accounts, though different from unfiltered daily practices, reveal the broader frames of meaning participants construct around their roles, challenges, and experiences, which I believe can be valuable for understanding how HRI is conceptualized and enacted by developers. While these findings may not fully capture the participants' native ways of thinking in the flow of daily work, they nonetheless enrich our understanding of the attitudes, assumptions, and professional values that shape HRI design practices. Therefore, although further observational data would deepen this understanding, the interview-based insights still make a meaningful contribution to the field.

With the benefit of hindsight, I recognize that expanding the participant pool to include company staff involved in different stages or roles within robot development would have yielded richer knowledge as it would have increased the diversity of perspectives captured. Access to such participants would likely have been possible with a well-argued case, though decisions about whom I could interview may not have been entirely within my control. Unfortunately, this omission narrows the scope of insights gathered from the three interviews conducted, especially as these reflect the perspectives of individuals occupying relatively senior positions in the company.

6.5 Summary

In this chapter, I explored the perspectives of Starship robot developers to understand how inconsequential encounters between robots and people influence the design process itself. Relying on reflexive thematic analysis, I identified several key themes that highlighted the complex dynamics shaping design decisions, including the overlap of commercial, technological, and specific socio-material arrangements and processes; how the company made sense of the situated encounters and behaviors towards robots on the street, highlighting the challenges of developing robots to be deployed in public settings populated by many actors, only few of which have some form of formal relations to the company.

CHAPTER 7

In Search of Robot Sociality

The work presented in this chapter was done in collaboration with Ralf Vetter, Astrid Weiss and Silke Buchberger. The choice of the theoretical framework and design of the two studies were driven by me. Astrid Weiss and Silke Buchberger assisted with the quantitative analysis of the data. Interpretation of the data and development of the ASOR-revised scale were done by me and Ralf Vetter, with the feedback from Glenda Hannibal at the early stages of work. Part of the work on Study 1. was published in Dobrosovestnova, Vetter, and Weiss, 2024a. Given the highly collaborative nature of the work presented in this chapter, in sections that relied on collaboration, instead of the first-person singular pronoun I use plural "we". Where it concerns the choices made by me, I return to the first-person singular pronoun.

7.1 Motivation and Research Questions

Anthropomorphizing robots is commonly discussed in HRI and social robotics (SR) in relation to the efforts to develop robots with "social presence" and "social behaviors", and endeavors addressed to understand why people treat robots as social actors (Fink, 2012), (Duffy, 2003)). Acknowledging diversity definitions and assessments of anthropomorphism and sociality (Damholdt, Quick, et al., 2023; Damiano and Dumouchel, 2018), the work presented in this chapter is rooted in a theoretical contention that not all experiences of sociality with robots amount to attributing to nonhuman agents human-like states, motivations, intentions and emotions, cf. (Epley, Waytz, and Cacioppo, 2007). As discussed in preceding chapters, related to sociality, the outcomes of the analysis of interviews and online content about Starship robots suggested: i) people engaged in prosocial behaviors towards functional service robots and experience them as social actors of a kind, ii) people relied on anthropomorphic language to describe these interactions, simultaneously recognizing how such language fails in accurately accounting for their experience of the robots as *somewhat social* but differently so than people or pets.

As pointed out in Section 5.4.5, this lack of linguistically precise tools to describe social experiences with robots has been pointed out by Johanna Seibt and colleagues in reference to the so-called descriptive problem (Seibt, 2014; Seibt, Vestergaard, and Damholdt, 2020). To assert that not all experiences of sociality converge to imagined or projected human-like capacities and qualities – even though both lay people – as well as HRI scholars – are prone to describe them as such cf. (Damholdt, Quick, et al., 2023), Seibt et al. proposed **sociomorphing** as a better fit for conceptually anchoring the *actual asymmetric* social capacities people attribute to and experience with robots (Seibt, Vestergaard, and Damholdt, 2020). Without assuming projecting human traits onto non-human agents, sociomorphing acknowledges the distinct *real* (as opposed to pretend-play) capabilities of non-human agents. In this view, robot sociality is seen as a multi-dimensional construct where which dimensions manifest will depend on many situational, robot-specific and human-centered factors.

Aiming to investigate further how people experience Starship robots socially, the empirical work presented in this chapter adopts the concept of sociomorphing as its theoretical foundation. To address this question, together with my collaborators, I designed and conducted two online studies with four robot conditions (Telenoid, Vector, Blossom, Starship), probing dimensions of sociality attributed to these four robots with the Attitudes Towards Social Robots (ASOR) scale, evaluating participants attributions of mental, socio-practical, and socio-moral capacities to robots (Damholdt, Vestergaard, et al., 2020). I chose to work with this scale because of its conceptual bridge to the Ontology of Asymmetric Social Interactions (OASIS) framework developed by Seibt et al. around the notion of sociomorphing (Seibt, Vestergaard, and Damholdt, 2020) – both of which I explicate in more detail in what follows.

My initial research question for the first study was: *Will the four robots be perceived differently on different dimensions of sociality as measured by the ASOR scale?* However, when designing the study and taking a closer look at the ASOR scale, I realized the scale – though conceptually aligned with my goal to explore dimensions of sociality – may suffer from several weaknesses, including the descriptive problem as defined above. Recognizing this has led me to extend my initial research goals to include: an empirically driven evaluation of the properties of the ASOR scale; and – if the assumptions about potential weaknesses are confirmed – developing and evaluating a set of suggestions for how the scale could be further developed to achieve a more reliable performance. The overarching research questions guiding the studies presented in this chapter can be summarized as follows:

- RQ1: Do people perceive the Starship robot as a social agent?
- RQ2: What dimensions of sociality are attributed to the Starship robot given that it is a functional service robot?
- RQ3: Can we reliably gauge dimensions of sociality using a quantitative survey?

- RQ4: How do the dimensions of sociality manifested for Starship compare to dimensions of sociality manifested for social (companion) robots?
- RQ5: What can we learn from how people people assess the Starship robot on dimensions of sociality for how we theoretically understand sociality in HRI?

The remainder of the chapter is structured as follows. In Section 7.2, I detail the concept of sociomorphing and related theoretical framework developed by Seibt et al., as these informed both the methodological choices and the interpretation of the two studies. This section also presents the ASOR scale and overviews the limitations that were identified by Damholdt et al. in the original study. In Section 7.3, I proceed to outline the two studies conducted, for each of the study specifying its design, participants recruitment procedure, analysis process, and outcomes. The chapter concludes with a Discussion 7.4 overviewing the limitations of the studies conducted, suggestions for future work, and a brief overview of the main conceptual lessons I have learned from these studies with respect to the theory and assessment tools of sociality in HRI.

7.2 Theoretical and Methodological Grounding

7.2.1 Sociomorphing, not Anthropomorphizing

In her work "Towards an Ontology of Simulated Social Interaction", philosopher Johanna Seibt points to the terminological challenge underlying the notion of 'social robot' in HRI and social robotics (SR) where what a 'social robot' is remains a moving target (Seibt, 2017). The reasons for this challenge include the rapid pace of changes in the field of social robotics as well as the lack of a unified and stabilized terminology in the fields studying human sociality (philosophy, anthropology, cognitive science).

When it comes to how we understand sociality in HRI and SR, Seibt criticizes fictionalist accounts that assume that *all* experiences of sociality in human-robot interactions boil down to metaphorical and pretend-play instances of ascribing human-like qualities to an artificial system (ibid.) cf. (Epley, Waytz, and Cacioppo, 2007). The problem with this "temptingly easy–strategy" (Seibt, 2017, p.4) is that such accounts, intentionally or unintentionally, leave out the possibility that interactions with robots may in fact bear a *genuine* social character and significance, which we risk to miss out on when we label all social experiences with robots as a pretend-play. To counter the dualist divide between social and non-social interaction implicit to fictional and make-believe interpretations, Seibt's proposal is to conceive of robot sociality as a *matter of degree*.

Rooted in the premise that people's interactions with robots are social – though to a different degree and differently expressed than those with humans – Seibt et al. put forth the concept of **sociomorphing** to conceptually anchor and describe dimensions and degrees of sociality in social robotics (Seibt, Vestergaard, and Damholdt, 2020). Sociomorphing can take different forms, including the cases when people interacting with a robot assume "symmetric distribution of the relevant capacities and quickly proceed to anthropomorphizing i.e., to fictionally projecting the human capacities onto the robot that it does not have" (Seibt, Vestergaard, and Damholdt, 2020, p.64). However, this does not mean that this will *always* be the case, nor will it be the only way to engage with the robot socially. To descriptively delineate the core elements constitutive of different types of experienced sociality, Seibt et al. sketch out what they call the Ontology of Asymmetric Social Interactions (OASIS) framework – a comprehensive theoretical proposal, incorporating levels of sociality, five different degrees of sociality (functional replication, imitation, mimicking, displaying, and approximating), and at (at least) seven perspectival descriptions (i.e. first person perspective, second person perspective, third person perspective, and combinations of thereof) (ibid.). [1]

7.2.2 Attitudes towards Social Robots Scale (ASOR)

The ASOR scale was developed by Damholdt et al. as a proposal for a measurement tool for social robotics and HRI to gauge how social robots can influence five dimensions of social relatedness. The proposed dimensions relate, according to the authors, to the distinction between anthropomorphizing and sociomorphing, and sociality levels of the OASIS framework (Damholdt, Vestergaard, et al., 2020, p.29), which contributed to my motivation to rely on this scale to address the research questions underpinning the two studies. The five dimensions formulated by the authors at the onset of the original study were: *(1) Socio-practical relatedness* is obtained when "the agent is perceived as an interaction partner capable of training or acting in accordance with a norm" (ibid., p.28); *(2) Intimate-personal relatedness* is obtained "when a person is attached to an item"; *(3) Moral relatedness* is obtained "when the agent is perceived as a moral agent or as a moral patient."; *(4) Psychological relatedness* refers to the situations when "the agent is perceived as having feelings and emotions and the perceiver is engaged in the processes of social cognition that are described by accounts of emotional contagion, sympathy, or compassion."; *(5) Mental relatedness* is obtained when "the agent is perceived as having intentions and beliefs, and the perceiver is (consciously or unconsciously) engaged in the processes of social cognition that are described by theories of 'mind-reading'" (ibid.).

To quantitatively gauge the five dimensions of sociality, Damholdt et al. generated 37 items and statistically assessed responses to them with a sample of 339 participants. A factor analysis yielded a three-factor solution consisting of 25 items. The resulting three factors were defined by Damholdt et al. as follows: *(1) ascription of mental capacities (AMC)* assessing whether the respondent perceives the "existence of an emotional and mental life, hereunder the robot's self-understanding and the social obligations towards robot", *(2) ascription of socio-practical capacities (APC)* encompassing items that gauge whether the respondent believes "the robot will act in the respondent's best interest and will act consistently over time" ibid., p.48.; *(3) ascription of socio-moral status (AMS)*, including items that "reflect the status of the robot as a social agent but also the specific expected role and status it would have to the respondent" (ibid.). I want to

[1] Please refer to the original publication for a detailed account of each component of the OASIS framework.

emphasize that the resulting three-factor scale thus reformulated the definitions of the initial five dimensions in response to the necessity to redefine the outcome factors of the 25-item ASOR scale. Importantly – while the ASOR scale was developed and evaluated in the context of a study with a Telenoid robot, – according to the authors, the scale is applicable to any other social robot (ibid., p.34).

Despite its potential to supplement existing measures typically used in social robotics and HRI research, such as the Godspeed questionnaire series (Bartneck, Kulić, et al., 2009; Złotowski et al., 2017), the Robotics Social Attributes Scale (RoSAS) (Bartneck, Kulić, et al., 2009), Individual Differences in Anthropomorphism Questionnaire (Fraune et al., 2020) (for more, see: (Damholdt, Quick, et al., 2023)), as a result of the statistical evaluation of the proposed ASOR scale, Damholdt, Vestergaard, et al., 2020 identified several limitations of the 25-item ASOR scale. First limitation concerned weak performance of the ascription of the socio-moral factor, with some items being recognized by the authors as ambiguous (ibid.). Secondly, soliciting qualitative feedback through additional interviews, pointed towards the struggle participants had when asked about mental capacities of the robot (Telenoid), on the one hand, felt concerned about the robot potentially having mental capacities but, on the other hand, were willing to ascribe such capacities to a point.

7.3 Online Studies with Four Types of Robots

This section presents two online studies we conducted to investigate the research questions as specified in Section 7.1. Section 7.3.1 details research aims, study design, analysis procedure and outcomes of Study 1. In Section 7.3.4, I detail Study 2 and its outcomes.

7.3.1 Study 1

For Study 1, our research aims were to: i) investigate whether the ASOR scale achieves different outcomes for Starship robot compared to other (social companion) robots, ii) evaluate statistical properties of the ASOR scale and, if limitations are established/confirmed, to offer iterative suggestions for improvement.

Participants and measures

Study 1 was conducted in March 2023 and consisted of the 25-item ASOR scale and four experimental conditions with four robots: the humanoid robot Telenoid, the small creature-like robot Vector, the DIY social robot Blossom, and the autonomous delivery robot by Starship (see Figure 7.1). We chose these four robots for the following reasons. Telenoid was the robot used in the original ASOR study by Damholdt et al. (ibid.); Starship was included because it is the robot at the core of the thesis project, and ultimately, the goal for me was to better understand sociality as experienced with this specific robot. Blossom and Vector were chosen because they are examples of social companion robots that are different from Telenoid in terms of their morphology and the tasks they can support.

Figure 7.1: Four robots. From left to right: Telenoid, Starship, Vector, Blossom

I recruited a sample of n = 202 participants (aiming at 50 per robot type) on the online research platform Prolific ©(2023). Balanced sample (50% male and 50 % female participants, mean age 27.88 years, SD=7.77) and "All countries" settings were used. Participants were paid a reward of £15.38/hr for their participation in the study. The study took on average about 8 minutes to complete. A participant was excluded due to an unrealistically short survey completion time.

After reviewing the informed consent sheet participants were asked a demographic question (age). Participants were then taken to the video of one of the four robots (more on this in Section 7.3.1). As an attention check and additional qualitative data input, participants were asked to describe the robots they saw in the video in their own words. They were then directed to the pages displaying the ASOR scale items (see Table 7.1 for an overview of the original items and the codes we used in the study). The items were presented in the same order as they were presented in the original study by Damholdt et al.[2] For consistency, we also preserved the 4-point Likert scale, from 1 (not at all) to 4 (to a high degree), used in the original study.[3]

As we were also interested in how participants engaged with the individual items and whether they found some of them ambiguous or challenging to respond to, we included an option to respond "not applicable/other" (N/A) for each of the 25 items of the ASOR scale. When the N/A option was selected, participants were asked to further elaborate on their choice in an open response text field. To solicit more in-depth qualitative feedback, we also recruited six participants among colleagues and friends. These participants had various disciplinary backgrounds including sociology, Human-Computer Interaction,

[2]We thank Malene Damholdt for sharing the video of the Telenoid robot and providing the original structure of the questionnaire.

[3]Please refer to the article by Damholdt et al. (Damholdt, Vestergaard, et al., 2020) for further details on why 4-point scale was chosen.

			Factor Loading					
Construct and code	Question	#NA						
			1	2	3	4	5	6
AMC_B04	Do you think that the robot can wish for something?	0	0,592		0,23	0,245		
AMC_B05	Do you think that you would help fulfill the robot's wish, if it asked you to (e.g. take it with you on holiday?)	1	0,364	0,423	0,444			
AMC_B06	Do you think that it matters how people treat the robot?	0	0,35		0,711	0,203		
AMC_B07	Do you believe that the robot has a sense of justice?	2	0,616		0,311	0,368		
AMC_B08	Do you believe that the robot can feel sad?	4	0,854					
AMC_B09	Do you believe that the robot can feel pain?	2	0,744					
AMC_C01	Do you believe that the robot can be happy?	3	0,847					
AMC_C02	Do you believe that the robot can have hobbies and interests?	2	0,739					
AMC_C03	Do you think that the robot can understand a joke?	0	0,652	0,253				
AMC_C04	You know who you are. Do you think that the robot knows who it is?	0			0,384	0,621		0,23
AMC_D01	I think that I would feel sorry for the robot if I saw others being evil to it (e.g. kick it or speak badly to it)?	0	0,317		0,775			
APC_A01	Do you think that you would take the robot's advice on choice of medication?	5		0,491		0,641		
APC_A02	Do you think that you would take the robot's advice on personal finances (e.g. choice of pension fund)?	5	0,213	0,414		0,728		
APC_A04	Do you think that you will trust what the robot tells you?	0	0,202	0,778				
APC_A06	Do you believe that the robot will give you the best possible advice?	2		0,694		0,281		
APC_A07	Do you think that the robot gives correct information, and that it always gives the same answer to a specific question (e.g. the ingredients for meat sauce)?	5		0,691				
APC_B02	Do you think that you would like doing things with the robot (e.g. play Ludo, chit-chat, learn a new language, or cook)?	1	0,238	0,587	0,278		0,24	
APC_B03	If you owned a robot, would you consider giving it a human name?	3	0,275	0,447	0,336			-0,361
APC_D03	Do you think that you could give an order to a robot?	0		0,455				0,34
APC_D05	Do you believe that the robot would be able to recognise you, if it had met you more than once?	0	0,283	0,247				0,718
AMS_A03_r	Do you think that you would feel insecure being with robot, if it were more intelligent than you?	2					0,719	
AMS_A05_r	Do you think that you will be afraid of the robot?	0		0,286		-0,305	0,652	
AMS_B01_r	If you had the robot at home, would you store it in a broom cupboard?	1		0,235	0,398		0,319	-0,216
AMS_D02_r	I think I would be annoyed, if the robot cut me off during a conversation?	1			-0,236		0,36	-0,581
AMS_D04_r	Would you feel embarrassed if other people saw you hugging the robot?	1			0,222		0,705	
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization. Rotation converged in 18 iterations. Items ending with an "r" have been reversed								

Table 7.1: Study 1. Original ASOR items with respective codes, nr of Non Applicable responses, Factor loadings.

developmental biology/philosophy of science, computer science, physics, and design. These participants were instructed to provide more extended feedback to the items they found challenging or not applicable. These six participants were asked to fill in the survey for all 4 robots with a break several days between each survey. Only qualitative data (feedback to the items) from these six participants were included in the analysis. These participants were not compensated monetarily.

Stimulus Videos

The videos were chosen such that they showcased (social) affordances of each of the robots and depicted tasks aligning with realistic use case scenarios. For the Telenoid condition, the same video as in the original ASOR study by Damholdt et al. (Damholdt, Vestergaard, et al., 2020) was used. The video, lasting 77 seconds, depicted a conversation between a woman and a *Telenoid robot*. The original video was in Danish; for our study we included English subtitles.[4] In the conversation, the woman expressed her concerns about her daughter's slow progress at school. In response, the robot suggested help with tutoring. The *Starship* robot video (80 seconds long) depicted a Starship robot delivering a package to its destination. The video started with the robot introducing itself in English, followed by it driving away. The video also included a scene where the robot asked a pedestrian to press the traffic light button at the street crossing, and the robot thanking the person for granting the request. The video of the *Vector* robot (72 seconds long) consisted of a series of interactions between a woman and the robot. These included: the robot "waking up" following the woman's command, the robot responding to the question about the identity of the woman, the robot "purring" in response to being "petted" on its back, and reporting the weather. The video of the *Blossom* robot (73 seconds long) depicted a woman inquiring the robot: "Hey Blossom, how are you?" In response, the robot moved its body and the woman commented jokingly "You seem happy today" and asked whether it would like to watch a movie together. The rest of the video depicted the woman and the robot in front of a laptop screen, with the robot moving in response to the animated film. The videos for Starship, Vector and Blossom[5] were created by the first author out of videos available on the free video sharing website Youtube.

