Designing for Capabilities

A Phenomenological Approach to the Design of Enabling Technologies for Older Adults

Suhas Govind Joshi

Thesis submitted for the degree of Philosophiae Doctor
Department of Informatics
Faculty of Mathematics and Natural Sciences
University of Oslo
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Abstract

Technology is playing an increasingly important role in society's response to the emerging need of caretaking of the oldest citizens. This dissertation presents a design approach that focuses on capabilities rather than disabilities as the foundation for the design of enabling technologies for older adults. To answer the overarching research question of how we can design for capabilities, this dissertation addresses three research questions that concerns construction of a theoretical design framework, the operationalization of the framework by informing a tailored methodology, and reflection of design outcomes to generate knowledge that can inform back to theory.

Maurice Merleau-Ponty's phenomenology of the lived body has been used to construct a design framework with theoretical concepts, design considerations, and design opportunities that frame an understanding of capabilities as the basis for design. This framework has informed the adaptation of a phenomenological Participatory Design (PD) methodology which has then been continuously adjusted to support the practical limitations of engaging older adults in co-design activities. The methodology has guided the facilitation of 14 different research explorations involving 542 participants over four years. The design outcomes from these research explorations have been used as analytic tools to generate knowledge through reflection that has contributed to the revision of the theoretically informed design framework. The design outcomes have also been used to reflect on the phenomenological PD process.

This dissertation answers the overarching research questions by making three contributions: a phenomenological design framework that emphasizes designing for capabilities revised by knowledge generated through design; a tailored phenomenological PD process with supportive analyses of preconditions, participation, and decision-making; and presentation of two sets of design artifacts and the knowledge they have generated.

The design approach suggested has been followed from conception of theory to long-term use of design outcomes in realistic settings to fully utilize the reciprocal interplay between theory and design. Results from the testing of use after design in real environments suggest that this design approach can open up new opportunities to design long-lasting relationships between people and the digital artifacts they use in their everyday life by designing for capabilities rather than disabilities.

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Chapter 1

Introduction

1.1. Background

Norway faces a major long-term societal challenge with meeting the caretaking needs of the future. We are currently experiencing an increased need for health services and a parallel decrease in available labor within the health sector (Directorate of Health, 2012; NOU, 2011). As such, an important area of focus for the Norwegian government is finding new opportunities for technology to play an increasingly more important role in the lives of the oldest citizens in need of caretaking. Since the Norwegian government's official report on innovation in care (NOU, 2011) brought attention to the rapidly emerging need of caretaking of this demographic, we are seeing increased attention directed towards new models for delivering care built around technology-based products and services. Welfare technology is the common umbrella term used in Scandinavian countries to describe the wide range of technologies intended to change the current means of delivering health and care services. The Norwegian definition emphasizes technological assistance that supports autonomy, safety, mobility, and social participation (NOU, 2011, p. 98). As the official report states, the technology itself is not expected or designed to create any revolution within the care services, but rather support individuals in maintaining their everyday independence despite reduced physical or cognitive capacities. The average population of Norway is aging, and official reports from the government suggest that the expected number of people above the age of 80 years will double in less than 20 years (Norwegian Board of Technology, 2009, p. 7). As such, the number of citizens in need of assistance to maintain their autonomy is expected to increase over the next decades. The access to qualified caretakers and caretaking facilities for this demographic is already scarce in Norway, and technology-based

products and services are being produced and used in increasing numbers as a countermeasure to the expected deficit in governmental care services (Norwegian Board of Technology, 2009). Welfare technology also aims to support *"aging in place"* where citizens can remain in their homes for as long as possible through the assistance from welfare technology (Directorate of Health, 2012), which is one of the reasons behind the nationwide focus on smart home technology, both within research and industry.

The delivery of welfare technology builds on the Nordic model where the government promotes social well-being and individual autonomy through its public services. As such, there is a high demand from local municipalities and all organizational levels up to the Department of Health, calling for more insight, innovation, and research on welfare technology for the older population. We see increased emphasis on welfare technology within education, innovation, and municipal services. Several governmental initiatives involve municipal, research departmental, and industrial cooperation (Directorate of Health, 2012, p. 14) in search for knowledge on how we can meet the caretaking needs of the future. The work presented in this dissertation was part of one such long-term and interdisciplinary project called *"A3: Autonomy and Automation in an Information Society for All"* (Verdikt grant no. 193172/S10). The project ran from 2009-2014 and was led by the Department of Informatics at the University of Oslo, and involved both municipal and industrial stakeholders in addition to the researchers from the University. One area of focus described in this project was welfare technology. More precisely, the research aimed to address (1) the technology's effect on individuals and society; (2) the users' autonomy and mastery; (3) delegation of tasks to machines; and (4) user participation in design. With these research aims in mind, I will later in this chapter return to the particular focus and contribution of this dissertation.