7.3.2 Analysis and Findings

In this section, I specify the analysis methods we used and the main outcomes.

First Impressions of the Robots

To summarize the qualitative impressions of the robots, the data were uploaded to MAXQDA qualitative analysis software (2022). In MAXQDA, I coded individual comments with the codes capturing the adjectives and reactions people had to each robot.

[4]We thank Glenda Hannibal for helping us with the translation.

[5]We thank Yolanda Leite and Sarah Gillet for facilitating video recording with Blossom.

The response to the *Starship* video was predominantly positive. The technology behind the robot was described as "cool", "interesting" and "innovative". The respondents commented on robot's appealing visual design, calling it "nice" and "well designed". The robot's size was described as "small" and "compact". It was common to refer to the robot as "cute", which aligns with the outcomes of the content analysis presented in Chapter 4. People also commented on the voice of the robot noting it did not sound robotic. One participant even characterized it as "sassy". The robot was also described as "friendly", " smart" and "polite". Participants commented on the robot's ability to navigate the obstacles and participate in communication with people. However, they also questioned its practical utility. Participants emphasized the robot's (seeming) dependency on humans (needing a person to press a traffic light button); some participants referred to it as "helplessness". They were wondering how practically useful the robot is compared to human delivery, which also aligns with the insights from the qualitative interviews with vendors and passerby. Some participants further questioned the robot's navigation skills in busy city environments and on difficult terrains; several participants defined the robot as "slow". While some people called it impressive and considered the robot as easy to use and convenient; others doubted whether such technology can exist in reality.

Telenoid provoked ambivalent reactions. Many respondents characterized it as "creepy", "scary", "weird" and leaving them feeling uncomfortable. At the same time, some participants commented on its fluid, human-like conversation skills (participants did not realize the video depicted a Wizard of Oz scenario) and (appropriate) emotion display, which they found impressive. However, they noted how the fluid conversational skills were in dissonance with the robot's design (absence of arms), non human-like movements, and absence of blinking, which further contributed to the eerie impression (*"The way the robot looks, as well as its movements, is quite creepy and unsettling. It has a horror movie doll essence to it. However, I have no problem with how it speaks, it sounds normal", "My first impression of the Robot is that it looked like it had no emotions. It looked as if it were just a doll or a toy. However, when it speaks it is as if it were a human being"*. Despite generally seeing Telenoid robot as eerie, some respondents still described it as "helpful".

The impressions of the *Blossom* robot were divided. While many participants found it "cute", and described it as "friendly", others did not find the design of the robot appealing, with several participants even calling it "creepy". Participants noted that – even though Blossom seemed to be interactive and expressive (through its movements) – these movements seemed random. Some respondents even called the erratic movements "annoying". Several participants wondered whether the robot responds to voices, or any sounds in general. Other participants indicated they found the interactivity of the robot limited, but noted it could be a toy for children. While some participants found the lack of ability to speak furthermore limiting, others commented that it makes the robot more "realistic" and non-threatening.

Participants described *Vector* robot as "likable", "small", "cute," and playful; many compared it to a pet or even a child. Several participants remarked that it seemed to them that the design of the robot was intentionally striving to create an impression of the robot being cute. Participants positively commented on the robot's ability to respond to its owner, provide information, and assist with simple tasks. While several participants suggested it could potentially play an educational role, or be a companion, others, however, questioned whether the robot is really useful beyond its basic tasks when compared to other existing technologies, such as smartphones. Some participants shared negative remarks about Vector's voice being too robotic, and not very well audible.

Insights on the Four Robots

To analyze how people evaluated the four robots on the 25-item ASOR scale, we computed the scales by averaging the items. Through that, the subscales become continuous variables. Table 7.2 shows the means and standard deviations for each robot and subscale:

Table 7.2: Ratings for each ASOR scale and each robot

Robot		AMC		APC		AMS	
	n	mean	SD	mean	SD	mean	SD
Starship	51	1.90	.66	2.81	.50	2.82	.65
Telenoid	50	2.10	.67	2.86	.56	**2.59**	.65
Blossom	50	2.10	.66	**2.53**	.64	2.96	.59
Vector	50	1.97	.66	2.84	.54	3.11	.57

All four robots were rated rather low in the AMC (Ascription of Mental Capacity) subscale, but higher on the APC (Ascription of Socio-Practical Capacity) subscale, and the AMS (Ascription of Social-Moral Status) subscale. We assumed the robots would be rated lower on their mental capacities because of the descriptive problem suggested in Chapter 5 i.e. people do not actually think a robot can reason in a similar way as humans. On the APC subscale, we also expected Telenoid robot to be assessed higher because of the WoZ depicting a range of interactive capacities, and Blossom robot would be rated the lowest because of limited interaction capacities. The results for the AMC and APC subscale were in line with our expectations. For the AMS subscale, we were surprised by the high ratings for all robots, and by the fact that Telenoid was rated the lowest. We assume that the results on the AMS subscale are potentially inverse. For the subscale calculation, we reversed the items following the procedure specified by Damholdt, Vestergaard, et al., 2020. However, when looking at the semantic core of the items assessing the AMS construct, reversing seems counter-intuitive (see Table 7.1 for an overview of how the items are phrased). A One-Way ANOVA with a subsequent Tukey HSD post hoc test partly supported our assumptions. There was a significant effect of the robot type on the AMS subscale: $F(3, 197)=6.54$, $p<.001$ ($\eta^2=.09$). The post hoc tests revealed significant differences between the Telenoid group and the Blossom and Vector group, with Telenoid being rated the lowest, but the difference in rating between

Telenoid and Starship was not significant. We assume that the absence of significant difference between Telenoid and Starship might be related to the sample size and the overall weak performance of the AMS subscale (more on this below). Another significant difference was found for the APC subscale: F(3,197)=3.8, p<.01 (η^2=.06). Here, the post hoc tests revealed significant differences between the Blossom group, and the Telenoid and Vector groups, but again not Starship. The η^2 values indicated medium effects, however, the actual differences in the mean ratings are small. In other words, based on these outcomes, we infer that Starship was not perceived significantly differently from the social companion robots in the study.

Evaluating Statistical Properties of the ASOR Scale

Towards the research aim (ii) of exploring statistical properties of the ASOR scale, we performed a *reliability analysis* with listwise deletion on all data (n = 201). Both the AMC (n = 196, α = .88) and APC (n = 187, α = .80) subscales had satisfying reliability. The AMS subscale had low reliability (n = 197, α = .56) which aligned with the outcomes in the original study by Damholdt et al. (ibid.). Given no AMS item stood out for improving reliability by deletion, this pointed to uncertainty regarding the dimensionality of the ASOR scale and confirmed the need for further elaboration of the AMS construct, as suggested by Damholdt et al. (ibid.).

We then conducted an *exploratory principle factor analysis* on the 25 ASOR items with varimax rotation to test if the factor structure as described by (ibid.) is replicated in our data. Pairwise deletion was applied to retain the maximum of possible data points considering the "not applicable" option. At most, 5 participants were excluded for an item. We performed the Kaiser-Meyer-Olkin test (KMO = .845) to measure the sampling adequacy, and Barlett's test of sphericity (BTS = [χ^2] (300) = 1860.635, p = <.001). The results indicated that our data were appropriate for analysis.

An initial inspection of the eigenvalues showed six factors with eigenvalues above 1. The first four factors explained a combined 51.7% of the total variance (27.3%, 10.6%, 8.2%, 5.6%) and had eigenvalues between 6.8 and 1.4, while the fifth and sixth factor explained 4.4% and 4.2% of the total variance and had eigenvalues slightly above 1 (1.09 and 1.04). The scree plot indicated retaining a four to six factor solution would be justified (see 7.2). Thus, the factor analysis did not replicate the expected three-factor solution. We investigated the rotated component matrix to identify the items that constituted the factors in our solution (see Table 7.1 for the full overview of how the items loaded on the rotated component matrix), and to establish which items caused ambiguity compared to the original ASOR scale.

We specified three criteria for factor interpretation: (A) An item needed a loading above 0.6 to be allocated to a factor. (B) An item was allocated to a factor if the difference between its highest loading on a factor and any loading on another factor was at least 0.2. (C) A factor was suitable for interpretation if at least four items adhered to the first two criteria.

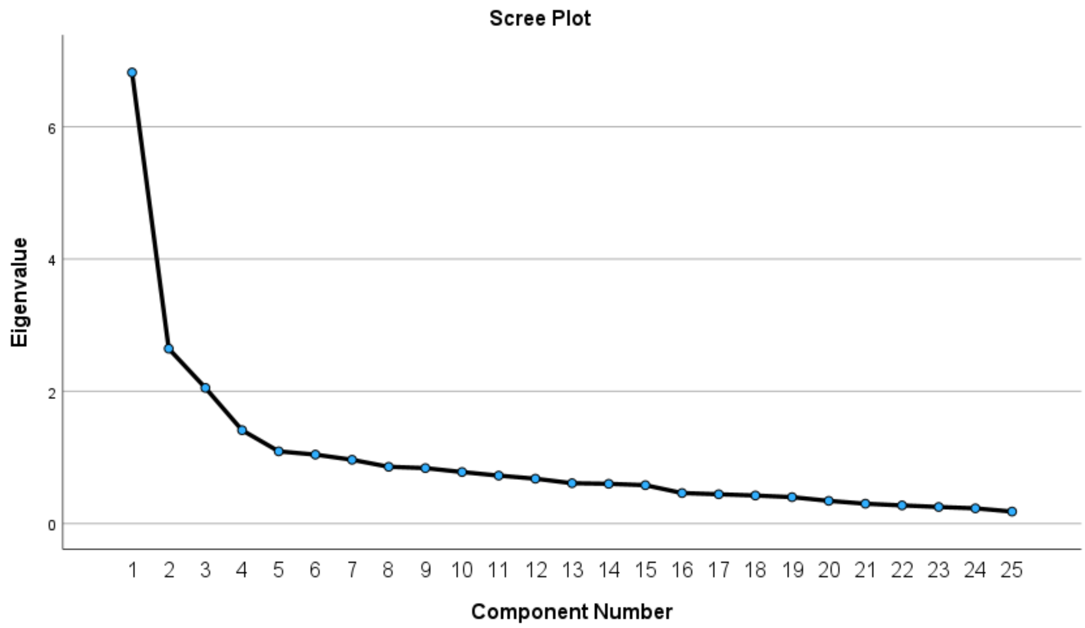

Figure 7.2: Scree plot of the exploratory factor analysis over all robot conditions.

The overall structure of component 1 mostly aligned with the AMC subscale as in (Damholdt, Vestergaard, et al., 2020), and included six items that gauged people's expectations about the robot having mental and emotional states (AMC B07, AMC B08, AMC B09, AMC C01, AMC C02, AMC C03). The remaining five of the original AMC items (AMC B05, AMC B06, AMC C04, AMC D01) loaded elsewhere (on component 3) than the core group.

The clustering of the items under component 2 (APC A04, APC A06, APC A07) suggested a semantic core that aligned with the ascription of the socio-practical capacities as predicted by Damholdt et al. However, five items of the original APC subscale (APC A01, APC A02, APC B02, APC B03, APC D03, APC D05) loaded elsewhere, thus deeming component 2 overall unsuitable for interpretation per our criteria.

The clustering under component 3 (AMC B06, AMC D01), based on the semantic core of the two items, suggested that the underlying construct tapped into the dimension of perception of the robot as a moral patient, although again the factor included only two items. Component 4 consisted of only two items (APC A02, AMC C04). Component 5 consisted of the grouping of the three items gauging ascription of socio-moral status (AMS A03, AMS A05, AMS D04). Semantically though, these items were associated with a feeling of discomfort experienced in relation to the robot. On component 6, only one item loaded sufficiently (APC D05). In sum, these results suggested that – though there is some alignment between the factor structures resulting from our study and the one of ibid. – only the AMC subscale performed as expected per our criteria.

Qualitative Feedback to the Items

Very few participants recruited on Prolific opted for the "Not Applicable" (from here on N/A) answer option (in total, 40 N/A responses were chosen, which represents 0.75 percent of all responses; see Table 7.1 for an overview of how many N/A responses were chosen per item). 15 of those were chosen in the Blossom condition, 11 in the Vector condition, 10 in the Starship condition, and 4 – for the Telenoid. The smaller number of N/A responses in the Telenoid condition might suggest that the ASOR scale in its current form may be tailored for a specific type of social robot and does not translate well to all types of social robots. Given that among the four robots, Blossom is the one that can be said to differ the most in terms of its interactive and task-related affordances from other robots in the study, this adds more evidence in support of this assumption.

We speculate that people choosing N/A for a given item does not necessarily mean they found it difficult to interpret, but rather that they thought the question refers to a task that the robot in a given condition cannot perform because it does not have respective design features to support such a task. At the same time, even if an item is found ambiguous, it does not follow that a participant will choose N/A because it requires additional time and effort to provide an explanation – we assume, this might also be the reason why so few N/A responses were chosen on Prolific. This is why, the total number of N/A responses in itself seemed insufficient to us to make meaningful conclusions about performance of individual items. Below, we summarize the main insights we derived from examining qualitative feedback to the items demarcated as N/A, both from the main sample of participants, and from additionally recruited 6 participants.

The qualitative feedback to item APC A01 (Do you think that you would take the robot's advice on choice of medication?) suggested that it mattered to the participants whether the robot is developed to perform a specific function or task. For the Starship robot, participants indicated that the robot is designed as a food delivery system, this is why it would not make sense to take medical advice from it. A participant with professional background in AI indicated that a robot is just the 'front end', and that for them it would matter more what the technical process behind the generation of advice was, rather than the (type of) robot itself: (*"As someone who has worked in the field of AI, I would first aim to understand the technical process behind the generation of advice that the robot is giving me. I consider the robot as just 'front end' in this case and would probably try to disregard how good/bad it is. [...] Due to the current state of AI applications I would be distrustful of most of their outputs without extra confirmation"*). In contrast, another participant, while also pointing out that it matters to them what the process of generating the advice content is, they also considered it helpful if the robot was not too human-like and 'creepy' (*"I'd first want to know what process is generating the advice content. I will say that it helps that this robot is less human-like as it does not have a creepy vibe, and I don't get the feeling its design is trying to convince me to trust it on its human likeness alone."*). Similarly, qualitative responses to the item APC A02 (Do you think you would take the robot's advice on personal finance e.g., choice of pension fund?) indicated that if a robot is designed for a different task, they do not see why it should be giving financial advice (*"It is not a financial robot."*, *"Starship robot isn't designed for this."*, *"This is too far away from it's intended use to answer for me."*) Participants also indicated that the affordances of the robot mattered. Specifically, this applied to Blossom robot that has no dialogue-based nor other communication modalities other than movement (*"The robot showed no signs of communication. I don't think it would be able to recommend me personal finance."*).

For the item APC A07 (Do you think that the robot gives correct information, and that it always gives the same answer to a specific question e.g., the ingredients for meat sauce), several participants pointed out that this item contains two, and not one, questions, and that they would respond differently to each of these questions. They further shared that it would matter to them what the (technical) process behind generating such an advice was, and how reliable/trustworthy/intelligent they perceived the background algorithm to be (*"It looks more likely to be run by simple logic and therefore more likely to repeat the same answer. Having said that, it still depends entirely on the software."*, *"I do not know how this robot is programmed. It is a Wizard of Oz scenario we see or completely staged... if it is connected to ChatGPT, for example, it might know an answer to meat sauce as well."*). The affordances of the robot, e.g., not being able to 'speak' as in the case of the Blossom robot were also mentioned as an impediment to answering this item.

The qualitative feedback to the item AMC B08 (Do you believe that the robot can feel sad?) as well as to the item AMC C01 (Do you believe that the robot can be happy?), and the item AMC B09 (Do you believe that the robot can feel pain?) from Prolific and additional participants converged to differentiating between expression of emotion as opposed to genuine phenomenological experience of an emotion. Participants indicated that they were not sure what exactly "feeling sad" or " be happy" meant for the robot. They specified that a robot could, in their view, be programmed to display or simulate an emotion, but it is unable to genuinely experience it: *"Vector is not a human being therefore I do not believe it can sense or feel like a human being, as it has been programmed."*, *"It can simulate feeling sad for sure...but feeling sad is such a complex construct not even understood for humans fully..."*. Participants differentiating between degrees of sociality (mimicking, displaying or functionally replicating) provides further evidence in support of the OASIS framework (Seibt, 2017; Seibt, Vestergaard, and Damholdt, 2020) on the conceptual level – a distinction that got "lost" in the ASOR scale. At the same time, it contributes further evidence as to why ASOR items gauging attributions of mental and emotional states may not be straightforward for participants to interpret in the absence of knowledge whether the item is gauging emotional state as genuinely experienced (i.e., symmetric to a human), or it is questioning a possibility of imitating emotion algorithmically. Similar feedback extended to the item AMC B07 (Do you believe that the robot has a sense of justice?), with one participant pointing out it might if it was programmed to do so, and the another participant highlighting how it is a misleading question as it obscures how and who programmed the robot.

Item AMS A03 (Do you think that you would feel insecure being with the robot if it were more intelligent than you?) also provoked several respondents to question what exactly "intelligence" means in this context; participants pointed out that their response would depend on which type of "intelligence" they are invited to assess: *"What does intelligent mean here? That it has access to more information that I do? That it has a higher computational power? Or that it can adapt to unexpected situations with high flexibility? To answer this, the underlying construct of intelligence [needs] to be clear"*.

With respect to the items B06 (Do you think that it matters how people treat the robot?) and D01 (I think that I would feel sorry for the robot if I saw others being evil to it), several participants pointed out the question would need to specify whose perspective the question is probing. More precisely, respondents indicated that it probably did not matter to the robot because it cannot authentically experience an emotion, as a human would, but it might matter to *them* and other people because they considered it inappropriate to behave in such manner. This insight aligns with how passersby reasoned about inappropriateness of vandalism as discussed in Chapter 5. On the other hand, it also aligns with the OASIS framework pointing to perspective-taking playing a role in how humans evaluate what appropriate (social) behaviors towards the robot are (Seibt, Vestergaard, and Damholdt, 2020).

To sum up, participants' feedback highlighted several potential issues with how selected ASOR survey items are phrased: the design and intended function of a robot, for some robots, were in tension with the task the performance of which an item was gauging. Further, an ambiguous phrasing led to confusion about concepts like robot's emotional capacity and intelligence, where respondents were unsure whether to interpret the question as asking about genuine experiences and capacities, or programmed displays. Further, some participants felt that items combining multiple questions or lacking clarity on complex terms, like "intelligence", hindered their ability to respond meaningfully. At the same time, we wish to point out that not all items that were evaluated as N/A and solicited qualitative feedback performed weakly in factor analysis. Specifically, items probing attributions of emotional states (e.g., robot feeling sadness or pain) loaded strongly on the AMC factor.

7.3.3 Interim Summary

To summarize the interim findings of Study 1., the ratings for the four robots showed moderate overall effect sizes, with only small differences in mean ratings between them. This suggests that the robots were not perceived as substantially different in terms of sociality, as measured by the ASOR 25-item scale. These results align with insights from qualitative studies discussed in previous chapters, indicating that a robot does not need anthropomorphic design features or fluid social interaction capabilities (Breazeal, 2004) to be assessed as a social agent.

As anticipated, participants generally attributed low mental capacities to all four robots while assigning higher ratings for socio-practical capacities. This finding reinforces the theoretical basis of the OASIS framework and the concept of sociomorphing, which views sociality as varying along degrees and dimensions. Specifically, a robot may be perceived as less social in terms of its mental capacities while scoring higher on other aspects of sociality. The relatively high socio-moral status ratings – despite Telenoid receiving the lowest overall ratings of the four robots – can be attributed to the inversion of items measuring this construct. Upon closer examination of these items' semantic cores, such inversions may not be necessary.

Regarding the evaluation of the ASOR scale's statistical properties, our findings from Study 1., both quantitative and qualitative, corroborate the weaknesses identified by Damholdt et al. (Damholdt, Vestergaard, et al., 2020), particularly the poor performance of the socio-moral capacities construct. Additionally the socio-practical capacities construct in our study performed only partially satisfactorily. Qualitative feedback on individual scale items highlighted further challenges related to item phrasing. While the OASIS framework (Seibt, Vestergaard, and Damholdt, 2020) distinguishes between simulation modes, such as functional replication, imitation, display, and approximation, many ASOR items use language that conflates these distinctions, potentially leading to interpretive inconsistencies.

7.3.4 Study 2

Our aims in Study 2. were to: (i) introduce steps towards improving the ASOR scale, at the level of subconstructs and individual items, (ii) probe statistical properties of the ASOR-revised scale, and investigate the relationship between the ASOR-revised subscales and an established anthropomorphism survey (anthropomorphism items of the Godspeed questionnaire); (iii) evaluate whether the ASOR-revised scale achieves different results on the four robots; (iv) because cuteness emerged as an important factor shaping people's perceptions of the Starship robot in the qualitative studies presented in preceding chapters, to evaluate quantitatively whether the four robots will differ as measured by the adapted cuteness/kawaii scale (Berque et al., 2020).

In Section 7.3.4, I detail the process we undertook towards developing an ASOR-revised scale. In Section 7.3.4 I proceed to detail Study 2. procedure, participants, and measures used. In Section 7.3.4, I describe the analysis and results of the evaluation of the statistical properties of the ASOR-revised scale, and follow with the analysis and results of how the ASOR-revised and other measures performed for the four robots.

Revising the ASOR scale

Our first step in revising the ASOR scale was to revisit the original five dimensions of relatedness that the ASOR scale was developed to explore before the scale was reduced to the three-factor solution as an outcome of statistical evaluation (Damholdt, Vestergaard, et al., 2020). Our decision to return to the five dimensions of relatedness as the theoretical foundation of the ASOR scale – with five-component scale structure evaluating these dimensions respectively – was motivated by two key considerations. First, the three-factor solution did not replicate in our study: only the Ascription of Mental Capacities (AMC) subscale (Component 1) performed as expected, while the Ascription of Socio-

Practical Capacities (APC) subscale (Component 2) performed partially as expected, and the Ascription of Socio-Moral Status (AMS) subscale (Component 3) performed insufficiently. Second, while the remaining components were unsuitable for interpretation, the semantic cores of the clusters of items aligned somewhat with the original five dimensions of relatedness. This prompted us to return to these dimensions as a starting point, anchoring their definitions (i.e., what the respective components are expected to evaluate), and mapping and revising the items gauging these. As a reminder, the original five dimensions were: (1) Socio-Practical Relatedness, (2) Intimate-Personal Relatedness, (3) Moral Relatedness, (4) Psychological Relatedness, and (5) Mental Relatedness.

Informed by the outcomes of the study by Damholdt et al., and what we learned in our Study 1., we defined **Socio-Practical Relatedness** as perception of the robot performing its task well and reliably, as well as perception of the robot as having capacity for low-level normativity i.e., abiding by the established social norms and rules. Importantly, low-level normativity must be differentiated from the concept of moral agency – an agent need not to have a capacity for ethical decisions to be capable to follow, at least to a point, established norms. Aligned with Damholdt et al., we defined **Intimate-Personal Relatedness** as the capacity to form attachment to the robot, independent of its ability to reciprocate. For **Moral Relatedness** again we preserved the definition by Damholdt et al. as the perception of the robot as a moral agent or a moral patient. We specified **Psychological Relatedness** as the perception of the robot as having emotions and feelings. This revised definition deliberately excludes the human perspective-centered view, specifically removing the aspect of emotion contagion and empathy that people feel in relation to the robot (which was part of the original definition by Damholdt et al.). Our choice to restrict the dimension of psychological relatedness to the robot-centered – whether people perceived the robot as capable of having emotional and affective states – stemmed from the qualitative feedback to the items mixing different perspectives being perceived as ambiguous by respondents. For **Mental Relatedness**, we narrowed the definition down to: perception of the robot as having cognitive states (e.g., intentions, beliefs) and processes (e.g., reasoning, planning). These five conceptual dimensions of relatedness formed the foundation for the five-factor structure we assumed for the ASOR-revised scale.

Our next step was to review the 25 items of the ASOR scale to: first, map these items according to the five-factors structure. Since we did not have access to the original assumed structure of the ASOR scale by Damholdt et al. for mapping the items, we based our approach on a combination of sources of information: the statistical findings from the original study, the results of our Study 1., and the semantic interpretation of each item as understood by Ralf Vetter and myself.

Once the mapping was complete, we excluded the items that loaded across multiple factors in our factor analysis. The excluded items were: "AMS A05 Do you think you will be afraid of the robot?", AMS D04 Would you feel embarrassed if other people saw you hugging the robot?", AMS B05 Do you think that you would help fulfill the robot's wish, if it asked you to (e.g., take it with you on holiday?)", AMS B01 If you had the robot at home, would you store it in a broom cupboard?"

Because very few ASOR items could be allocated to the *Intimate-Personal Relatedness* and *Moral Relatedness* dimensions, we decided to introduce new items. To achieve this, we consulted literature from social robotics and related fields to identify validated scales suitable for adaptation. For *Intimate-Personal Relatedness*, in the absence of a unified theory of attachment (Jiménez and Voss, 2014), we adapted six items from the Pets as a Source of Social Support and Attachment Scale (Meehan, Massavelli, and Pachana, 2017). This scale, with its focus on attachment dynamics between humans and pets, offered a meaningful foundation for probing this dimension within the context of human-robot relationships.

For *Moral Relatedness*, two existing scales suggested a good fit: the Perceived Moral Agency (PMA) scale (Banks, 2019) and the Perceived Moral Patiency (PMP) scale (Banks and Bowman, 2023). The PMA scale, developed by Banks, 2019, is a two-factor measure assessing perceptions of moral agency in social machines. Its morality factor (6 items) captures intuitive and rational judgments of an agent's morality, while the functional dependency factor (4 items) reflects perceptions of the agent's reliance on programming or human control, with the two factors being negatively related. The PMP scale is an omnibus six-factor scale (18 items total), measuring the extent to which people believe robots deserve moral consideration, grounded in moral foundations theory (Banks and Bowman, 2023). Given the thorough validation of both scales, and because our factor analysis for the AMS scale highlighted semantic connections to both moral agency and moral patiency, we opted to use these validated measures for *Moral Relatedness* rather than creating new items. Consequently, *Moral Relatedness* in the revised ASOR is represented by two separate constructs—moral agency and moral patiency—measured through these scales. This resulted in eight subscales that we evaluated as components of the ASOR-revised.

Lastly, for some items on the ASOR scale that we decided to retain, we introduced paraphrasing in an effort to improve clarity. Specifically, for items that participants found ambiguous – such as whether the robot was perceived to have emotional or mental states similar to humans versus simply mimicking emotions or approximating cognitive processes algorithmically – we incorporated comparisons to humans or pets as reference points to anchor interpretation. For example, the item APC D05 (Do you believe that the robot would be able to recognize you if it had met you more than once?) was rephrased as "Pets recognize their owners. Do you think the robot recognizes its owners?"[6]

Table 7.3 presents a comprehensive overview of the constructs, items, and their sources (whether from Damholdt et al., existing scales, or newly introduced by us) along with the codes used to facilitate statistical analysis. Items sourced from Damholdt et al. but paraphrased by us are marked with an asterisk (*).

[6]We also categorized this item under Mental Relatedness because we interpreted it as implying a capacity for memory and recollection, which we considered a cognitive process.

Source	Code	Construct and items	Answer category
		Construct - Socio-Practical Relatedness (SPR)	4-point Likert
APC A06*	SPR_05	1. Do you think you would take the robot's advice on important matters such as career choices?	
APC A02*	SPR_53	2. Do you think the robot would be helpful to you in learning a new skill e.g., new language?	
APC A07*	SPR_04	3. Do you think the robot always gives correct information?	
Introduced by us	SPR_01	4. Do you think the robot is polite?	
APC A04*	SPR_54	5. Do you think you will trust the information that the robot gives you?	
Introduced by us	SPR_07	6. Do you think you trust the robot to perform its task well?	
Introduced by us	SPR_51	7. Do you think the robot will greet you if it meets you more than once?	
AMS D02*	SPR_37	8. Do you think you would be annoyed if the robot interrupted you during a conversation?	
		Construct - Intimate-Personal Relatedness (IPR)	4-point Likert
Meehan et al 2017	IPR_09	1. If you owned this robot, do you think you would evolve an emotional connection to it?	
Meehan et al 2017	IPR_58	2. Would you feel you have company if the robot was with you in the same room?	
APC B03	IPR_56	3. If you owned this robot, would you give it a human name?	
Meehan et al 2017	IPR_39	4. If you owned this robot, do you think it would be a source of joy to you?	
Meehan et al 2017	IPR_10	5. If you owned this robot, do you think you would talk to it about things that are happening in your life?	
Meehan et al 2017	IPR_33	6. If you owned this robot, would you think about it when you are away e.g., on holidays?	
Meehan et al 2017	IPR_36	7. If you owned this robot and it broke would you throw it away?	
		Construct - Mental Relatedness (MR)	4-point Likert
AMC C02*	MR_38	1. Do you think that the R can have hobbies?	
AMC C03	MR_03	2. Do you think that the R can understand a joke?	
Introduced by us	MR_32	3. Do you think the R can make plans for the future?	
AMC C04	MR_52	4. You know who you are. Do you think the R knows who it is?	
AMC B04*	MR_08	5. People have wishes. For example, they can wish for a better future. Do you think the R can have a wish?	
APC D05*	MR_59	6. Pets recognize their owners. Do you think the R recognizes its owners?	
Introduced by us	MR_55	7. Do you think the R can lie to you?	
		Construct - Psychological Relatedness (PR)	4-point Likert
Introduced by us	PR_34	1. Do you think the R can feel lonely?	
Introduced by us	PR_06	2. Do you think the R can feel hopeful?	
AMC D01*	PR_510	3. Would you feel compassionate towards the R if you saw people kicking it or treating it badly?	
Introduced by us	PR_D31	4. Do you think the R can feel angry?	
AMC_B08	PR_57	5. Do you believe the R can feel sad?	
AMC_B09	PR_310	6. Do you believe the R can feel pain?	
AMC_C01	PR_02	7. Do you believe the R can be happy?	
		Construct -Moral Agency (MA)	7-point Likert
Banks 2019	MA_01	1. This robot has a sense for what is right and wrong.	
	MA_02	2. This robot can think through whether an action is moral.	
	MD_03	3. This robot can only do what humans tell it to do.	
	MA_04	4. This robot might feel obligated to behave in a moral way.	
	MD_05	5. This robot can only behave how it is programmed to behave.	
	MA_06	6. This robot is capable of being rational about good and evil.	
	MA_08	7. This robot behaves according to moral rules.	
	MD_09	8. This robot's actions are the result of its programming.	
	MA_10	9. This robot would refrain from doing this that have painful repercussions.	
	MD_11	10. This robot would never do anything it was not programmed to do.	
		Construct -Moral Patiency (MP)	7-point Likert
Banks and Bowman 2023	MP_21	1. This robot should have its opinions considered	
	MP_22	2. This robot should be engaged in conversation.	
	MP_23	3. This robot should be helped to achieve its goals.	
	MP_24	4. This robot should be treated as an equal.	
	MP_25	5. This robot should have advocates for equal rights.	
	MP_26	6. This robot should be treated as humans are treated.	
	MP_28	7. This robot should be respected.	
	MP_29	8. This robot should be admired for its skills.	
	MP_30	9. This robot should be obeyed.	
	MP_31	10. This robot should have someone who always has its back.	
	MP_32	11. This robot should have a devoted protector.	
	MP_33	12. This robot should have humans support its purpose.	
	MP_34	13. This robot should be protected from violent or lewd media.	
	MP_35	14. This robot should be protected from the harsh realities of humanity.	
	MP_36	15. This robot should only be allowed to consume wholesome information.	
	MP_37	16. This robot should be programmed to be free.	
	MP_38	17. This robot should be freed from control by others.	
	MP_39	18. This robot should be given free reign.	
		Cuteness/kawaii	5-point Likert
Berque et al. 2020	C11	1.I think the design of the robot is cute	
	C12	2. I think the design of the robot is cool	
	C13	3. I think the design of the robot is beautiful	
	C14	4. I think the design of the robot is approachable	
	C15_R	5. I think the design of the robot is scary	
	C16	6. I think the design of the robot is comfortable	
		Godspeed, revised presentation method (Kaplan et al. 2021) - excluded from analysis because of mistake	5-point Likert
Bartneck et al 2009		1. I found the robot moving elegantly	
		2. I found the robot conscious	
		3. I found the robot machinelike	
		4. I found the robot humanlike	
		5. I found the robot natural	
		6. I found the robot moving rigidly	
		7. I found the robot unconscious	
		8. I found the robot artificial	
		9. I found the robot fake	
		10. I found the robot lifelike	

Figure 7.3: Study 2: ASOR-revised candidate items, their sources and codes used in analysis.

Participants

Lay participants (n=400) were recruited on Prolific (100 participants per condition) from around the world; using balanced sample setting (50 % male and 50 % female participants). We applied an exclusion criterion to exclude all participants who had taken part in the Study 1. Four participants were excluded because they failed attention checks or completed the survey in unrealistically short time, leaving 396 participants in total. Participants were mean=29.03 years old (SD=9.05), 191 (48.2%) identified as female, 196 (49.5%) as male, 8 (2%) as non-binary, 1 (0.3%) preferred not to disclose their gender. The highest degree completed was an undergraduate degree for 163 (41.2%) participants, followed by graduate degree for 88 (22.2%), secondary education for 79 (19.9%), technical/community college for 56 (14.1%) and doctorate degree for 4 (1%). 2 (0.5%) participants stated having no formal qualifications and 4 (1%) preferred not to disclose their highest level of education completed.

Procedure and Measures

As in Study 1., Study 2. was an in-between study with four experimental conditions including the four robots (Starship, Telenoid, Vector, Blossom). After reviewing the informed consent form, participants were directed to the same stimulus video depicting one of the four robots (see Section 7.3.1 for detailed overview of the videos). As an attention check, we asked participants to summarize in their own words what they saw in the videos. Following this, participants were invited to rate their perception of the robot with the ASOR-revised scale. The items of the Socio-Practical Relatedness (SPR), Intimate-Personal Relatedness (IPR), Mental Relatedness (MR), and Psychological Relatedness (PR) had to be evaluated on a 4-point Likert scale, from 1 (not at all) to 4 (to a high degree); and of the constructs Moral Agency (MA) and Moral Patiency (MP) – on a 7-point Likert scale (1 = strongly disagree, 7 = strongly agree).

For the ASOR-revised items (excluding the moral agency and moral patiency constructs), we introduced a “Not Applicable (N/A)” response option. Participants who selected N/A for any item were also invited to provide optional feedback in their own words. Unlike Study 1., this feedback field was not mandatory. The N/A option was not included for items of the Moral Agency and Moral Patiency constructs, as these items had already undergone rigorous validation within the context of social robotics.

In addition to the ASOR-revised items, the study included ten items of the anthropomorphism sub-scale of the Godspeed series using the revised presentation method (Kaplan, Sanders, and Hancock, 2021) presented as a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree).[7]

Because cuteness emerged as an important factor shaping the perception of the Starship robot among participants in qualitative interviews and online content analysis, as well

[7]Unfortunately, I made a mistake labeling the Likert points. This rendered the data collected with this measure unsuitable for interpretation. This is why, I omit it from the analysis and results Section.

as how participants in Study 1. described their impressions of robots, we also included 6 items adapted from the cuteness/kawaii scale (Berque et al., 2020), presented as a 5-point (1 = strongly disagree, 5 = strongly agree) Likert scale.

Evaluating Statistical Properties of the Revised ASOR Scale

We conducted an *exploratory principle factor analysis* on the 29 items comprising the ASOR-revised scale, as well as the cuteness/kawaii scale with varimax rotation to test if the factor structure as assumed by the seven-factor composition of our survey would be replicated in the data. Pairwise deletion was applied to retain the maximum of possible data points. Missing values per item ranged from 0 (majority of the items) to 47 (item PR_02). We performed the Kaiser-Meyer-Olkin test (KMO = .935) and Barlett's test of sphericity (BTS = $[\chi^2]$ (1935) = 13 513.638, p = <.001) to assess the sampling adequacy. The results indicated that our data were appropriate for analysis.

An initial inspection of the eigenvalues showed 12 factors with eigenvalues above 1. The first five factors explained a combined 51.7% of the total variance (30.1%, 8.6%, 5.2%, 4.4%, 3.4%) and had eigenvalues between 18.9 and 2.1, while the sixth to twelfth factors explained between 2.9% and 1.6% of the total variance and had eigenvalues between 1.8 and 1.0. The visual examination of the scree plot indicated retaining a 4, 6, or 8 factor solution would be justified (see Figure 7.4).

The factor analysis did not replicate the anticipated seven-factor solution. Upon examining the rotated component matrix (see Table 7.3), we observed that the scales for Moral Patiency (Component 1), Moral Agency (Components 3 and 8), and Cuteness (Component 4) each clustered distinctly on a single factor. This supports the structure proposed in their respective studies (Banks, 2019; Banks and Bowman, 2023; Berque et al., 2020).[8]

For the other ASOR-revised constructs, we observed clear clustering for the cores of the Intimate-Personal relatedness items (Component 5) and Socio-Practical relatedness items (SPR - Component 6). However, there was some ambiguity with items from Psychological relatedness (PR) and Mental relatedness (MR), which tended to cluster together on Component 2 (thus supporting the AMC factor of the ASOR scale that also consisted of the items gauging both mental and psychological capacities of the robot). Additionally, several items from SPR and MR were outliers, complicating their alignment with the expected structure.

[8]The moral agency construct was derived from two subscales assessing moral agency and moral dependency, which resulted in its items loading on two separate factors.