1.2. Designing for capabilities in changing bodies

The motivation for writing this dissertation did not come from the technology I explored, but rather from the users with whom I got to work. I was motivated by the perspective through which we can respect, address, understand, and include the users when designing technology for older adults. My perception – which bears strong resemblance to the work of other

researchers such as Light et al. (2016) and Blythe et al. (2015, 2016) – is that most of the technology currently being tailored towards the older population begins with a perspective on aging that does not consider it a natural part of life, but rather as an inconvenient condition involving disabilities. Such approaches have been referred to as deficit-driven design (Carroll et al., 2012, p. 7). I argue that such a perspective can only generate designs with a very limited use period because it considers aging a static consequence of being old. Whichever disabilities the designers aimed to address and regardless of their intentions, the assumptions brought into the design space by the designer will only hold until the process of aging introduces a mismatch between the designer's idea of a user and the user's self-perception – at which point I believe the human-technology relationship will begin to crumble. As such, this dissertation attempts to avoid a solutionist trend (Blythe et al., 2015, p. 3849) where large challenges are tentatively solved without addressing the complexity at hand.

I believe that there are other more salutary perspectives (Antonovsky, 1996) that can structure a salutogenic understanding of the nature of aging through which I can find design opportunities that do not make older people *feel* old (Light et al., 2016) and do not romanticize or patronize the participants (Blythe et al., 2005, p. 673). I wanted to adopt a perspective that did not see aging as a *"solvable"* problem, but rather as one of many continuously evolving phases of life from which we can elicit opportunities to design for and with this demographic as we would with any other demographic: by building a design process that sees them for who they are and what they know, and that allows them to be and feel like themselves both during the design and use. As such, I am shifting my concerns from what older adults cannot do to what they can do; *I am designing for capabilities rather than disabilities*.

I have chosen to use the word *"capability"* in this dissertation to describe the active and changing potential related to someone's *"actual ability to achieve various valuable functionings as a part of living"* (Sen, 1993, p. 30). I position my understanding of capabilities within my design space in Chapter 3 and 4 to help clarify my understanding. The underlying assumption for this dissertation remains that my perspective holds a strong potential to yield enhanced agency as well as longer-lasting human-technology relations. My

perspective attempts to capture the rich layers of experience, competence, and capacities still available to the users.

In my published papers, I have used the notion of both welfare technology and assistive technology to contextualize the type of technology I concern myself with, but it has become clear to me that those terms do not properly capture or communicate how I envision the role of the technology when designing for older adults. I will instead use *enabling technologies* (Light et al., 2015, p. 303) in the rest of this dissertation. This notion expands on the basic understanding of assistive technology by emphasizing the dynamic nature of aging the technology cannot escape; allowing people to gracefully continue with their lives alongside technology that enables them to engage in everyday activities and that can evolve along with them.

There are many epistemological backdrops and theoretical rationales that can support similar perspectives on aging as presented here, but my approach involves seeing aging as a subjectively experienced phenomenon which can only be understood through the bodies in which the aging takes place. It is not a process beginning at a certain age or stage in life; it is merely a continuation of a life-long body-world relationship constantly in change. I draw on the work of the phenomenologist Maurice Merleau-Ponty who used the notion of the lived body to describe a worldview beginning with the body as the epistemic center. Rather than understanding the process of aging through symptoms and medical diagnoses, I want to capture the subjective experience of the aging process, and this branch of phenomenology offers an embodied philosophy that I can use to frame my understanding. This approach allows me to reduce the distance between how I understand the lived experiences of older adults and how I choose to respond to that understanding through design (Blythe et al., 2010, p. 169). When I say that I am designing for capabilities rather than disabilities, I understand capabilities through the bodily capabilities of the users, i.e., *the capabilities of their changing bodies*. Merleau-Ponty's work does not see human beings as biological species defined by a predetermined essence but rather as defined by what we can make of situations (Matthews, 2014, p. 102).