Factor Loading Item Code	1	2	3	4	5	6	7	8	9	10	11	12
MP_31	0,799	0,153	0,139	0,144	0,163	0,047	0,225	-0,036	0,076	0,024	0,032	-0,002
MP_33	0,784	0,076	0,184	0,099	0,125	0,069	0,132	-0,043	-0,011	-0,003	0,04	-0,063
MP_32	0,77	0,159	0,15	0,106	0,131	0,093	0,186	-0,09	0,096	-0,026	0,062	-0,112
MP_35	0,769	0,213	0,13	0,029	0,13	0,015	0,173	-0,057	-0,035	0,008	0,047	-0,255
MP_34	0,764	0,144	0,153	0,046	0,2	0,049	0,068	-0,074	0,016	-0,022	0,024	-0,221
MP_23	0,692	0,156	0,211	0,016	0,025	0,154	0,017	0,08	0,071	0,032	0,031	0,215
MP_28	0,678	0,138	0,227	0,134	0,1	0,057	0,168	0,069	0,097	0,219	-0,009	0,109
MP_29	0,657	0,061	0,176	0,09	0,238	0,227	0,026	0,041	0,025	0,191	-0,014	-0,008
MP_24	0,628	0,236	0,263	0,121	0,114	0,076	0,361	-0,086	-0,091	0,04	0,111	0,321
MP_26	0,582	0,224	0,225	0,059	0,109	0,029	0,335	-0,078	-0,121	0,032	0,082	0,371
MP_25	0,529	0,268	0,29	0,069	0,082	0,102	0,384	-0,108	-0,093	0,033	0,091	0,332
MP_36	0,523	0,067	0,159	0,036	0,261	0,057	0,061	0,06	0,003	-0,151	0,005	-0,493
MP_22	0,512	0,151	0,352	0,024	0,389	0,153	0,082	0,029	0,106	-0,041	0,072	0,103
MP_30	0,505	0,13	0,128	0,053	0,079	0,154	0,409	-0,068	-0,21	-0,176	0,102	0,212
PR_510	0,449	0,148	0,109	0,181	0,378	0,044	0,068	0,051	0,209	0,221	0,074	-0,035
IPR_36_R	0,426	0,028	0,007	0,19	0,235	0,062	0,048	-0,002	0,033	0,422	0,107	-0,021
MP_21	0,414	0,196	0,371	-0,041	0,273	0,199	0,176	-0,104	0,106	-0,082	0,063	0,196
PR_310	0,163	0,763	0,084	0,028	0,02	0,072	-0,008	-0,158	0,017	-0,183	-0,013	0,12
PR_57	0,215	0,763	0,228	-0,021	0,127	0,057	0,142	-0,13	0,032	0,024	0,024	-0,042
PR_34	0,19	0,736	0,231	0,043	0,163	0,004	0,112	-0,103	0,052	0,068	0,024	-0,044
PR_D31	0,119	0,702	0,261	-0,105	0,174	-0,037	0,082	-0,078	0,068	-0,098	0,094	-0,087
MR_08	0,202	0,632	0,215	-0,008	0,093	0,149	0,273	-0,174	0,119	-0,061	-0,034	0,042
MR_38	0,211	0,611	0,155	0,054	0,268	0,144	-0,012	-0,098	0,101	0,012	-0,074	0,088
PR_06	0,046	0,542	0,338	-0,038	0,255	0,083	0,19	-0,057	-0,006	0,167	0,21	-0,011
PR_02	0,176	0,448	0,292	0,02	0,334	-0,076	0,099	-0,104	-0,072	0,113	0,419	-0,049
MR_32	0,231	0,391	0,25	-0,037	0,162	0,302	-0,069	-0,146	0,319	-0,128	-0,229	0,08
MA_08	0,262	0,143	0,752	0,096	0,006	0,094	0,095	-0,001	-0,003	0,083	-0,004	0,065
MA_04	0,237	0,186	0,749	0,058	0,098	0,017	0,074	-0,057	0,074	-0,019	0,007	-0,127
MA_06	0,162	0,318	0,727	-0,017	0,126	0,124	0,06	-0,181	0,101	0,054	-0,009	0,035
MA_01	0,268	0,233	0,682	0,033	0,206	0,161	0,08	-0,1	0,033	-0,02	0,083	0,065
MA_02	0,189	0,309	0,664	0,009	0,217	0,093	0,108	-0,225	0,079	-0,004	0,111	0,053
MA_10	0,325	0,172	0,623	0,088	-0,108	0,089	0,065	-0,101	0,069	-0,011	0,01	-0,071
MR_52	0,296	0,189	0,396	0,004	0,253	0,245	0,059	-0,055	0,197	0,138	0,033	0,014
C11	0,022	0,008	-0,018	0,866	0,055	-0,049	0,018	0,011	0,037	0,063	0,018	0,046
C14	0,12	0,054	0,057	0,825	0,1	0,056	0,073	0,191	0,026	0,014	-0,027	-0,03
C13	0,087	-0,047	0,073	0,824	0,121	0,041	0,081	-0,012	-0,011	0,014	0,066	0,031
C16	0,16	0,042	0,096	0,779	0,097	0,071	-0,004	0,094	-0,015	0,047	0,054	-0,001
C12	0,146	-0,017	0,037	0,761	0,061	0,235	0,061	-0,032	-0,064	0,051	0,122	0,015
C15_R	0,01	-0,049	-0,042	0,739	-0,06	-0,068	-0,037	0,084	-0,062	0,054	-0,047	-0,06
IPR_10	0,172	0,3	0,153	-0,007	0,682	0,111	0,13	0,005	0,063	0,047	-0,013	-0,02
IPR_58	0,288	0,251	0,181	0,147	0,618	0,146	0,207	0,059	0,074	0,078	0,088	-0,144
IPR_39	0,194	0,213	-0,024	0,265	0,594	0,126	0,051	0,019	0,118	0,211	0,066	0,039
IPR_09	0,223	0,357	0,033	0,151	0,58	0,081	0,021	-0,016	0,138	0,185	0,043	0,011
IPR_33	0,38	0,296	0,063	0,114	0,555	0,159	-0,015	-0,038	-0,008	0,145	-0,052	-0,029
IPR_56	0,36	-0,14	0,142	0,098	0,548	-0,008	-0,026	0,119	-0,012	-0,162	0,166	0,041
SPR_54	0,161	0,097	0,104	0,07	0,181	0,779	-0,036	0,017	0,103	0,002	0,052	0,05
SPR_04	0,026	0,031	0,154	0,074	0,03	0,76	0,087	-0,021	-0,057	0,088	-0,009	-0,119
SPR_07	0,217	0,03	0,04	0,18	0,011	0,704	0,063	0,111	0,11	0,094	0,17	0,083
SPR_05	0,167	0,243	0,181	-0,112	0,414	0,509	0,186	-0,188	-0,05	-0,115	-0,076	0,008
SPR_53	0,066	0,1	0,179	-0,085	0,442	0,499	0,081	-0,141	0,139	-0,129	0,21	0,008
MP_38	0,387	0,196	0,128	0,078	0,075	0,09	0,752	-0,058	0,121	-0,005	-0,014	0,005
MP_39	0,393	0,135	0,071	0,109	0,079	0,069	0,751	-0,12	0,056	-0,004	-0,006	0,042
MP_37	0,413	0,122	0,191	0,012	0,151	0,032	0,709	-0,063	0,041	0,018	-0,054	-0,124
MD_09	-0,083	-0,201	-0,092	0,053	0,069	-0,006	-0,151	0,787	0,113	0,053	-0,043	0,021
MD_05	0,003	-0,307	-0,099	0,083	0,069	-0,032	-0,132	0,753	-0,018	-0,089	-0,079	0,028
MD_03	-0,06	-0,107	-0,125	0,075	0,003	-0,008	0,031	0,732	0,036	0,008	0,054	-0,004
MD_11	0,055	-0,008	-0,093	0,134	-0,112	0,027	0,007	0,626	-0,292	0,066	0,102	-0,109
SPR_51	0,132	0,131	0,094	-0,039	0,101	0,225	0,073	0,019	0,656	0,065	0,241	-0,194
MR_55	-0,163	0,091	0,162	-0,113	0,171	-0,16	0,05	-0,228	0,538	-0,16	-0,067	0,277
MR_59	0,278	0,196	0,324	0,016	0,149	0,281	0,077	0,124	0,446	0,002	0,061	-0,018
SPR_37	-0,069	0,122	-0,069	-0,142	-0,13	-0,054	0,039	-0,032	0,052	-0,803	0,018	-0,042
SPR_01	0,171	0,013	0,043	0,196	0,105	0,221	-0,063	0,1	0,18	0,001	0,722	0,045
MR_03	0,098	0,37	0,332	-0,02	0,244	0,293	0,025	-0,124	-0,052	-0,03	0,384	-0,05

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 40 iterations.

Table 7.3

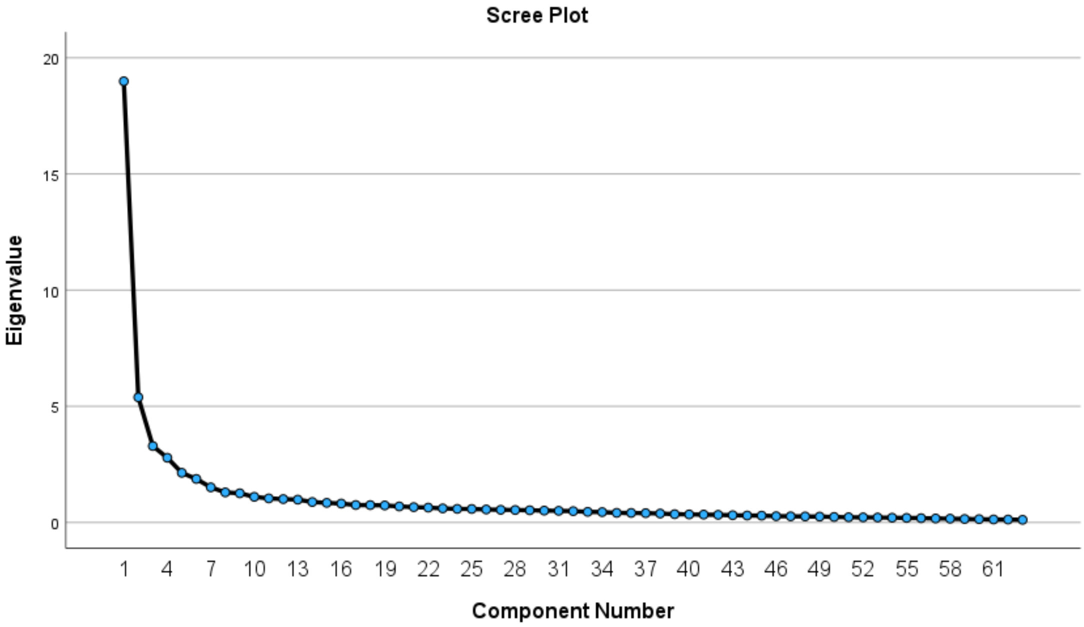

Figure 7.4: Study 2. Scree Plot of the exploratory factor analysis over all robot Conditions including all Items.

Towards the aim of refining the ASOR-revised scale, only the 29 items of the constructs Socio-Practical relatedness (SPR), Intimate-Personal relatedness (IPR), Mental relatedness (MR) and Psychological relatedness (PR) were subjected to another exploratory factor analysis with varimax rotation on the four cases of robots. Pairwise deletion was applied. Missing values per item ranged from 0 to 47, with most of items having at least one missing value. The Kaiser-Meyer-Olkin measure of sampling adequacy was 0.922 and Barlett's test of sphericity was significant ($[\chi^2]$ (406) = 4290,349, p = <.001) indicating suitability for structure analysis.

Variance analysis resulted in 6 factors with eigenvalues above 1. The first four factors explained a combined 52.4% of the total variance (32.3%, 9.3%, 6.6%, 4.2%) and had eigenvalues between 9.4 and 1.2, while the fourth and fifth factors explained 3.6% and 3.5% of the total variance with eigenvalues just above 1 (1.056 and 1.003). The scree plot indicated retaining a 3 factor solution would be justified (See Figure 7.5).

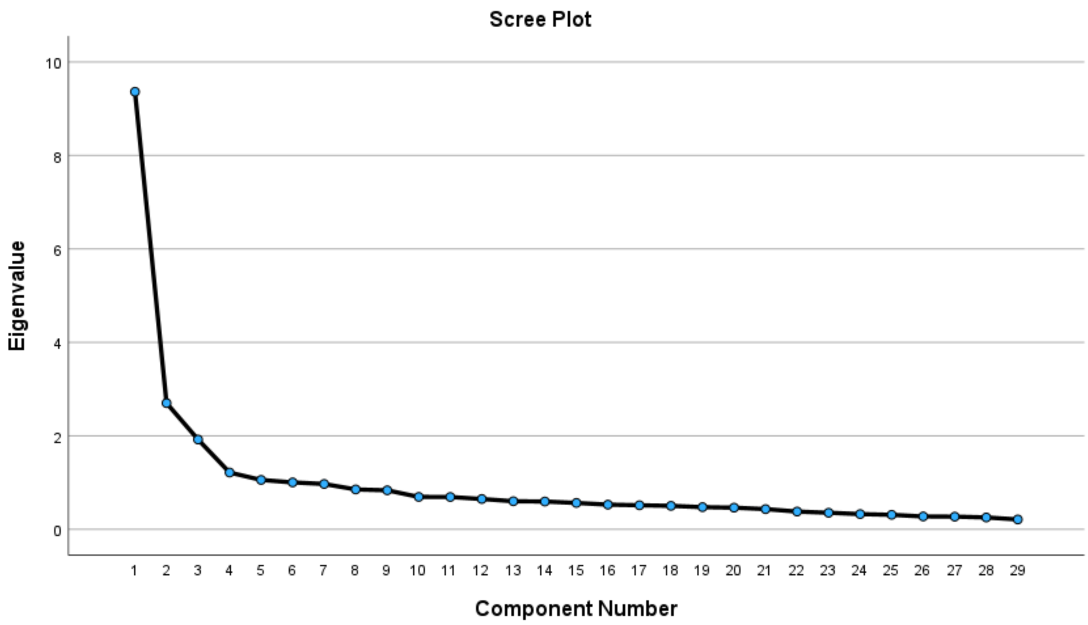

Figure 7.5: Study 2: Scree plot of the exploratory factor analysis for SPR, IPR, MR and PR items

Because a four-factor solution was expected but not confirmed, we investigated the rotated component matrix (see Table 7.4. We specified two criteria for factor interpretation: (A) An item needed a loading above 0.6 to be allocated to a factor. (B) An item was allocated to a factor if the difference between its highest loading on a factor and any loading on another factor was at least 0.2.[9]

[9]In the first study, we established three criteria for assignment, with the third requiring that at least four items load onto a factor for it to be deemed suitable for interpretation. However, applying this

Table 7.4: Study 2: rotated component matrix ASOR-revised Scales

Study 2: Rotated Component Matrix ASOR-revised Scales						
	Component					
Item	1	2	3	4	5	6
PR_57	0,826	0,165	0,078	0,107	0,064	0,010
PR_D31	0,770	0,141	-0,029	0,158	-0,105	0,130
PR_34	0,769	0,217	0,023	0,144	0,124	-0,003
PR_310	0,750	0,102	0,090	-0,006	-0,163	-0,062
MR_08	0,710	0,151	0,178	0,212	-0,011	-0,058
PR_06	0,677	0,133	0,100	0,111	0,172	0,265
MR_38	0,619	0,326	0,164	0,130	0,035	-0,083
PR_02	0,597	0,269	-0,039	0,010	0,119	0,491
MR_03	0,511	0,143	0,322	0,064	-0,030	0,458
MR_32	0,450	0,172	0,313	0,427	-0,090	-0,189
IPR_09	0,308	0,709	0,105	0,073	0,081	0,037
IPR_39	0,164	0,706	0,149	0,012	0,154	0,066
IPR_58	0,297	0,703	0,180	0,153	0,123	0,135
IPR_10	0,351	0,657	0,129	0,133	-0,017	0,037
IPR_56	-0,077	0,644	0,032	0,080	-0,036	0,265
IPR_33	0,330	0,639	0,197	0,040	0,199	-0,046
PR_510	0,159	0,601	0,081	0,198	0,303	0,074
SPR_54	0,082	0,218	0,790	0,138	0,001	0,073
SPR_04	0,072	0,006	0,777	0,002	0,119	0,024
SPR_07	0,016	0,098	0,721	0,067	0,212	0,188
SPR_05	0,390	0,315	0,551	0,089	-0,144	-0,036
SPR_53	0,202	0,325	0,511	0,214	-0,185	0,237
SPR_51	0,069	0,168	0,197	0,627	0,057	0,213
MR_59	0,190	0,261	0,288	0,613	0,117	0,065
MR_55	0,183	-0,043	-0,178	0,600	-0,205	-0,029
MR_52	0,330	0,240	0,279	0,424	0,262	0,089
SPR_37	0,065	-0,102	-0,054	0,096	-0,762	-0,032
IPR_36_R	0,079	0,359	0,082	0,088	0,624	0,060
SPR_01	-0,034	0,197	0,231	0,131	0,080	0,705
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.						
Rotation converged in 6 iterations. Items ending with an ”R" have been reversed.						

criterion in the current study would have required excluding the SPR construct. Since SPR represents a theoretically important dimension of sociality, and because two items only narrowly missed the threshold, we opted to reduce the criteria to two for this study.

Component 1 is primarily composed of the items that gauge psychological relatedness (PR_57, PR_D31, PR_34, PR_310, PR_06) and two items of the mental relatedness subscale probing participants' opinion about robot having a hobby and wishes for the future (MR_38 and MR_08). Three items (PR_02, MR_03, MR_32) did not meet our inclusion criteria, but nevertheless showed strongest relation to the semantic core underlying emerging factor 1.

Component 2 consisted of the items of the intimate-personal relatedness subscale (IPR_09, IPR_39, IPR_58, IPR_10, IPR_56, IPR_33), and one item from the psychological relatedness scale (PR_510). Upon examining the meaning of this item, it made sense to us it loaded on the IPR dimension – and not on the psychological relatedness one, as we had assumed prior – because it asks respondents to assess whether they would feel compassionate towards the robot. Having discussed this item, we agreed the robot need not to be perceived as having capacity to experience an emotion (psychological relatedness per our definition) for people experience a form of emotional connection to it (intimate-personal bond).

Component 3 consisted of the items assessing socio-practical relatedness. However, only three items (SPR_54, SPR_04, SPR_07) loaded sufficiently, with two items marginally loading below the threshold of 0.6 (SPR_05, SPR_53). We speculate this outcome may be explained by the mismatch between the specific tasks the items refer to and the morphology and communication modalities of the robot in a given condition – a problem we had identified through qualitative feedback to the items solicited in Study 1., and that was also reported in qualitative feedback by participants in Study 2.

While we only considered the first three components suitable for interpretation per our criteria, the grouping of items under Component 4 nevertheless offered some insights that may be relevant for any future work on the ASOR-revised scale. Specifically, three items (SPR_51, MR_59, MR_55) loaded sufficiently on the component, with a fourth item (MR_52) having high cross-loadings, yet loading highest on this component. Looking at the semantic cores, these items gauge whether participants perceived the robot as capable of recognizing the person after one encounter, its perceived capacity to lie, recognize one's owner like a pet would, or having a sense of self. While some of these elements reflect, we argue, the perceived capacity to have mental states, others seem to probe more narrowly the perceived capacity of the robot to exhibit theory of mind (Thellman, Silvervarg, and Ziemke, 2017)). We return to this point in Discussion 7.4.

The remaining items loaded on component 5 (SPR_37 and IPR_36_R) and component 6 (SPR_01). We speculate that the item SPR_37 does not load to any other component because two aspects are inquired in the questions: whether the robot has the capability and intentionality (mental relatedness) to interrupt a conversation, and whether one would be annoyed by such an act as a form of violating social norms (socio-practical relatedness).

With respect to the results of the factor analysis, we continued our work with the items that performed reliably under Component 3 (Socio-Practical relatedness), Component 2

(Intimate-Personal relatedness), and Component 1 (Psychological and Mental relatedness). Because some items' loadings deviated from the factor solutions we initially expected for the ASOR-revised scale, we removed the items that did not perform reliably and restructured the remaining items into respective three subscales intended to assess: i) Mental-psychological relatedness (MPR), ii) Intimate-Personal relatedness (IPR), iii) Socio-Practical relatedness (SPR). We then conducted reliability analysis with listwise deletion for the adapted subscales: SPR ($n = 380$, $\alpha = .759$), IPR ($n = 380$, $\alpha = .833$), and MPR ($n = 331$, $\alpha = .888$). All subscales had satisfying reliability. Table 7.5 provides an overview of the resulting three subscales and items of the ASOR-revised scale following removal of the items that did not perform reliably.[10]

Table 7.5: Items of the ASOR-revised (excluding Moral Agency and Moral Patiency scales).