The users inhabit the bodies for which I am designing; I consider them to be the ultimate experts on understanding the users, use, and use experience. As such, they are vital to the design process' ability to

acknowledge, capture, and incorporate important considerations regarding the nature of aging and its effects on the human-technology relationship. Related to my understanding of aging is a strong desire to include the users in a respectful manner where I see them as full-worthy members of society rather than as a marginalized group of users. I believe they can contribute to a design process as equal co-designers. To facilitate a process where users can participate on own terms and not feel neglected I have applied Participatory Design (PD) as my design approach. All PD processes are unique, and mine is no exception; I have designed a process that I believe supports a phenomenological worldview and that simultaneously allows the participants, i.e., older adults, to serve as full-worthy members of the design team.

One quality of PD I find admirable is its ability to maintain a strong link between the users and problem solving throughout the whole design process. As I am anchoring my search for new design opportunities in the phenomenology of the lived body, I can – alongside my older co-designers – let theory and design evolve hand in hand as I co-explore new enabling technologies. And I can then use the design outcomes from the PD activities to reflect on my understanding of changing bodies and reflect on its suitability as an underlying perspective on how to approach the design of enabling technologies. These design outcomes will not be designed to solve specific problems – they will be representative manifestations of my design approach, i.e., designing for the capabilities in changing bodies. As such, the multiple conceptual prototypes, research prototypes, and research products (Odom et al., 2016) can serve as tools for both reflection and communication; they will encompass the operationalization of my theoretical understanding anchored in phenomenology, and they will demonstrate how we can shift the way we can go about *"meeting the caretaking needs of the future"* (NOU, 2011).

And this remains my motivation; older people's world becomes smaller as their capabilities to act in the world gradually disappears, and I try to find those capabilities that still demonstrate to them, as well as to others, their potential to engage in long-lasting interactions with technology. Also hidden in my approach is a premonition of how older people engaging in positive experiences with technology can reconnect them with their embodied abilities in a way that provides a healthy perception of accomplishment; constant reminders of active capabilities rather than disabilities can provide positive

sensations that reinforce their self-perception and hopefully allow them to remain optimistic and thereby independent longer. In some cases, it may be a matter of rediscovering capabilities, while in other it may require rearranging of circumstances and allowing capabilities to re-emerge. Nevertheless, changing bodies contain rich history and vast knowledge on which I can scaffold the foundation of my design.

1.3. Defining the design space

The research I present in this dissertation all happens within the same design space which I choose to label *enabling interaction*. The phenomenological lens and the methodology of PD I use to study the interplay between older adults and enabling technology in everyday life constitute my design space of enabling interaction. It is within this space I look for opportunities and challenges, and this design space helps me frame my research questions and situate the context I am addressing with my research. In addition, the choice of phenomenology as theory and PD as methodology reflect the epistemology and values I bring with me. The 14 research explorations I present at the end of Chapter 2 are all examples of different lines of inquiry into this one and same design space.

1.4. Research problem and contributions

My research involves both theory and practice of design, which is not easily narrated in a linear order. However, it is important for me to tell the overarching story of my research in one coherent structure that can reflect the holistic nature of my research rather than tell it through different fragments spread across individual papers. I believe this is the only format that allows me to show the broad specter my research covers and demonstrate the cyclic moves I make from theory to design practice and back to theory again.

1.4.1. Research questions

I have summarized my focus into one overarching research question: **How to design enabling technology for and with older adults based on their capabilities rather than disabilities?** I address this overarching research

question by answering three interrelated and mutually informing subordinate research questions:

- **Research Question 1:** How can the phenomenology of the lived body be used to address capabilities rather than the disabilities in changing bodies?
- **Research Question 2:** How to design for capabilities when working with older adults?
- **Research Question 3:** How can the design outcomes be interpreted and situated within the design space of enabling interaction?

1.4.2. Answering the research questions

This dissertation is structured in such a way that the main bodies of work used to answer the three research questions later are introduced separately, but are then pulled together in the discussion to combine the theoretical knowledge with knowledge generated through design as I state my final contributions. To explain the exact nature of how the three mutually informing research questions are answered, I briefly outline the series of steps I have followed and then point to where in the dissertation the answers have been constructed in **Table 1.1**.