Dimension	**Items**
Socio-Practical Relatedness (SPR)	
SPR_04	Do you think the robot always gives correct information?
SPR_54	Do you think you will trust the information that the robot gives you?
SPR_07	Do you think you trust the robot to perform its task well?
Intimate-Personal Relatedness (IPR)	
IPR_09	If you owned this robot, do you think you would evolve an emotional connection to it?
IPR_58	Would you feel you have company if the robot was with you in the same room?
IPR_56	If you owned this robot, would you give it a human name?
IPR_39	If you owned this robot, do you think it would be a source of joy to you?
IPR_33	If you owned this robot, would you think about it when you are away e.g., on holidays?
PR_510	Would you feel compassionate towards the robot if you saw people kicking it or treating it badly?
Psychological and Mental Relatedness (PMR)	
PR_34	Do you think the robot can feel lonely?
PR_06	Do you think the robot can feel hopeful?
PR_D31	Do you think the robot can feel angry?
PR_57	Do you believe the robot can feel sad?
PR_310	Do you believe the robot can feel pain?
MR_38	Do you think that the robot can have hobbies?
MR_08	People have wishes. For example, they can wish for a better future. Do you think the robot can have a wish?
PR_02	Do you believe the robot can be happy?

[10]We do not include Moral agency and Moral dependency scales because they performed reliably, and we continue further analysis without modifications of these scales.

The following analysis was conducted using the adapted ASOR-revised subscales outlined in Table 7.5.

Insights on the Four

To analyze how participants assessed the four robots on the ASOR-revised subscales (SPR, IPR, PMR), we recalculated the subscale scores by averaging the items, thereby treating all subscales as continuous variables.

For the SPR (Socio-Practical relatedness) subscale, the robots received similar ratings, with a mean score of approximately 3, except for Blossom, which was rated lower (mean = 2.41; SD = 0.55). Although the differences between robots were small, it is understandable that participants perceived the socio-practicality of Blossom lower, given its more limited interaction capabilities and task-performance features compared to the other robots in the study.

On the IPR (Intimate-Personal relatedness) subscale, the four robots were again rated similarly, though Starship robot received slightly lower ratings (mean = 2.41; SD = 0.77). The slightly lower IPR rating for the Starship robot makes sense to us if we consider that Starship is a functional service robot deployed in public spaces, while the other three robots are companion robots.

On the PMR (Psychological and Mental relatedness) subscale, all robots were rated low, with the Starship robot receiving the lowest scores. This outcome is consistent with Study 1., where participants also attributed low mental and psychological capacities to the four robots on the AMC (Ascription of Mental Status) subscale. We speculate that the lower ratings for the Starship robot may again be related to its functional service-oriented design and the kind of interaction capacities it displayed in the video (for example, differently from the Telenoid and Vector robots, Starship robot did not display any emotion cues).

Table 7.6 provides an overview of the ratings on the SPR, IPR and PMR subscales per robot.

Table 7.6: Study 2: Ratings for the SPR, IPR, and PMR subsscales

Robot		SPR		IPR		PMR	
	n	mean	SD	mean	SD	mean	SD
Starship	99	3.04	.55	2.41	.77	1.31	.48
Telenoid	99	3.06	.52	2.66	.75	1.92	.76
Blossom	102	2.41	.84	2.63	.76	1.60	.69
Vector	96	3.10	.63	2.66	.74	1.56	.64

For the Moral Agency scale (MA), an interesting pattern emerged: While all robots received similar ratings, Telenoid robot was rated higher among the four robots. This suggests that the use case presented in the video introduced a deeper moral component, reinforcing the content validity of the Perception of Moral Agency scale (Banks, 2019).

On the Moral Patiency (MP) scale, we observed generally higher ratings compared to those on the Moral Agency (MA) scale, with the Starship robot once again receiving the lowest score among the four. While the differences were small, these results seem meaningful, as the Starship robot may be perceived differently due to its specific (functional) task and deployment context.

On the cuteness/kawaii scale, Vector received the highest ratings (mean = 3.88, median = 4), followed by Starship (mean = 3.62, median = 3.67). In contrast, the Telenoid robot was rated the lowest on cuteness, a result we attribute to its distinctive appearance design that participants characterized as creepy in qualitative feedback in Study 1. The rather high score for Starship triangulates the outcomes of the qualitative studies presented in Chapters 4 and 5, where cuteness emerged as an important factor in how people perceived the robot. This finding also aligns with the qualitative feedback participants gave to the robots in Study 1., where they characterized Starship and Blossom robots as cute. Table 7.7 provides an overview of the mean scores and SD on these scales for the four robots.

Table 7.7: Ratings for the MA, MP, and Cuteness/kawaii scales

Robot		MA		MP		CUTE	
	n	mean	SD	mean	SD	mean	SD
Starship	99	2.34	0.95	2.88	1.27	3.62	0.73
Telenoid	99	3.27	1.02	3.33	1.32	2.43	0.93
Blossom	102	2.49	1.09	3.03	1.49	3.28	0.85
Vector	96	2.67	1.22	3.02	1.34	3.88	0.72

We conducted an ANOVA to explore the effect of the robot type (independent variable) on the individual subscales (dependent variables). There was a significant effect of the type of robot on the SPR scale [F(3,392)=26.56, p=0.001, (η^2=.17)]. Post hoc comparisons using the LSD test indicated that the mean score for the Blossom robot (mean= 2.41, SD=0.84) was significantly lower compared to the other three robots (Starship: mean=3.04, SD 0.55; Telenoid: mean=3.06, SD=0.52; Vector: mean=3.10, SD=0.63). Similarly, we found a significant effect of the robot type on the PMR scale [F(3,392)=14.05, p=0.001, (η^2=.10)]. The post hoc comparisons using the LSD test indicated that the mean score for the Starship robot (mean= 1.31, SD=0.48) was significantly lower compared to the other three robots (Telenoid: mean=1.92, SD=0.76; Vector: mean=1.56, SD=0.64; Blossom: mean=1.60, SD=0.69, (η^2=.10)). For the two subscales on morality we only found a significant effect of the type of robot on the MA scale [F(3,392)=14.25, p=0.001], with post hoc comparisons using the LSD test indicating that the mean score for the Telenoid robot (mean= 3.27, SD=1.02) was significantly higher compared to the other three robots (Starship: mean=2.34, SD=0.95; Vector: mean=2.67, SD=1.22; Blossom: mean=2.49, SD=1.09). Finally, we found a significant effect of the type of robot on the

Cuteness/kawaii scale [F(3,392)=58.94, p=0.001, (η^2=.31)], which was also the largest effect we found. All the pairwise comparisons of a post hoc LSD test indicated that the mean scores for the four robots differed significantly from each other (Starship: mean=3.62, SD=0.73; Telenoid: mean=2.43, SD=0.93; Vector: mean=3.88, SD=0.72; Blossom: mean=3.28, SD=0.85). The η^2 values indicate large effects for the SPR and the Cutness/kawaii scale, and medium effects for PMR and MA. Together, these results suggest the type of robots does indeed affect robot sociality perception.

Correlation analyses of all subscales (see Table 7.8) revealed strong relationships between IPR, PMR, MP, and MA, with Pearson's R values ranging from 0.55 to 0.64 ($p < 0.001$). SPR also showed highly significant correlations with these scales but with moderate strength (Pearson's R = 0.25–0.36, $p < 0.001$). This suggests that while there is a relationship between SPR and other dimensions of sociality perception, the other dimensions exhibit a stronger interrelationship. Lastly, the Cuteness/kawaii scale correlated significantly with SPR, IPR, and MP, highlighting the connection between appearance design and these dimensions of sociality.

Table 7.8: Pearson's correlation coefficients (R) for the relationship between all subscales of the ASOR-revised, the Moral Agency and Patiency scales, as well as the Cuteness/kawaii scale indicating the strength and direction of associations. Statistically significant correlations ($p < 0.01$) are highlighted with **.

Correlations							
		SPR	IPR	PMR	MP	MA	CUTE
SPR	Pearson Correlation	1	.357**	.243**	.345**	.248**	.222**
	Sig. (2-tailed)		.001	.001	.001	.001	.001
	N	396	396	389	396	396	396
IPR	Pearson Correlation	.357**	1	.539**	.636**	.365**	.318**
	Sig. (2-tailed)	.001		.001	.001	.001	.001
	N	396	396	389	396	396	396
PMR	Pearson Correlation	.243**	.539**	1	.550**	.618**	.060
	Sig. (2-tailed)	.001	.001		.001	.001	.240
	N	389	389	389	389	389	389
MP	Pearson Correlation	.345**	.636**	.550**	1	.557**	.227**
	Sig. (2-tailed)	.001	.001	.001		.001	.001
	N	396	396	389	396	396	396
MA	Pearson Correlation	.248**	.365**	.618**	.557**	1	.032
	Sig. (2-tailed)	.001	.001	.001	.001		.523
	N	396	396	389	396	396	396
CUTE	Pearson Correlation	.222**	.318**	.060	.227**	.032	1
	Sig. (2-tailed)	.001	.001	.240	.001	.523	
	N	396	396	389	396	396	396
** Correlation is significant at the 0.01 level (2-tailed).							

7.4 Discussion, Limitations, and Future Work

The discussion Section comprises three subsections. In Section 7.4.1, I address the limitations of the two studies. Section 7.4.2 addresses research questions 1, 2 and 4 and centers around dimensions of sociality attributed to the Starship robot; and Section 7.4.3 addresses research questions 3 and 5, related to the ASOR as a tool for quantitative assessment of attributed sociality.

7.4.1 Limitations and Future Work

I acknowledge several limitations in our study design. First, the video stimuli depicted four distinct robots in markedly different contexts. As outlined in Section 7.3.1, we decided against presenting the robots performing identical tasks in identical settings. This decision was intentional, as we aimed at capturing how participants perceive the *actual* social affordances of each robot and exploring how the sub-constructs of sociality manifest in relation to the robots' exhibited behaviors and skills. However, we recognize that these contextual differences in the videos could have influenced participants' evaluations, potentially extending their assessments to the broader situation and task depicted in each video. Future research could address this by examining sociality attributions across scenarios where different types of robots perform the same or similar tasks, as well as cases where the same robot type performs varying tasks in diverse social contexts. Future research could also consider including a condition where a human performs a task similar to the robots'. This approach would allow researchers to assess attributions of sociality not only across robot types but also in comparison to attributions of human sociality (symmetric) and pet sociality (asymmetric) as control conditions. Such comparisons would provide a more comprehensive understanding of how sociality is attributed across various agents and offer further evidence to the construct validity of the ASOR-revised scale.

Another limitation stems from the inherent constraints of studies relying on one-time online exposure to robots. Practical challenges in participant recruitment and achieving adequate sample sizes for statistical analysis often restrict what can be achieved, and our study is no exception. A brief visual encounter with a robot provides only a partial understanding of its perceived sociality (Hortensius and Cross, 2018) and most likely does not capture (or to a limited degree) sociality as *experienced* in situated interactions (Seibt, Vestergaard, and Damholdt, 2020). Furthermore, we agree with (ibid.) that sociality – especially as experienced rather than assessed ad hoc – is inherently dynamic. It evolves over time as individuals interact with, observe and get to know the robot through lived and embodied interactions. Sociality can also shift fluidly with changes in context, perspective, or situational norms, as reflected in the OASIS framework (ibid.). Furthermore, existing research in HRI and SR suggests that humans respond more positively to physically embodied and co-located robots than to visual representations of the same robots. This may partially explain why participants in the online study rated Starship lower on some ASOR subscales as we would expect based on the qualitative data collected in interviews with participants who had actual experiences of the Starship robot. Future research on sociality attributions using quantitative survey thus might also benefit from participant samples exposed to robots in situ, at different levels of familiarity, and across varying time points.

Lastly, Study 2. is just an initial step in the refinement of the ASOR-revised scale. To develop a robust tool for assessing robot sociality in HRI and SR, further work is needed at both the item and construct development levels (see Section 7.4.3 in the Discussion). Additionally, the scale must undergo rigorous evaluation, including validation through correlation with other sociality-related measures in HRI, such as the RoSAS and Godspeed scales, to better establish its convergent validity.

7.4.2 Is Starship Robot a Social Robot?

The primary goal of the studies presented in this chapter was to quantitatively assess attributions of sociality to the Starship robot when compared to other robots. The findings indicate that Starship is indeed perceived as social, even when compared to the robots explicitly designed for social interaction and having anthropomorphic or zoomorphic features. However, it is the dimensions and nuances of how the sociality is assessed that provide the most valuable insights.

In Study 2., using the revised ASOR scale, Starship scored lower on the intimate-personal relatedness subscale than the other three robots. To us, this finding suggests that the robot's design and task domain influence its perceived potential to foster (unreciprocated) emotional attachment. Specifically, it is understandable that people do not associate such attachment with a functional robot operating in public spaces. Yet, it would be interesting to explore whether populations with daily exposure to Starship, such as vendors who personalize their interactions by naming the robots (see Chapter 5), might attribute higher scores on this dimension.

Conversely, Starship received higher ratings on the socio-practical relatedness subscale, aligning with robots like Vector and Telenoid that perform (arguably) practical tasks in the study's stimulus videos. This outcome resonates with the qualitative findings, where passersby and vendors commented positively on the Starship's ability to navigate public spaces while adhering to formal and informal norms. Nonetheless, it is intriguing that participants in both qualitative and quantitative studies expressed doubts about the robot's practical utility as related to the robot's primary function – delivering food. This discrepancy underscores the importance of distinguishing socio-practicality from mere pragmatic utility, further supporting the argument for nuanced dimensions of sociality and strengthening the concept of existence acceptance as a form of acceptance that is not related to the the use-intention (Abrams, Dautzenberg, et al., 2021).

Lastly, the consistently low ratings across all four robots on the personal and mental relatedness subscale in Studies 1. and 2. highlight the value of the sociomorphing concept, which separates sociality from attributions of mental or psychological states. As robots increasingly operate in real-world environments, focusing solely on mental state attributions risks overlooking other critical dimensions of social perception and acceptance.

7.4.3 The Future of the ASOR Scale

Our Study 1. reinforced the limitations of the 25-item ASOR scale as identified by Damholdt, Vestergaard, et al., 2020, particularly with respect to the weakly performing socio-moral attributions factor. However, Study 2 advanced the aim of strengthening the ASOR scale by integrating two validated scales that assessed perceptions of robots' moral agency and moral patiency, re-introducing a subscale for assessment of intimate-personal bond. Furthermore, the results of the statistical analysis on the revised ASOR scale, integrating these changes, provided evidence to the relationship between intimate-personal relatedness, mental-psychological relatedness, perceived moral agency, and perceived moral patiency, further substantiating the conceptual framework of the OASIS and the ASOR scale underscoring the notion of robot sociality as multidimensional and graded.

That said, our studies are just the first step towards a reliable and consistent survey tool for robot sociality assessment. Related to that, we wish to propose two directions for future research. In Study 2., the subscale for mental-psychological relatedness was refined to include six items probing the robot's perceived psychological states and two items assessing its capacity for mental states such as wishes or plans. At the same time, a separate group of items clustered under Component 4, which – though not fully interpretable by our criteria, – hinted at perceptions of the robot's capacity for theory of mind (ToM). Indeed, cognitive processing, such as decision making and reasoning, represents only one facet of mental life, and ToM remains a critical, though not singular, component of social understanding. Empirical evidence from cognitive neuroscience, including activation of the ToM-related brain regions in response to robots (Hortensius and Cross, 2018), supports the relevance of exploring this dimension further. Future iterations of the ASOR scale could attempt at incorporating items explicitly addressing perceived ToM capacity, drawing on existing scales from cognitive and social psychology. At the same time, in approaching this task, one must consider the challenge related to the lack of consistency in how ToM and mental states attribution are conceptualized and studied in HRI and SR (Thellman, Graaf, and Ziemke, 2022). This means, attempts at assessing ToM with a survey may suffer from the same limitation we discussed in Section 7.4.1 and specified in Seibt, Vestergaard, and Damholdt, 2020: surveys cannot effectively capture subconscious or automatic cognitive processes. While we do not wish to discourage from further attempts to refine this dimension of sociality as part of the ASOR scale, we want to highlight the importance of mixed methods research for more nuanced and comprehensive investigations of the mental and psychological attributions phenomenon as a part of the overall efforts to investigate robot sociality.

The socio-practical dimension also requires further theoretical development and refinement. Of the eight proposed items for the respective subscale, only three aligned with the established criteria for factor inclusion. These three items primarily addressed trust in the robot's task performance and reliability of information provided by the robot, neglecting low-level normativity aspect that we consider crucial to preserve. The importance of low-level normativity for how people perceived the robot emerged in analysis of the qualitative data (refer to Chapter 5), at the same time it is becoming increasingly recognized in HRI as more autonomous robots move into everyday public spaces e.g. (Babel, Thellman, et al., 2024). That said, in the HRI community we are yet to develop a comprehensive understanding of socio-practicality as a theoretical basis necessary for any development of quantitative assessment tools. In other words, unlike dimensions such as moral agency or patiency, which draw on established theoretical work in different disciplines including psychology, anthropology and philosophy, socio-practicality lacks a developed theory. We suggest, one promising avenue to explore is phenomenology as a branch of philosophy focused on structure of experience and consciousness, including how people make sense of their everyday (social) world. For example, the work of Matthew Ratcliffe emphasizes the importance of shared worlds, situational contexts, and social roles in interpreting others, offering a relational and context-sensitive perspective as an alternative to folk psychology based explanations of intersubjective understanding (Ratcliffe, 2006). Drawing on Heidegger and Gurwitsch, Ratcliffe underscores that individuals inhabit a shared practical world shaped by norms and purposes, where understanding others does not rely solely on attributing internal mental states (folk psychology). This perspective could inform further theorizing of socio-practicality in HRI and SR, focusing on common human-robot situations, the norms governing these interactions – both established (e.g., traffic regulation) and emerging (e.g., not yielding path to robots), – and the roles attributed to robots and enacted by people in these situations. With that, we do, however, acknowledge that – even with the sound theoretical basis – translating these concepts into a quantitative survey will also pose a challenge, given that such approach might again require to define situations and roles more precisely which – as we have seen through qualitative feedback to items that attempt to do that – limits the scale transferability to different kinds of robots.

With these limitations and future refinements acknowledged, we contend that the ASOR is nevertheless a valuable tool for HRI and SR, contributing more nuanced assessment of sociality attributions with robots that need not necessarily be social robots by design.

7.5 Summary

This chapter introduced the two studies I conducted with collaborators Astrid Weiss, Ralf Vetter, and Silke Buchberger. These quantitative studies were inspired by the qualitative findings presented in the preceding chapters, which suggest that Starship robots are perceived as social actors distinct from humans—not necessarily because people attribute human-like mental or psychological states to them.

These findings led us to adopt the concept of sociomorphing, which proposes that robot sociality exists along dimensions and degrees. To explore selected dimensions of sociality, we applied the ASOR scale in two online studies with four robot conditions. Recognizing the limitations of the ASOR scale as developed by Damholdt et al. (Damholdt, Vestergaard, et al., 2020), we proposed several improvements, including the introduction of three existing scales that assess moral agency, moral patiency, and intimate-personal bonds.

Study 2 examined the revised ASOR scale, providing further evidence of its construct validity and offering additional insights into the dimensions of sociality attributed to the Starship robot. Specifically, we found that Starship scored high on the socio-practicality subscale but lower on the intimate-personal bond subscale compared to the other three robots in the study. Additionally, all robots scored low on the mental-psychological relatedness subscale. Lastly, Study 2, which incorporated cuteness/kawaii measures, further supported qualitative insights suggesting that the Starship robot is perceived as cute.

CHAPTER 8

Beyond Users: Mapping Subject Positions in Relation to Sidewalk Robots

This chapter builds heavily on the Dobrosovestnova, Babel, and Pelikan, 2025 paper, developed in collaboration with Franziska Babel and Hannah Pelikan. As the first author, I led the conceptual development, selected key theoretical grounding concepts such as subject position, and was primarily responsible for drafting and editing the manuscript. However, none of this would have been possible without Franziska and Hannah, whose expertise as HRI scholars – particularly in studying functional robots in public spaces and successfully publishing in the field – was invaluable throughout the process. The initial idea to map non-users emerged and took shape through our discussions. Hannah contributed significantly to writing the Street Ecology section, while Franziska's suggestions were crucial in developing the discussion section and bridging theory with design.

While our publication covers three case studies – including, besides Starship robots, an autonomous cleaning robot at a train station and an autonomous shuttle bus – this chapter focuses specifically on Starship robots.

The chapter is structured as follows: In Section 8.1, I outline the motivation for this work. The next section provides background by briefly reiterating the concept of subject position, introduced earlier in Chapter 2, and explaining our adaptation of the notion of ecology. Section 8.3 details the inductive process underlying our theoretical proposal and introduces the three ecologies (Service, Street Life, and Public Discourse) that we derived. The chapter concludes with a discussion, where I formulate suggestions for a more holistic and socially sustainable approach to HRI design in public service robotics, framed through the lens of these three ecologies. The discussion also includes a section on limitations, particularly addressing the chapter's narrower focus on service robots and specific types of public spaces.

8.1 Motivation

As mentioned in Chapter 2, the recent wave of studies in HRI in public spaces, including my own, further challenges and destabilizes the notion of the 'user', persistent focus on whom, as rightfully pointed out by Astrid Rosenthal-von der Pütten et al., 2020, leaves a broad category of people "forgotten". This omission is regretful not only from a theoretical standpoint, but also, as discussed in Chapter 6 because the diversity of people beyond users, and forms of their interactions with robots bear significant consequences for decision making about robot design. While the term Incidentally Co-present Persons (InCoPs) proposed by ibid. is a meaningful step toward including people *"who do not deliberately seek an interaction with a robot (users) but find themselves in coincidental presence with robots."* (ibid., p.1.), it may still be insufficient, as it inadvertently construes people more passive as they are and does not offer a nuanced differentiation in terms of what exactly transpires between people and the robot in their coincidental co-presence. While in HRI there were attempts to propose classifications of people based on their respective roles e.g., (Scholtz, 2003), in the domain of robots in public spaces, we are still missing a comprehensive classificatory framework.

This chapter represents an attempt to respond to this gap based on the experience of the empirical work I conducted on Starship robots. More precisely, I rely on the notion of **subject position** from HCI and the notion of **ecology** to synthesize the empirical findings into a descriptive framework mapping people and their roles in relation to the robot. The resulting framework contributes to the HRI discourse through: i) offering a systematic and more comprehensive account of people and interactions in the domain of functional robots in public spaces; ii) identifying gaps in existing research and suggesting directions for future HRI studies; iii) deriving general recommendations for a more holistic approach to design that exceeds designing the robotic system per se and integrates relevant considerations for public communication and urban planning.

Before proceeding, I want to clarify that I define public space as any area accessible to all members of a community, regardless of socioeconomic status, identity, or professional activity. Public spaces can differ in terms of ownership structures (e.g., public versus semi-private ownership) and access conditions (e.g., more restricted and supervised access in institutional settings such as schools or hospitals). However, my work primarily focuses on public spaces characterized by a high degree of accessibility for all community members and substantial public oversight, such as city streets and university campuses. While these environments serve as the primary context for the operation of robots like Starship, they are not the only sites relevant to human-robot interactions in the domain of functional service robots. As discussed, for example, in the Section on Public Discourse Ecology (8.3.3), other types of spaces, including virtual spaces, also play a significant role in shaping these relationships.

8.2 Theoretical Grounding

As briefly mentioned in Section 2.2, J. Bardzell and S. Bardzell, 2015 distinguish between subject positions and subjectivities to emphasize the difference between 'users' as a theoretical construct in HCI and actual people with embodied and lived experiences. The term subject position is used to describe the structural or social roles of people as envisioned or assumed by technology developers and scholars. In HCI, familiar subject positions include categories like user, power user, non-user, maker, hacker, gamer, and others. These labels are valuable because they enable researchers to articulate people's relationships to designed systems. Importantly, subject positions are always relational – they emerge through and are defined by their relationship to technology and other subject positions (Baumer and Brubaker, 2017).

In contrast, subjectivity refers to how these structural and social roles are experienced, performed, and sometimes resisted by actual people. Subject positions are analytically available to researchers, while subjectivities are empirically accessible. For instance, one might conduct an ethnographic or phenomenological study to explore how different individuals experience technology (J. Bardzell and S. Bardzell, 2015). Such empirical studies can, in turn, inform the emergence of new, relevant subject positions or challenge existing ones. For example, the empirical work presented in preceding chapters questions the subject position of 'user' as a dominant way to conceptualize people in HRI.

Another important concept, ecology, also emerged from empirical studies examining people's interactions with technology in deployment contexts. In the work of Sung, Forlizzi, and colleagues (Forlizzi, 2007, 2008; Sung, R. Grinter, et al., 2008), ecology refers to a complex, dynamic system of relationships encompassing products, people within a household (in their respective social roles, such as 'dad' or 'mom'), and the domestic environment that scaffolds these interactions. This term emphasizes a holistic perspective, urging consideration of not only individual user-device interactions but also the broader social, material, and temporal contexts that shape – and are shaped by – those interactions. Importantly, ecologies are not static; the introduction of a new artifact, such as a robot, can reconfigure existing relationships and practices over time (see Section 2.1).

In what follows, I rely on these two concepts as a theoretical backbone to propose a mapping of subject positions into respective three ecologies I term: Service Ecology, Street Life ecology and Public Discourse ecology.

8.3 Three Ecologies of Sidewalk Robots in Public Spaces

As elaborated above, the notion of a subject position is an analytical category – an abstraction that serves a pragmatic purpose for (HRI) scholars and developers. The categories I discuss below are, first and foremost, theoretical concepts that simplify the complexity of empirical data, such as the detailed descriptive themes developed in ethnographic studies. In philosophy of science, reduction of complexity is a key distinction between theoretical models and empirical data. Theoretical models selectively omit certain features while retaining enough fidelity to achieve explanatory goals or provide a unified framework for interpreting empirical findings (Carrillo and Martínez, 2023; Vorms, 2018).

In this thesis, the proposed theoretical categories were developed inductively, grounded in the empirical data gathered throughout the research project. These categories were further refined through discussions with my collaborators Franziska Babel and Hannah Pelikan and by engaging with relevant literature both within and beyond the field of HRI.

In the following Section, I present the subject positions by organizing them into three ecologies: Service, Street Life, and Public Discourse. For each ecology, I first specify the defining site(s), including, but not limited to, physical environments, that bound the given ecology. I then describe the role of the robot (in this case, the Starship robot) within each ecology and outline the respective subject positions and their roles and relations to the robot.

8.3.1 Service Ecology

Service ecology integrates geographically distributed environments, relations and interactions as these are bound by the people and robot participating in a service provision and acquisition. For Starship robots, the associated environments include areas nearing supermarkets and restaurants, as well as the order recipients' doorsteps. Beyond these sites, service stations where robots are maintained and stored and remote assistants' call centers are also part of the environments constituting service ecology.

Subject positions within Service ecology

Within this ecology, I differentiate between three broader groups of subject positions: service receivers, or customers, service providers, or service initiators, service up-keepers.

First, the subject position of **customers** is enacted by people who request and consume a service, such as purchasing goods and using robot-based delivery. Customers engage in some form of exchange, often involving money or data, for the service. They can exercise choice and influence over the service (Waqas, Hamzah, and Salleh, 2021). In other words, these are the individuals who, as described by Starship Technologies interviewees (see Chapter 6), have a kind of *formal* relationship with the company. For Starship, this involves placing an order through the application, tracking the robot delivery, and using the app to unlock the robot and retrieve the order.

Beyond individual customers, the subject position of customers also includes organizational units and corporate entities that request and contract services from the company to deploy robot-based last-mile delivery solutions. Customers within this category may include supermarket chains or individual vendors, such as those I interviewed (see Chapter

5). In relation to individual customers placing orders, these vendors enact the role of **service providers**.

The interactions between service providers, customers, and robots can vary significantly depending on their roles and organizational context. For example, individuals placing an order and sales personnel responsible for packaging the delivery may interact directly with the robot and its corresponding app. In contrast, service providers in managerial roles, such as senior managers in a supermarket chain, may not interact with the robot directly, yet still participate in shaping the service ecology by not in the very least participating in decision making about contracting Starship Technologies for last-mile delivery service.

The **up-keepers** subject position is enacted by individuals responsible for maintenance and supervision tasks that ensure the proper functioning of robots as part of service provision. These tasks include repairs, making sure the robots return back to a service base, cleaning, and other forms of upkeep. This subject position encompasses tele-operators (Scholtz, 2003), who work remotely – typically from call centers – using interfaces that allow them to control the robot's sensors and actuators without being physically co-present with the robot. It also includes maintenance personnel, who engage in direct, hands-on interactions with the robots, such as physically manipulating them, accessing their shells, or replacing hardware components.

Unlike service providers, who are more visible and often recognized by customers using robot-based services, up-keepers often remain invisible or intentionally obscured within the service ecosystem. For example, the intervention of a tele-operator during a critical situation involving a sidewalk robot may go completely unnoticed by a passerby co-located with the robot. In the case of Starship robots, several passersby I spoke with were unaware that tele-operators existed and that they could intervene when needed. Conversely, some online commentators speculated that the robots were fully manually operated (see Chapter 4), illustrating the lack of the public awareness about the robots' degree of autonomy (Kim, Anthis, and Sebo, 2024). This ambiguity in the visibility and autonomy of robots highlights an important aspect of the up-keepers' role: while structurally essential to service provision, their contributions are often overlooked in HRI discussions. Despite this, their work remains critical to the overall functioning and reliability of robot-based services.

Robot in Service Ecology

In the Service ecology, the robot's intended function in service provision and value co-creation.[1] Value co-creation is central to how people understand the robot and how interaction patterns and activities emerge within the Service Ecology. Accordingly, customers evaluate their experiences based on dimensions that define what makes the service 'good.' For Starship robots, as discussed in Chapter 5, these dimensions may be

[1]The value need not be understood exclusively as economic or monetary. Contemporary service management recognizes multiple forms of value that can be derived in service ecologies (Ekman, Raggio, and S. M. Thompson, 2016; Lusch and Vargo, 2006).

utility-driven and include factors, such as the robot's size (e.g., the volume it can carry), delivery speed, and insulating properties (e.g., whether food preserves its temperature). Importantly, these evaluations extend beyond robot-specific features and encompass the overall service experience, including, for example, the app's ease of use, the payment process, and access to customer support.

For service providers and up-keepers, functional features are also important but are evaluated through different dimension tied to their roles and respective tasks in the Service Ecology. For example, for vendors interacting with sidewalk delivery robots as new delivery option, the usability of the interface for receiving orders and ease of loading the robot is crucial. Additionally, practical considerations, such as the number of robots they need to service and the distance of the robots from the vendor site are significant factors (see Chapter 5).

The functionality of the robot, however, is not the sole determinant of how it is construed, engaged with and evaluated. As discussed in Chapter 7, even for functional robots, their autonomous movement and perceived purpose are often coupled with sociomorphing (Seibt, Vestergaard, and Damholdt, 2020) and anthropomorphizing (Chun and Knight, 2020). This means that – even within the service ecology – some people will be prone to view the robot not just as a tool or functional device but as integrative of some aspects of sociality. This perception can manifest in behaviors such as giving the robot a name or playfully referring to it as one might refer to a colleague (see Chapter 5). Furthermore, from both customer and service provider perspectives, the robot may also carry a symbolic value (Forlizzi, 2008), representing their enterprise, professional identity, or even personal identity, as discussed in Chapter 5.

8.3.2 Street Life Ecology

Street Life ecology encompasses the environments through which the robots transition as they perform service provision. These environments are populated by many human and non-human (e.g., animals) actors who encounter the robot as part of their everyday lives. Importantly, these environments, and the actors within them, exist a priori – they are *already* there before the robot enters these spaces (Pelikan, S. Reeves, and Cantarutti, 2024). For a sidewalk robot, the Street Life environment includes the spaces the robot traverses (streets, traffic crossings, and other public pathways) on its way from the vendor's location to the customer's doorstep.

Subject Positions in Street Life Ecology

The first group of subject positions within this ecology is distinguished based on **modality of movement**. I propose **commuters** as a technical label to capture this sub-group. Specifically, as discussed in Chapter 6, robots can encounter pedestrians, cyclists, scooter riders, car drivers, truck drivers, and so forth. Depending on the modality of movement, people will move at different speeds, in different parts of the street (on the pavement vs. on the road), and will rely on different sensory modalities (sound, vision, haptic) to make their way. Mobility research already offers empirical evidence and descriptive frameworks capturing the intricate ways in which pedestrians coordinate their movement on the pavement (Ryave and Schenkein, 1974), or how car drivers coordinate on the road (Deppermann, 2018). The robot entering the street as new actor in these dynamic constellations will have to rely on patterns of movement and communication that are intuitively understandable to all these actors (Babel, Kraus, and Baumann, 2022) (see also Chapter refcompany).

Second group of subject positions within this ecology is differentiated based on **who people are moving 'with'**. People in the street are not only identifiable by their mode of movement but also by whether they are moving alone, in pairs, or in groups. For example, pedestrians may walk side by side and when encountering a delivery robot, they might briefly walk behind each other before returning to their original formation after passing the robot (also refer to Chapter 4). Ethnomethodological research refers to this as mobile formation (McIlvenny, 2014; McIlvenny, Broth, and Haddington, 2014), emphasizing how people are recognizable as a group, such as when cycling together (McIlvenny, 2014)[2]. For humans, it is immediately apparent when two people are walking together, making it easy to anticipate that one should avoid trying to pass between them and instead go around. However, for a robot, such social cues are difficult to recognize or remain completely unavailable. Furthermore, human can move in public spaces accompanied by their *pets* – interactions between robots and animals where one of the common themes in Instagram posts about Starship robots (see Chapter 4) and were also mentioned in other studies on sidewalk robots e.g., (Weinberg et al., 2023).

Third cluster of subject positions can be distinguished based on the **social category** people enact when being on the street. We can refer to this cluster as **social actors**. For instance, people will recognize another person as a senior citizen, a child, a person with movement impairment, or a mother pushing a stroller. As discussed in Chapter 6, such social categories may matter from the perspective of developers and scholars too, not in the least because they may be associated with respective patterns of movement (e.g., assumed reduced mobility of elderly people) and established social norms of behavior (e.g., allowing a mother with a stroller pass first).

Fourth, people on the street will also recognize and act within a category of **professional membership**. While not all professional categories may matter from the perspective of HRI, some – especially those that are bound to the street, for example, street cleaners or construction workers, will. Consider an instance I observed when I followed a robot as part of autoethnographic exploration, when the robot navigated dangerously to a glass plane carried by two workers. Or an example documented in Pelikan, S. Reeves, and Cantarutti, 2024 of an interaction between Starship robot and a window cleaner. While intuitively accessible to humans, these categories remain inaccessible to a robot.

Lastly, as discussed in the preceding chapters, another cluster of subject positions emerges based on the proactive stances people take toward the robot. People may actively engage

[2] I thank Hannah Pelikan for introducing me to this corpus of literature.

with the robot by exploring, bullying, or helping it, thereby significantly influencing its day-to-day operations. These subject positions can be referred to as: *Helper*, *Bully* and *Explorer*, constituting a broader group of **proactive participants** as part of the Street Life ecology. A key distinction between these roles and those described earlier is that they are less instinctual and depend on deliberate choices made by individuals in response to the robot. Moreover, these roles did not exist in the street environment before the robot's introduction.

Robot in Street Life Ecology

As a materially instantiated, dynamic and autonomous machine, the robot becomes another active participant in public space when it enters the street. Depending on its design – such as its morphology, speed, and placement (whether on the sidewalk or road) – people will apply various mental models and behavioral patterns to interpret and respond to its presence. When a sidewalk robot moves along the pavement, it occupies a space between pedestrians and vehicles. This can lead to mismatched expectations and interpretations, which may result in conflict situations (Thellman, Marsja, et al., 2023). In the case of Starship, as discussed earlier, such mismatch in expectation happened at early stages of deployment when drivers encountering the robot for the first time yielded path to it – as they would to a pedestrian – with the robot in turn 'waiting' for the car to pass (see Chapters 5 and 6).

Given that robots are generally less agile and socially apt than humans, their presence can provoke emotional reactions ranging from affection to annoyance or even anger. Strongly negative reactions may prompt individuals to step into the role of a Bully. While such responses were not commonly observed in Estonia, incidents of vandalism do occur (see Chapter 6) (Oravec, 2023). Annoyance or irritation can arise when the robot obstructs other pedestrians or vehicles, behaves erratically, creates excessive noise (e.g., sounding an alarm), or simply occupies public space that people expect to be reserved for human use.

Finally, as discussed in Chapter 5 and further developed in Chapter 7, people tend to sociomorph autonomous functional robots, even when these robots do not have anthropomorphic design features. Experienced sociality – whether attributed to the robot itself or because it is perceived as part of the community – may encourage individuals to step into the role of Helper (see Chapter 4).

8.3.3 Public Discourse Ecology

The *Public Discourse ecology* encompasses both physical environments (e.g., city halls, community centers, offices) and virtual spaces (e.g., social media, mass media channels, dedicated websites). What unites these diverse sites is that they serve as spaces where various stakeholders engage in conversations about robots and their deployment. While in the *Service ecology* and *Street Life ecology* I primarily discussed the robot as a socio-material actor involved in service value co-creation and as a new participant in urban spaces, in Public Discourse ecology I consider the robot as a **discursive subject**. More precisely, Bruno Latour distinguishes between "matters of fact" and "matters of concern", defining the latter as: *"gatherings of ideas, forces, players, and arenas in which 'things' and issues, not facts, come to be and persist, because they are supported, cared for, worried over"* (Latour, 2004). In Public Discourse ecology, the robot is considered one such "thing". Importantly, these conversations are performative (Callon, 2009) – they actively shape socio-material realities, influencing public opinion, regulatory efforts, group actions, and so on, as I elaborate on below.

Subject Positions

The subject positions I identify within Public Discourse ecology include: **citizens**, understood broadly as members of the community who are affected by robot deployment and choose to voice their opinions or take action; **mass media**; **industry**; **policymakers**; **expert communities**; and **opinion leaders**. The roles of these actors can generally be distinguished by two main functions: (i) identifying and articulating a concern (*concern* here need not be negative, it can also take the form of a position one advocates for), and (ii) engaging with the robot as an issue that has been articulated as a concern.

To begin, which social groups of people step forth or become relevant within the Public Discourse ecology depends on a complex network of social, material, cultural, and political factors. In the case of sidewalk delivery robots, *people with disabilities* emerged as a relevant group, particularly after path-yielding conflicts occurred following the robots' deployment on university campuses. These incidents were shared online, as discussed in (Ackerman, 2019). In other words, what first transpired as situated, individual experience in the *Street Life ecology* was translated into Public Discourse ecology through a broader online conversation about how sidewalk delivery robots affect people with reduced mobility.

Not all citizens though need to speak out or have situated encounters with the robots in order to participate or be actors within Public Discourse ecology. Socio-cultural norms surrounding certain social categories of citizens often create expectations about how these (sometimes very diverse) groups are perceived. For instance, in many societies – as well as in academic discourse (Burema, 2022) – senior citizens are often perceived and construed as frail and more vulnerable (see Chapter 6). Such socio-cultural narratives and norms about societal groups place additional pressure not only on the design process as such, but also on how conflict situations and errors involving representatives of these groups may reflect on the company's reputation and public image.

Media plays a crucial role in Public Discourse ecology by shaping public opinion about AI and robots in society (Nader et al., 2024), as well as informing the public about specific robots as new actors within the community. Explicitly or implicitly, media also offers guidance on how to interact with robots, providing blueprints and reassurances for the public. For example, as discussed in Chapter 5, when sidewalk delivery robots were first introduced in Tallinn, some people who were willing to step into the role of Helpers did not do so because they were unsure how to assist, or whether they were even allowed to. Reading news stories about other people helping the robots reassured them that it was both appropriate and safe to engage.