My journey began with the phenomenology of the lived body which did not contain a specific set of concepts that could be applied directly to understand the part of the aging and changing bodies I concerned myself with in this dissertation. As such, my first research efforts were focused towards finding the appropriate theoretical framework for my research interest. This resulted in the elicitation of eight specific concepts originally derived from Merleau-Ponty's work that has previously been applied within Human-Computer Interaction (HCI) and Interaction Design (ID) literature. These theoretical concepts constituted my own interpretation of how phenomenology can be used as a lens to help structure the understanding within my design space. I then used these theoretical concepts to operationalize a design framework. This design framework contained considerations and opportunities to design for capabilities that helped to inform my design practice. I arrived at this specific design framework by reflecting on considerations and possibilities through the literature on both Tangible Interaction (TI) and aging. Choosing TI was my way of positioning the type of interactions I wanted to co-design

with participants as this situates the space in which we looked for design opportunities in the same space as we live our everyday lives, i.e., the physical world. It also aligned with my phenomenological backdrop and supported my ideals of designing for increased agency – I have tried to find new ways of continuing interaction with digital artifacts in everyday life by focusing on the capabilities of users. At this point, I was still at a theoretical level, and all reflections and analyses were independent of empirical data and design outcomes; both the theoretical concepts and the design framework mentioned so far were derived from a theoretical-analytical process alone.

I then used the design considerations from my design framework to inform the adaptation of a phenomenological PD methodology that addressed my theoretical concerns. This phenomenological PD process – where the participants and I together engaged in the collaborative design of alternative and new tangible interactions by focusing on embodied experiences – was the starting point for my design practice. However, working with older adults as co-designers introduced many practical challenges in terms of facilitation, and the PD process was continuously adapted as practical considerations emerged to support the focus on embodied experiences while simultaneously respecting the limited opportunities for participation.

The design activities resulted in a number of prototypes, research prototypes, and research products (Odom et al., 2016). While they could have been interpreted in multiple ways, I used them in three specific manners: first, I used the design artifacts to reflect on the role and influence of the participants in the PD process; second, I used two selections of design artifacts as analytic tools for generating knowledge that could reinforce and revise the design framework I constructed with theory alone; and third, I used the research products to provide an additional layer of learning by testing them in real use contexts. The analyses and discussions of the design artifacts helped me revisit past intermediate results that were mainly theoretically informed, but now with knowledge from design practice that could complete the cycle between theory informing practice, and practice informing back to theory. As such, all the research questions are answered through the intertwining of theory and design practice by using the design outcomes to generate different types of knowledge that could mature the intermediate results into final

contributions. **Table 1.1** presents an overview of how and where in the dissertation the three research questions are answered.

Table 1.1: *Overview of research questions and key chapters*

Research questions	**Key chapters**
Research Question 1: How can the phenomenology of the lived body be used to address capabilities rather than the disabilities in changing bodies?	
▪ Which concepts can be used to structure a phenomenological understanding of capabilities rather than disabilities?	Chapter 4.2
▪ Can these concepts be operationalized into a design framework with considerations and opportunities to design for capabilities?	Chapter 4.3-4.4
▪ How can the design outcomes be used to revise the theoretically informed design framework?	Chapter 7.4
Research Question 2: How to design for capabilities when working with older adults?	
▪ How can the phenomenological concepts from the design framework inform the adaptation of a PD methodology?	Chapter 5.2-5.3
▪ How can the phenomenological PD process be adapted to the older adults' limited opportunities for participation?	Chapter 5.4
▪ Can the participants' design decisions be traced in the design outcomes?	Chapter 6
Research Question 3: How can the design outcomes be interpreted and situated within the design space of enabling interaction?	
▪ How can the design outcomes be used as analytic tools for knowledge generation?	Chapter 7.2-7.3
▪ Which questions emerge across the analyses of design outcomes?	Chapter 7.5

1.4.3. Contributions

I believe that using theory and design that mutually informs each other holds the potential to generate knowledge that would not be possible when doing either one alone. As such, the overall contribution of my research on designing for capabilities is targeted towards HCI design and design practice. However,

as my research contains analyses of design outcomes as well as theoretical and methodological contributions, the individual contributions are relevant to other research communities or more specific brackets within HCI. My phenomenological methodology and the reflections on how it can engage older adults in designing enabling technology contributes mainly to the PD community, and the theoretical concepts of Merleau-Ponty could be relevant to brackets of HCI emphasizing theoretical development in the context of design for older adults independently of design practice.

This dissertation aims at making three contributions by answering the three research questions. The first research question is answered with a design framework for the design of enabling interaction. It is constructed with theory and analysis, and then later revised by knowledge generated through reflection on selected design outcomes. This design framework encompassing both theoretical and practical concerns becomes my first contribution. This is intended as a theoretical contribution.