The media's role is especially prominent in amplifying stories about robots failing or encountering difficulties. These stories can take on a humorous tone e.g., (Koebler, 2022) or a more critical perspective (e.g., Reuters, 2024). In either case, media coverage plays a significant role in shaping public acceptance or rejection of the robots. It also serves as one of the key arenas where various stakeholders and interest groups can voice their opinions and lobby their interests.

In response to tensions arising from the deployment of robots in society, entirely new actors can emerge to mediate between different stakeholders. These actors can include *professional or expert organizations*. One such example is the Urban Robotics Foundation, established in 2021. According to its founders, the organization's goal is to "bring together stakeholders interested in public-area mobile robots (PMRs)" and ensure they have a well-rounded understanding of the opportunities and challenges of PMRs (Robotics, 2024). One of the founding members of the Urban Robotics Foundation, Bern Grush, has in recent years become a known public figure shaping the discourse on the present and future of sidewalk delivery robots. Grush actively contributes to the ongoing discussions on various topics related to the design, deployment, legislation and potential impact of sidewalk robots on urban life across multiple media channels and outlets, including professional networking websites, such as LinkedIn, and topical podcasts e.g., (Grush, 2024). It's important to note that my intention here is not to endorse or evaluate the activities of a particular organization or its members. Rather, I aim to illustrate how entirely new actors, holding significant influence over public discourse, emerge in response to the deployment of robots in public spaces.

Robot in Public Discourse Ecology

In the introduction to this Section, I explained how robots in the Public Discourse ecology can be broadly construed as a "matter of concern" – something that actors in various subject positions can dispute and attend to. While there are many ways that people can "attend to" robots as a matter of concern, I will focus here on those that relate more narrowly to the task of developing and deploying robots in public spaces.

First, concerned citizen groups can be included in the design process in various ways. In response to the concerns raised by people with disabilities, participatory design (PD) initiatives have been undertaken by developers to work closely with the interest group on developing strategies for robot behavior that better accommodate the needs of this group (see Chapter 6). Such engagements with community representatives can help address specific issues in HRI, and improve acceptance of robots in public spaces (see, e.g., (François et al., 2021; Han et al., 2024)). Additionally, these initiatives can in themselves be a part of the company's promotion strategy.

Second, in response to the tensions surrounding the development and deployment of robots in public spaces, interest groups occupying subject position of mediators can play a crucial role. As mentioned, these groups facilitate ongoing dialogue between various stakeholders, for example, by hosting workshops, providing expert commentary and building a community of experts around a specific topic. Such initiatives can also influence regulations and, ultimately, the design and integration processes of robots. In relation to the activity of the the Urban Robotics Foundation mentioned above, one example of such influence concerns the development of ISO standards (ISO TC204 WG19 DTS4448), which sets parameters and procedures for public-area mobile robots (Robotics, 2024).

Third, regulatory and legislative responses to robots as “matters of concern” can vary significantly. These responses may range from defining what a robot is as a new actor in the Street Life ecology and regulating interactions with it, such as the amendments made to Estonian traffic laws (*Liiklusseadus–Riigi Teataja* 2017) or outright bans on functional service robots in specific communities, as seen in the case of Toronto (Wessling, 2021).

Although these examples are far from exhaustive and only superficially cover the complexity of the Public Discourse ecology, they help to clarify how the robot’s status as a matter of (public) concern for different actors within Public Discourse ecology directly impacts the design and deployment processes.

8.4 Discussion

The proposed descriptive framework broadens the understanding of human-robot relations by incorporating a range of subject positions beyond those traditionally framed as ‘users’, ‘bystanders’, more recently, ‘InCoPs.’ Among the three ecologies – if anywhere – the ‘user’ in its traditional sense resides within the Service Ecology. Here, certain actors can be said to have regular and direct (one-on-one) interactions with the robot in the context of the tasks for which it is deployed. At the same time, framing customers, service providers, and up-keepers collectively as ‘users’ risks overlooking the diversity of interactions, relationships, and the kinds of robot affordances upon which these engagements depend. Much like for the Street Life Ecology, construing all people as ‘bystanders’ may frame people as more passive as they are (Pelikan, S. Reeves, and Cantarutti, 2024) and overlook dimensions critical to the existence acceptance (Abrams, Dautzenberg, et al., 2021) and (commercial) success. As discussed in Chapter 6, ensuring that robots integrate seamlessly into real-world contexts requires design efforts focused on people who lack formal or direct relationships with the company (i.e. cannot be framed as ‘customers’). Continuous research into how diverse groups of people interact with and perceive robots – paired with theoretical refinements based on insights from field studies – remains essential for developing socially and ethically sustainable robots in public spaces.

At the same time, what the notion of ecology emphasizes is that both subject positions and robots are embedded in a complex web of socio-material and relational configurations. This raises a key question: *How can we design with ecologies in mind?* I address this question by elaborating on three points: (i) who is included in research and design, and how they are included; (ii) the importance of interdisciplinary learning and collaborations; and (iii) how introducing a robot into an ecology transforms the relationships and practices within it. Through sketching out preliminary answers to these questions, in this Discussion Section I will also identify what I consider productive avenues for future research.

8.4.1 Who is Included in Research and Design, and How

Currently, within the Service Ecology, interactions between robots and end customers are often framed as dyadic exchanges, focusing on a limited range of actions that the human and robot are assumed to perform. During the design process, the 'customer' (or end user) is typically represented as a persona – a generalized construct that treats individuals as interchangeable subjects (H. Lee et al., 2022). In the broader field of research on functional autonomous robots in public spaces, progress toward diversifying representations of customers has been made. For example, in the broader context of developing autonomous robots for public spaces, *participatory design approaches* have begun to consider the needs of 'customers' with visual impairments (Colley et al., 2020) or mild cognitive disabilities (Arvola et al., 2023).

At the same time, while prioritizing customers in design is understandable given their central role in generating revenue, neglecting or minimizing the importance of other subject positions within the Service Ecology may hinder value creation. Overemphasis on customers can lead to HRI for up-keepers and service providers being developed reactively rather than intentionally. For example, controls for these groups might be designed solely by engineers without adequate testing from a UX perspective. This oversight can result in practical issues, such as maintenance personnel struggling to access screws hidden within the robot's outer shell during repairs. To address these challenges, incorporating the perspectives of up-keepers and service providers into participatory and UX design processes represents a valuable avenue for advancing HRI research.

The numerous and diverse interactions within the Street Life Ecology highlight the need to broaden the scope of design while also raising several tensions and unanswered questions. For example, although intentional behaviors like bullying and vandalism have been partially addressed in HRI (Tan et al., 2018), effective design solutions to prevent such behaviors without causing negative externalities remain elusive. Sounding an alarm, for example, might deter vandals but would also contribute to noise pollution in public spaces. Furthermore, as discussed in Chapter 6, not all obtrusive behaviors in fact stem from bad intentions, so it remains an ongoing challenge how to address these at the level of design.

For subject positions categorized as 'vulnerable', such as children, cyclists, and elderly people, potential conflict situations can – and already are to extent – addressed through precautionary measures. For example, robots may be programmed to stop at a safe distance (see Chapter 6). However, the challenge remains in determining how – or whether – it is appropriate to differentiate potentially vulnerable individuals in situ. Even if such differentiation is technically feasible and could enhance the fluidity of interactions, significant questions persist regarding the ethical and legal viability of algorithmically assigning social membership categories (T. Williams, 2023).

Lastly, in Section 8.3.3, I discussed how not all social and structural categories of citizens will, or *should*, necessarily be considered relevant subject positions from the perspective of developers. Related to this, among the many people inhabiting public spaces, there will be people who lack societal standing and representation. These include human delivery couriers who may find themselves competing with sidewalk robots for jobs, as well as individuals without permanent housing, whose attitudes toward robots in public spaces remain largely unexplored. This is not to suggest that these groups should necessarily be a focus in HRI design. Any such inclusion, if undertaken, would require significant care and consideration. Rather, these examples serve to illustrate how the decision to include certain groups while excluding others is inherently tied to broader questions of ethics and responsibility.

8.4.2 The Importance of Interdisciplinary Learning and Collaborations

Designing with ecologies in mind is a complex endeavor that extends beyond HRI and requires interdisciplinary and multi-stakeholder collaborations. To be clear, calls for interdisciplinarity in HRI are not new. As early as the 2000s, Fong et al. emphasized the importance of connections to other research fields and methodological approaches for building socially interactive robots (Fong, Nourbakhsh, and Dautenhahn, 2003). Similarly, in their comprehensive review aiming to unify HRI-related challenges and integrate research from universities, government, and industry labs, Goodrich and Schultz, 2008 highlighted the many disciplines that contribute to the field of HRI.

My view aligns with these calls but I also propose further broadening the scope of disciplines and collaborations. For example, within the Service Ecology, concepts and methods from service design studies, such as Customer Journey Mapping and Service Blueprinting (Stickdorn and Schneider, 2012), offer valuable tools for enriching HRI. Approaches from service design (Ekman, Raggio, and S. M. Thompson, 2016) and management (Baraldi, Gregori, and Perna, 2011) not only support customer-centered design but also provide strategies for optimizing 'behind-the-scenes' processes, such as up-keeping. In the context of the Street Life Ecology, conceptual frameworks and methods from urban planning and transportation studies e.g., (Madadi et al., 2021) can contribute significantly.

Furthermore, as touched upon in the Public Discourse Ecology Section, ongoing collaboration with diverse stakeholders, including city planners, urban designers, regulators, and especially citizens, is essential when addressing robots as matters of public concern. These collaborations extend beyond the immediate design of robots to encompass broader initiatives, such as awareness-raising campaigns, public engagement programs, and community events. Such efforts are crucial for fostering a shared understanding and ensuring the integration of robots into public spaces is both socially and ethically sustainable.

8.4.3 Introducing a robot into an ecology transforms the relationships and practices within it

Designing with ecologies in mind involves acknowledging how robots will inevitably reshape, challenge, and subvert existing practices and relationships. Extensive research in STS (Oudshoorn and Pinch, 2007), HCI (Xu et al., 2023), and organizational studies (Johnson et al., 2020; Orlikowski, 2007) has demonstrated how technologies reconfigure established practices and (workplace) identities (see also Section 2.2 and (Dobrosovestnova and Hannibal, 2021)). Sidewalk robots, as a new form of last-mile delivery, introduce a novel dimension of technological labor (Meissner et al., 2022). Service providers, such as vendors, are now tasked with loading these robots and operating associated interfaces. This highlights the critical need for providing adequate training and support for service up-keepers, as well as fostering participatory design practices that empower different actors within service ecology and ensure their voices are heard in decisions about deploying functional service robots. A more significant societal shift involves the potential for robotization to displace human jobs, particularly as gig economy platforms (Vertesi et al., 2021) increasingly partner with robot developers. To anticipate and address such transformations, it is essential to continue research into the mid-term and long-term effects of robotization on work and society.

8.5 Limitations

I would like to remind that subject positions are an abstraction – a category defined by HRI scholars to map and guide research and development efforts. The structural categories presented in this chapter – though rooting in empirical data – are not intended to map directly to real-world social roles (Wyatt, 2008), nor represent nuances of individual experiences (subjectivities) and the full complexity of social life. While subject positions are discursively fixed, in practice, people can and will move fluidly between subject positions, often occupying several within a single interaction (Hornecker et al., 2022; Scholtz, 2003) and within different ecologies. For example, a person in the role of the vendor (Service ecology) can simultaneously enact the subject position of commuter (passersby) and someone moving in a mobile formation as they walk on the street accompanied by their colleague (Street Life Ecology). The very same person can also post their commentary on the social media about their experiences with the robots, or be interviewed by a local newspaper (Public Discourse ecology).

Further, though more comprehensive than existing classificatory frameworks when it comes to HRI in public spaces, ecologies as they are formulated here are certainly non-exhaustive. For example, while legislators are mentioned as important subject position in the Public Discourse ecology, in here I addressed them to a very limited degree, with more comprehensive overview remaining outside the scope of this thesis. In addition, with further empirical work, new categories will undoubtedly emerge, and the proposed categories will require iterative refinement.

The framework is also limited in scope, as it primarily addresses mobile service robots deployed in specific public spaces, excluding other types such as social robots in settings like libraries, museums, or hospitals. While the socio-material configurations of roles and interactions in these spaces will differ significantly, I believe the general relational mechanisms described in each ecology can be adapted to other domains and case studies.

8.6 Summary

In conclusion, this chapter proposed a broadened conceptual framework for understanding HRI in public spaces by extending beyond the traditional focus on users. Through the lens of three ecologies – Service, Street life, and Public Discourse – I have addressed how diverse subject positions emerge in relation to robots and each other, and encompass a range of interactions and relations, ranging from direct interactions, incidental encounters, to public conversations and initiatives that may be distantly removed from the robots but that shape their deployment substantially. This work underscores both the limitations of confining HRI research to dyadic robot-user interactions and argues for a more holistic view that considers the broader social, material, and institutional contexts that robots are co-constitutive of and co-constituted by.

CHAPTER 9

Discussion/Major Contributions

In this chapter, I review the key contributions of the Inconsequential Encounters project by revisiting the aims and research questions I posed in the Introduction 1 and reflecting on them in the light of the state of the art of the field at the moment of completion of the project.

9.0.1 Aims

Aim 1: Investigate human-robot interactions that transpire (and relations that emerge based on these) as the robot makes its way from the site of vendor to the point of delivery.

To meet this aim, Inconsequential Encounters project integrated ethnography-inspired observations, online content analysis, and interviews of participants native to Tallinn and Cambridge communities where Starship robots are deployed. The triangulation of methods allowed to identify not only how people on the streets respond to the robots in situated encounters – by stepping into roles of Helpers, Observers, Explorers, or through more subtle and fleeting responses, such as adjusting path trajectories, steering away from the robots or affectionately patting them – but also how people generally perceive and make sense of the robots as new actors on the street. The project is one of the early works in the domain of functional service robots HRI in public investigating robotic technology in the immediate context of its deployment and focusing on people who are native to this context. By centering on more subtle and less direct types of interactions people – who are not "lead users" (Oudshoorn and Pinch, 2007), – the project directly addresses the gap in HRI research with respect to the "forgotten" (Astrid Rosenthal-von der Pütten et al., 2020) people in HRI with robots in public spaces.

Aim 2: To explore what these interactions mean for different stakeholders, and for the robot development process.

This aim was addressed by involving a range of stakeholders, including passersby, vendors, and Starship robot developers in the interviews. Key outcomes suggested that from the community's perspective, Starship robots were widely regarded as cute, helpful *to someone*, and symbolic of technological progress, fostering pride, particularly among Estonian participants. From the company's perspective, feedback and experiences from street-level interactions played considerable role in shaping the design trajectory, with these interactions constituting the bulk of development efforts. By incorporating diverse viewpoints, Inconsequential Encounters provides a more comprehensive understanding of how various actors perceive and interpret sidewalk robots as socio-technical participants in urban spaces.

Aim 3: Informed by the empirical data, to put to test and refine existing theories and methods in HRI, more specifically as these concern how we frame people and interactions, as well as social and affective processes underpinning human-robot relations.

The project addressed this aim through two main strands of research and respective contributions. First, adopting the concept of sociomorphing positing that robot sociality varies in dimensions and degrees (Seibt, Vestergaard, and Damholdt, 2020), I relied on qualitative and quantitative studies to substantiate the dimensions of sociality participants attributed to Starship robots, and how these compared to other types of robots designed to support social interactions ('social' by design). This work, one the one hand, allowed to highlight dimension of socio-practicality as crucial for deeper and more complex understanding of (functional service) robot sociality. On the other hand, this strand of research resulted in contribution towards refinement of the Attitudes towards Social Robots (ASOR) scale as a survey-based tool intended to assess robot sociality dimensions. Second, rooting in the empirical data, the project integrated a theoretical descriptive framework mapping subject positions people can occupy (beyond being a 'user') in relation to each other and the robot into three respective ecologies (Service Ecology, Street Life Ecology, Public Discourse Ecology). The framework contributes to extending the corpus of classificatory theoretical models in HRI, specifically as these concern (functional service) robots deployed in public spaces.

9.0.2 Research Questions

RQ 1.1. and 1.2.: What kinds of interactions people have with robots deployed in their communities? Which situational, social and design-related aspects scaffold these interactions?

In the studies presented in Chapters 4 and 5, I used a combination of methods – observations, online content analysis, and interviews – to address these research questions. The findings suggested that, several months into the service's roll-out in central Tallinn, Starship robots attracted considerable attention from passersby. While reactions varied, very few people ignored the robots entirely. Many paused to observe, with some approaching closer or taking photos or videos on their phones. Groups or pairs often responded more expressively, engaging in conversations, pointing, or laughing. Some passersby interacted directly with the robots, such as stepping in front of them to see how they would react. Children, in particular, showed enthusiasm, following the robots, patting them affectionately, or discussing them with parents.

Even fleeting encounters revealed adjustments to the robots' presence, such as people briefly glancing at them, altering their paths slightly, or giving way to the robots. These findings align with similar studies of sidewalk delivery robots, such as Pelikan, S. Reeves, and Cantarutti, 2024, who relied on ethnomethodological approach building on video recordings to investigate how Starship robots enmesh with the social organisation of everyday street life in the UK, and Weinberg et al., 2023, who observed Kiwibot deployments during a in Pittsburgh.

Not everyone responded positively or neutrally to the robots, or adapted seamlessly to their presence. Some passersby appeared confused, moving in ways that suggested uncertainty about how to navigate around the robot. These observations also align with existing studies on functional service robots in public spaces. For instance, Babel, Kraus, and Baumann, 2022 documented similar concerns about collisions with an autonomous cleaning robot in a train station. However, while potential collisions and lack of communication capabilities were mentioned in follow-up interviews, participants in the interviews reported in Chapter 5 generally informally assessed the Starship robot's navigation abilities favorably. Path-yielding conflicts were also observed in the study by Gehrke et al., 2023, which examined Starship robots deployed on university campuses and reported conflicts involving cyclists, pedestrians, and robots. Interestingly, such incidents were relatively rare in Tallinn. One possible reason is methodological: my observations prioritized situational factors facilitating help, so some incidents might simply have been missed. Alternatively, site-specific differences may offer another explanation for the discrepancy. Compared to the busy university campuses studied by Gehrke et al., Tallinn streets are less crowded, and Telliskivi street in particular being wider enough to allow cyclists and pedestrians to overtake the robots. The significance of site-specific factors for robot navigation and signaling was also emphasized by developers in interviews (see Chapter 6), supporting this explanation.

Unlike existing studies on robots in public spaces that have documented instances of direct vandalism or robot bullying e.g., (Oravec, 2023), or reported observing such behavior towards sidewalk robots e.g., (Weinberg et al., 2023), I did not observe any cases of direct vandalism. Starship robot developers also noted the relative rarity of vandalism and bullying incidents compared to the total kilometers driven (see Chapter 6). The absence of vandalism in my observations data might be partly due to the limited observation hours in my study. However, it may also underscore a more general trend in HRI research, which often emphasizes "event" (interactions where humans explicitly engage with or take a stance toward robots), with the first study reported in Chapter 4 and focusing on help being no exception. Such studies may overlook the frequency and significance of subtler conflict situations, like the path-yielding conflicts discussed earlier, which may be more representative of everyday robot interactions in public spaces cf. (Pelikan, S. Reeves, and Cantarutti, 2024).