The second research question is answered by introducing a phenomenological PD process which is continuously tailored to the empirically-observed participation limitation of older adults. The design outcomes are used to reflect upon the type of decision-making offered by this process. The final version of the PD process, along with three different analyses of preconditions, participation, and decision-making constitutes my second contribution. This is intended as a methodological contribution.

The third research question is answered with and through the design outcomes. The various research explorations have generated a range of prototypes of different quality – ranging from conceptual prototypes to fully-functional research products. These have served as reflective tools that helped with strengthening my understanding of the theoretical and methodological components of how I design for capabilities. They have also suggested further directions by allowing salient questions and concerns to emerge. As design artifacts, they themselves encompass an implicit contribution.

1.5. Structure

While theory and design have been studied and refined in parallel throughout my research, the sequential structure of this dissertation is divided into separate chapters to more clearly narrate the story.

Chapter 1 has introduced the design space and the research problem to position my research and target my contributions. **Chapter 2** gives an account of the empirical context of my research. This chapter contains a descriptive section on the central components of the empirical work, namely the people I designed for and with, the relevant technology, and the 14 research explorations that constitute my empirical work. **Chapter 3** presents the phenomenology of the lived body and serves as a background chapter that frames my theoretical understanding. **Chapter 4** begins the operationalization of the phenomenology of the lived body by introducing eight theoretical concepts. These concepts are combined with concerns drawn from the literature on aging and TI to construct a theoretically informed design framework that can guide my design practice. **Chapter 5** describes my phenomenological PD methodology with particular emphasis on the move from theory to methodology and balancing theoretical concerns with practical challenges of working with older adults. **Chapter 6** uses selected design outcomes from various design explorations as PD results to reflect upon participants' role and influence in the design process. **Chapter 7** applies two sets of design outcomes as reflective tools for generation of knowledge. The reflection allows revision of the theoretically informed framework and raises significant concerns that can motivate further inquiries. **Chapter 8** is the discussion chapter and consists of four sections. The first section uses results from a statistical analysis of performance data to discuss the appropriateness of the design approach, while the second section reflects on ethical considerations. The third section summarizes the answers to the three research questions, and the fourth section presents a final reflection on the overarching concerns of this dissertation. **Chapter 9** ends the dissertation with a conclusion summarizing the entire dissertation and suggesting future work.

This dissertation does not present a shared literature review chapter. The particular combination of theory, methodology, and design context that constitute my design space – i.e., the specific concepts from Merleau-Ponty's phenomenology, the PD processes I facilitate, and the context of designing enabling technology for older adults – frames the research into a specific scope. Rather than presenting a separate chapter on literature review concerning the overarching approach of this dissertation, I bring in related

research relevant to the theoretical and methodological components respectively as I move along. The theoretical, methodological, and the practical components of my research seek to address different communities, and the work I build on within those communities does not necessarily share or address the remaining aspect of my overall structure. I believe this approach clarifies the role the related work has played in my own research by contextualizing it to the appropriate part of my research, while still satisfying the intent of the literature review (Wolcott, 2002, p. 96).

1.6. Papers

This dissertation contains five research papers. As no paper alone addresses all three research questions, the findings from these papers serve different roles in my dissertation, and I need to briefly present their relevance to my overarching objective. I end this introductory chapter by explaining the role of these five papers in answering my research questions. All papers mainly relate to one of my three research questions but may have additional arguments relevant to one or both of the other research questions. As such, **Table 1.2** includes a column for the other relevant research questions partly addressed in the paper. Papers with an entry in this column do not cover a complete issue alone, but they may contain key elements of larger points made in this dissertation.

Paper 1 discusses emerging ethical challenges that older adults experience when interacting and living with new technology. I shed light on several technical issues and individual perspectives to stress various challenges and stigmatizing effects of addressing the users as one homogenous group. This paper contextualizes my motivation and summarizes many of the troublesome cases behind my emphasis on facilitating a respectful design process. As such, the role of this paper is to provide some background to important long-term issues with poorly-designed technology, e.g., trust, safety, and intrusion, as well as a description of issues that I can later bring up again in my discussion.

The focus of **Paper 2** was on learning more about experiences and attitudes towards technology and demonstrating the need to acknowledge individual perspectives when designing for long-lasting interactions. The paper

also discusses five topics that can inform the development and maturation of my methodology with implications that bring us closer to the experience of the users.