Regarding voluntary assistance, a key focus of the project in relation to RQ 1.1. and

RQ 1.2., observations confirmed that such instances were not merely isolated anecdotes amplified by media coverage. Both observations and interviews revealed that people were often willing to assist Starship robots, performing tasks such as clearing snow from their paths, removing obstacles, or pressing traffic light buttons (see also Pelikan, S. Reeves, and Cantarutti, 2024). Furthermore, these acts were construed by the interviewees and online commentators as "commonsensical", or even a moral thing to do. The fact that the company observed similar behaviors shortly after the robots' roll-out and subsequently incorporated dialogue-based requests for help further supports the notion that such assistance is not a rare occurrence. However, it should also be noted that instances of robots relying on human help remain relatively marginal compared to the vast number of kilometers the robots have traveled (see Chapter 6).

RQ 2.1., 2.2. and 2.3.: How do community members make sense of the robots deployed on their city streets? What do they themselves make of the (incidental) encounters with robots? From developers perspective, what role do these encounters, if any, play in the design process?

Research questions 2.1. and 2.2. were primarily addressed through content analysis (Chapter 4) and interviews (Chapters 4 and 6). The findings indicated that Starship robots were generally perceived favorably, with many participants describing them as cute and helpful *to someone*, reflecting a high level of 'existence acceptance' (Abrams, Dautzenberg, et al., 2021) within the community. However, as discussed under the theme 'Not Using Does Not Mean Useless' in Section 5.4.3, perceiving the robots as useful – or purposeful – did not necessarily translate to personal usage. In fact, very few participants had tried robot-based delivery or considered themselves Starship customers. Participants also noted functional limitations, such as the robots' small carrying capacity and slow speed. This decoupling of existence acceptance from usage acceptance adds further validity to the concept of existence acceptance but leaves an open question with respect to which forms of acceptance – and from whose perspective – must be met such that (commercial) sidewalk robots can be considered a success?

A key insight from the studies regarding how people perceive robots on city streets is that positive attitudes were often tied to the robots symbolizing technological progress, which participants generally viewed as inherently "good" — provided it does not surpass a threshold when it becomes "too much". Additionally, perceptions of the robots were shaped by various identity constructs, including national, professional, and personal identities (see Section 5.4.1). For instance, Estonian participants associated the robots with their country's reputation as a leader in IT innovation, which evoked a sense of pride.

Another important takeaway was that participants experienced Starship robots as, in some way, social actors on the street and in the community. However, this did not necessarily result from people perceiving the robots as having human-like mental or emotional states – if anything, participants were unlikely to attribute such states to the robots. Instead, this perception related, on one hand, to how the robots aligned with existing formal and informal norms (such as politeness and traffic regulations), and, on the other hand, to an intersubjective element, where care for others (e.g., people waiting for their deliveries) also shaped how participants perceived and responded to the robots. Seeing the robots as actors in the community led participants to assume that others would also behave according to societal norms with respect to the robots. From this perspective, acts of vandalism or refusal to help were viewed as "impolite" or "uncivilized". From the vendor's point of view, Starship robots were similarly seen as social actors, which was reflected in practices such as assigning them names or referring to them as quasi-colleagues. These findings align with earlier HCI and HRI research suggesting that robots occupy a distinct ontological niche compared to other machines, with people inclined to ascribe lifelike qualities to them, even when not explicitly designed to elicit social responses e.g., (Young et al., 2010). However, this does not mean that robots are considered symmetrical to humans, or even pets (Seibt, Vestergaard, and Damholdt, 2020). For example, in terms of behavioral manifestations, as discussed in Chapter 4, vendors would still prioritize attending to a human courier first over a robot.

Regarding other dimensions of sociality, as discussed in Chapter 7, and consistent with the qualitative data, participants rated all robots in the study – including social companion robots – low on the mental and psychological relatedness dimension, as measured by the ASOR scale. However, Starship robots were rated highly on the socio-practical relatedness dimension, which also aligns with the outcomes from the qualitative interviews. When it came to attributions of moral agency, these were rated lower compared to attributions of moral patiency. These findings provide support for the conceptual validity of sociomorphing, which suggests that robot sociality exists along a continuum of degrees and dimensions (Seibt, Vestergaard, and Damholdt, 2020; Zebrowski and McGraw, 2022). They also highlight that even functional service robots – those not explicitly designed for social interaction – can be perceived as highly social based on their alignment with established formal and informal norms that shape everyday life cf. (Babel, Thellman, et al., 2024).

Regarding RQ 2.3, the Reflexive Thematic Analysis of interviews with Starship Technologies developers, presented in Chapter 6, revealed that Inconsequential Encounters (discussed in RQ 1.1) play a significant role in shaping the design trajectory of Starship robots. The majority of development efforts focus on street-level interactions, with user interactions (i.e., Starship customers) representing a smaller portion of the overall design process, often addressed through UX dimensions. Specifically, this chapter outlines several ways street-level interactions feed back into the design process, driven by two key logics: quantification (focused on quantitatively assessing resources required to implement an iteration and estimating impact) and reduction in dependency (focused on reducing dependency of the robots on external actors and factors). For instance, using the logic of quantification, common occurrences of damage (even if not malicious, such as a broken LED flag) are systematically addressed through design iterations, for example, improving the flag's material durability and incorporating software to detect breakage as it occurs.

Regarding prosocial interactions (e.g., voluntary help), participants generally agreed that these were "nice to have", especially in the early stages of the robots' rollout. However, applying the logic of reducing dependency, they also emphasized that, in the long term, it would be preferable for the company to minimize reliance on external help, even if this meant losing some of the positive aspects, such as people enjoying assisting the robots. In terms of the positive experiences people had when encountering the robots on the streets, all interviewees acknowledged that these experiences contributed to the company's positive reputation, though in a way that is difficult to quantify. Their views differed on the potential for designing social encounters with the robots: two interviewees expressed a desire for interactions to be "delightful", while another felt that merely avoiding rejection would be a sufficient criterion for success in how the robots are perceived by the public. As discussed in more detail in Chapter 6, the strong preference of industry players to reduce the robots' reliance on external help raises important questions for certain research strands in academic HRI. Specifically, studies investigating strategies for soliciting human help – assuming this to be a desirable approach in crisis situations – may be based on a misinterpretation of the actual problem at hand.

Regarding the differing interpretations of acceptance – acceptance as the absence of rejection versus acceptance as delight – an important takeaway from Chapter 6 is that acceptance it itself functions as a boundary object (Law and Callon, 1992). Developing a commercial service robot for deployment in public spaces is inherently a socio-technical challenge (see Chapter 8), and the concept of interpretative flexibility plays a crucial role not only in how people experience and interact with the robots but also in how company actors perceive and define acceptance. While the company primarily defines acceptance as the absence of rejection, with the ultimate goal of achieving usage-acceptance, the community's perspective, as discussed above, may place less emphasis on usage-acceptance. Instead, acceptance may take the form of delightful, albeit fleeting, encounters with the robots on the street.

RQ 3: If we can't refer to these interactions as 'use,' what other conceptual frameworks are available to capture these interactions? How does studying robots in public spaces challenges and informs these frameworks?

Addressing this research question was central to Chapter 8.2. Building on the empirical studies I conducted as part of the Inconsequential Encounters project – and in collaboration with my colleagues Franziska Babel and Hannah Pelikan, who also have extensive experience investigating robots in public spaces – I applied the concepts of subject position (Baumer and Brubaker, 2017) and ecology (Forlizzi, 2008) to map out three distinct ecologies (Service Ecology, Street Life Ecology, Public Discourse Ecology) based on the roles people play in relation to one another and the robots. While other classifications in HRI exist, such as Scholtz, 2003, which distinguishes between roles like supervisor, operator, bystander, and teammate, or Winfield et al., 2021, which differentiates end users, the wider public, bystanders, accident investigators, and lawyers, the proposed framework offers a more nuanced mapping of the structural categories of people relevant to service robots in public spaces, as well as highlights that what the robot is within the three ecology differs. In addition to systematically reviewing the roles people can enact in relation to functional service robots like Starship, this framework contributes to HRI by highlighting gaps for future research and advocating for a more holistic approach to the design and deployment of robots in public spaces.

RQ 4.1. and 4.2.: What challenges and opportunities arise when studying robots as socio-technical actors in community settings; how can insights from field studies further enrich and inform methodological approaches in HRI?

To address RQ 4.1, Chapters 4, 5, and 6 each integrated methodological reflections within their respective Discussion sections. In Chapter 4, these reflections highlighted both the benefits and drawbacks of conducting unstructured observations at the early stages of the project. The main benefits included increased flexibility and the ability to define the scope of the phenomena under investigation, which was particularly important for exploratory studies of a relatively new phenomenon. However, the drawbacks included challenges in identifying what constituted a relevant event and the difficulty of keeping detailed field notes while simultaneously observing. Additionally, I discussed how ethical concerns around respecting data privacy in my case conflicted with the video-based data analysis, which was the most effective method for detailed analysis of situations.

A key methodological takeaway in Chapter 4 was that, in ethnographic interviewing and Reflexive Thematic Analysis, the perception of data saturation during the data collection stage can be misleading. More often than not, each additional interview offers new insights and depth to the analysis. Experiencing this in my own project made me realize distinctly why information power (Malterud, Siersma, and Guassora, 2016) (discussed in Chapter 3) is a more appropriate criterion for evaluating the quality of interpretative research.

In Chapter 6, methodological reflections highlighted the challenges of gaining access to gatekeepers, which is necessary but not always sufficient – as evidenced by my unsuccessful attempts to interview remote assistance specialists – for investigating the perspectives of industry actors. I also emphasized the importance of remaining flexible, especially with regard to standard ethics protocols in academic research cf. (Frauenberger, Rauhala, and Fitzpatrick, 2017), such as consent forms. Different stakeholders may require different adaptations and situated responses. Overall, the reflections in this chapter underscored the complexity of balancing corporate interests, participant protection, and academic objectives.

Related to RQ 4.2., based on my experience conducting the Inconsequential Encounters project, I want to emphasize the critical importance of both empirical studies in the context of technology deployment and the accompanying theoretical work for advancing HRI as a field. As Chapters 7 and 8.2 demonstrate, a solid theoretical foundation cf. (Hannibal et al., 2022) is essential to underpin informed empirical research. If I had too quickly dismissed people's social and affective responses to Starship robots as "anthropomorphism", I would have missed many nuances related to the multi-dimensional understanding of sociality. Although this was an incremental part of the work – and not something I initially planned to do as part of the project – the attempt to translate the theoretical concept of sociomorphing into something measurable through a survey provided valuable insights and learning moments that I consider important outputs of the project. Conversely, without conducting the empirical studies and gaining in-depth knowledge of the field, it would have been difficult to develop the theoretical framework presented in Chapter 8.2 with the level of detail it provides.

CHAPTER 10

Conclusions

In this concluding chapter, I reiterate the key takeaways from the project by bridging them to the expected contributions outlined in the Introduction. The chapter concludes with some critical thoughts on how I perceive the limitations and possible futures of this project.

10.1 Main Takeaways

In Chapter 1 of the thesis, I specified three types of contributions expected from the project: empirical, theoretical and methodological. In this section, I will briefly revisit these contributions to outline the main takeaways from the project.

Empirical Contributions

The Inconsequential Encounters project offered novel empirical insights into how communities where Starship robots operate experience and interact with them on city streets, as well as what these interactions mean for the robots' developers. My research identified a range of responses to the robots, from fleeting reactions to proactive behaviors such as exploring or assisting the robots when they are perceived as in need of help. Instances of voluntary assistance highlighted tensions depending on the perspective – help as unpaid labor, help as interpersonal care, and help as a nice-to-have but nonessential dependency from developers' viewpoint.

Through qualitative interviews with passersby and vendors, the project highlighted how identity shapes public acceptance of sidewalk robots. Additionally, quantitative and qualitative findings also contributed to ongoing HRI research by underscoring the nuanced ways functional robots like Starship are perceived as social actors, with varying degrees and dimensions of sociality.

On the developer side, the outcomes of expert interviews highlighted how "inconsequential" encounters with Starship robots on the streets inform the iterative and multidimensional design process, which in turn is embedded in economic, technical, social, and interpersonal processes and negotiations. Importantly, the research detailed how street-level interactions feed back into design, reinforcing the dynamic relationship between interaction space and development space.

Theoretical Contributions

This monograph offers theoretical contributions by outlining a descriptive framework that maps diverse subject positions people can assume in relation to each other and the robots and moves beyond the concepts of 'users' and 'incidentally co-present persons'. The subject positions derived analytically based on the empirical data are organized into three ecologies: Service Ecology, Street Life Ecology, and Public Discourse Ecology. This framework is a significant outcome of the project, providing both a vocabulary for HRI scholars studying sidewalk delivery robots and a means to identify gaps and opportunities for further research. It also supports proposals for a more holistic understanding of design, extending beyond the level of technical robot design to address broader dimensions critical for integrating sidewalk robots into real-world contexts.

Methodological Contributions

This thesis offers a two-fold methodological contribution. First, by reflecting on the challenges and opportunities of studying commercial robots in real-world deployment contexts rather than laboratory settings, this work offers guidance for future researchers exploring technology in situ. Second, the refinement of the Attitudes Towards Social Robots (ASOR) scale extends the toolkit of quantitative surveys in HRI. This contribution – though incremental and open for future work – is particularly relevant as autonomous robots increasingly move into public spaces, demanding a nuanced understanding of the dimensions that facilitate their integration into everyday social life. By addressing these complexities beyond anthropomorphism, this work is a step towards advancing sustainable, long-term deployment of these technologies.

Taken together, the empirical, theoretical and methodological contributions of the Inconsequential Encounters project highlight how robots are never mere technical artifacts – they exist at the intersection of engineering, social, cultural, economic and political discourses. Designing robots for the real world means issues remain continuously negotiated, and they rarely can be resolved in a unique one-fits-all manner. Crucially, ambivalence as a "moment where multiple and incoherent ambiguous conditions are brought to light" (Bargetz, 2014, p.210) can enable us to rethink responsibility when it comes to designing technologies that not only will coexist with us in everyday life but will reshape it considerably.

10.2 Concluding Remarks on Limitations and Future Work

Although I did not directly ask about the socio-economic status of my participants in Estonia, based on my conversations with both passersby and vendors, the participants of the project form a relatively homogeneous group in terms of education and socio-economic background. The vendors I spoke with managed or worked in small cafes and shops located in central and northern Tallinn, areas predominantly home to middle and upper-middle-class residents. While two of these vendor-operated businesses have been around for over a decade and attract a more diverse clientele, others are newer and cater mainly to wealthier customers. As I mentioned in Chapter 5, my interviewees had the luxury of time to discuss robots with me over a cup of coffee. At the same time, all interviewees experiencing the robots in the role of passersby shared an overall positive outlook on technological progress. This means – while the experiences captured in this monograph are genuine – they represent only a segment of the broader picture of what Starship robots mean to the Estonian community. Notably absent are the voices of those who do not belong to the middle and upper-middle class – people working precariously in supermarket chains or those who may feel disconnected from the conversation about robots altogether. These people may not perceive the robots as relevant to *their* community or their personal or professional identities. I believe it is valuable in the future to explore the perspectives of more demographically diverse groups, including those whose views on technological progress differ from those of participants in the Inconsequential Encounters project.

Additionally, Estonia is just one relatively small market for Starship robots. The generally positive reception of the robots may be influenced not only by the socio-cultural aspects discussed in the monograph but also by more pragmatic factors, such as low volume of operations in Estonia and the less congested sidewalks compared to busier locations, such as university campuses cf. (Gehrke et al., 2023). While existing studies examine various aspects of human-robot interaction (see Chapter 9), a more comprehensive approach that considers how different dimensions of these interactions shape the role and meaning of sidewalk robots within specific communities would provide a more nuanced understanding of the impact these technologies have on urban life.

Time is another important aspect to consider when situating and framing both the research process and its findings. I am certainly not the first to highlight the dynamic, ever-changing nature of technology-society configurations (Law and Callon, 1992) or the process of diffusion of robots into everyday spaces e.g., (Gnambs and Appel, 2019) more narrowly. As discussed in Chapter 6, what commercial robots are remains a fluid process at the intersection of many factors and actors. How people perceive and interact with the robots on the street will also continue to evolve as time passes. As obvious as it may sound, the world we study as researchers does not stop once we leave the research site or complete a project. In June 2023, Starship Technologies announced a partnership with Bolt, the first European mobility app and another successful tech enterprise originating from Estonia (Reuters, 2023). As of mid-October 2024, Tallinn residents can have their orders from Bolt Food delivered by Starship (Sildmets, 2024). While this collaboration is widely portrayed in the media and company press releases as a powerful partnership that gives Starship access to millions of Bolt's customers in over 45 countries, it's hard to ignore the criticisms Bolt has faced regarding poor working conditions (Breese, 2023), worker exploitation, unfair pay, and other systemic issues common in platform economy businesses (Bajwa et al., 2018; Duggan et al., 2020). It is also clear that Bolt's expectation that using robots will increase long-term profitability per delivery (Reuters, 2023) ultimately means that many of these precarious jobs may be displaced altogether. While it would be foolish and irresponsible to speak for those performing these jobs about the impact of their potential loss, these developments nevertheless raise many open questions for me as I move on to the next stage of my life.

Although I view this project as only a snapshot in time – a kind of academic Polaroid that will inevitably fade – I hope that some of the lessons learned about what sidewalk robots *could* be for people in these communities will endure. The questions I ask myself as I close this chapter, however, are: Do vendors (who are no longer "Starship vendors") and Kalamaja residents still feel proud seeing the robots on the streets? Do they smile as they did when I first conducted my observations? Do my company interviewees still hope that encounters with the robots will be "delightful"? And what is indeed the worth of delight in an economic and geopolitical world driven by scalability, market expansion and everlasting pursuit of efficiency and profitability (Possati, 2024)?

While I don not have answers to these questions – or, rather, depending on the day the answer varies from very pessimistic to cautiously hopeful – I firmly believe that the time is now to extend research on sidewalk delivery robots to explore their broader impact on less visible actors in the three ecologies discussed in Chapter 8.2, such as delivery up-keepers and human delivery workers. These are the people who perform the invisible labor that underpins both automation and society as a whole, and these are the people who also remain "forgotten". I realize that to many this call may seem rather removed from the traditional HRI research. However, as highlighted in the Discussion in Chapter 8.2, I cannot imagine developing ethically and socially sustainable technologies without addressing these critical issues.

Overview of Generative AI Tools Used

A free version of Writefull for Overleaf was used to proofread selected sections of the manuscript. ChatGPT-4 was used to improve readability of selected sections of the monograph and in writing concise summaries of the chapter. In this case, the text generated was always edited by the author to ensure it accurately represents the intended meaning and utilizes language that reflects the author's writing style and voice. At no point AI tools were used to generate content points of the thesis.

Appendix

Interview Guide Passerby

Intro: thanking + reminder about rights

1. First impressions
   1.1 Do you remember when and how you first encountered Starship robots? Can you describe this situation?

   1.2. What was your reaction? What thoughts/feelings did you have? *(maybe steer them to talk about design)*

2. Usefulness/functionality related
   2.1. Do you know what these robots are for? What do they do?
   2.2. Do you consider them useful? For whom? In which way?
   2.3. Have you placed orders with Starship app?

3. Automation/socio-practical
   3.1. These robots are now new actors on the streets. Do you think they integrate well into city infrastructure?
   3.2. What do you think about how they handle navigating the streets? Overcoming challenges?
   3.3. Have you witnessed them experiencing challenges? What was the situation? How did you understand that it was experiencing challenges?
   3.4. Have you ever helped them? Why? Why not? How?
   3.5. Have you seen other people helping them?
   3.6. Do you think it's the right thing to do for people to help robots?

4. Socio-relational
   4.1. How are these robots different from other machines?
   4.2. Do you think they have their own intentions?
   4.3. Do you think they have emotions?
   4.4. What do you think about people having emotions towards these robots or developing some form of relationships? (give example from my fieldwork e.g. name giving)

5. Attitudes towards robots
   5.1. In general, what do you think about robots and humans sharing more spaces and more tasks?
   5.2. Would you like to see more robots in the future?

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