Paper 3 provides a rich and thorough description of the PD process with particular emphasis on practical issues with engaging older adults in participatory design activities. The methodology chapter (Chapter 5) provides a summary of the main content of this paper to clarify the essential points needed to answer the second research question. As the paper contains an analysis of how the facilitation of the design process opened up opportunities for agency, I am mainly focusing on the relationship between my theoretical rationale and the methodology it guided. Similarly, the results, analyses, and claims presented across the five papers use a wide set of research methods to capture the phenomenon I am addressing in each respective paper, and all papers contain dedicated sections on research methods applied as well as the procedure followed. As such, there is little emphasis on specific research methods in this dissertation. The notable exception would be those mentioned one subsection on research in Chapter 5 that are used to exemplify how my phenomenological methodology is compatible with multiple methods serving different purposes.

In **Paper 4**, I use four radios to demonstrate how users who are no longer able to interact with existing technology still inhabit capabilities on top of which I can find new opportunities for design. The paper presents four radios as concrete design results to show how I have operationalized the idea of designing for changing bodies by configuring and re-designing technology. The design results from this paper are central in Chapter 7 where I analyze and reflect on the appropriateness of the design framework. Furthermore, the paper includes a statistical analysis that I will use when evidencing the significance of the design approach.

I also use a specific design case in **Paper 5** to discuss the end-results we can generate with an approach like mine. This paper combines elements related to all of my research questions but mainly attempts at closing the gap between the theoretical underpinning and the generated design results. I use the design case to present a statistical analysis of how different users carried out an existing technology-related task with new configurations. The induction chargers will resurface in Chapter 7 as the second set of design outcomes

subject to a reflection. The paper also describes the move from theory to design activities and also reflects on points made in past papers, e.g., the need for individual adaptation.

The theoretical reasoning in this dissertation has never been published in its entirety in any of my papers. All papers are built on top of the same phenomenological perspective, but as they address different communities and aim to contribute with different types of findings and design outcomes, I only have one paper demonstrating the link between the theory, the practice, and the outcomes, i.e., **Paper 5**. The lack of theory in the majority of the papers is the main reason for the heavy emphasis on the theoretical part of this dissertation. Nevertheless, **Paper 2-4** contains elements of how I operationalized my phenomenological understanding, and I will draw on these design activities, design outcomes, analyses, and empirical stories despite their main contribution being directed towards one of the two other research questions.

Table 1.2 summarizes the papers included in this dissertation along with their main relevance and findings. The first research question in the second column represents the main research question addressed, while the research questions in parentheses are other relevant research questions dealt with in the paper.

Table 1.2: *Overview of the five papers and their relevance*

Paper	Research question addressed	Main relevance and findings
Joshi, S. G. (2014) **Emerging ethical considerations from the perspectives of the elderly** *Ninth International Conference on Culture, Technology, and Communication 2014*	RQ2	1. Introduces four ethical problem areas experienced with current technology 2. Demonstrate the need to address individual concerns when introducing new technology 3. Discusses the importance of choosing an open, honest, and patient process for participants to identify their own needs and allow the technology to adapt thereafter

Paper	Research question addressed	Main relevance and findings
Joshi, S.G. (2015) **Designing for Experienced Simplicity. Why Analytic and Imagined Simplicity Fail in Design of Assistive Technology** *International Journal on Advances in Intelligent Systems, 8(3-4), 2015*	RQ2 (RQ1)	1. Uses a statistical analysis of interaction with current technology to reveal a strong disparity between designers' ideas and the users' experiences 2. Demonstrates how mastery, sense of simplicity, and attitude towards technology evolve over time and affects users' relationship with technology 3. Presents and discusses five key implications for how we can advance towards the experiences of users when designing technology for older adults
Joshi, S. G. and Bratteteig, T. (2016) **Design for Prolonged Mastery. On Involving Old People in Participatory Design** *Scandinavian Journal of Information Systems, 28(1), 2016*	RQ2 (RQ1)	1. Introduces a PD process with older adults with emphasis on mutual learning and co-construction activities where participants engage on own terms 2. Provides descriptions of practical considerations necessary to adapt the design process to the capabilities of the participants such as recruiting, timing, continuity, and representation 3. Analyses and discusses the how participants with different needs and capacities for participation made choices and contributed to the process
Joshi, S.G. (2016) **Designing for Capacities Rather Than Disabilities** *International Journal on Advances in Intelligent Systems, 9(3-4), 2016*	RQ3 (RQ1)	1. Presents four design cases to show how we can configure similar technology in different ways based on bodily capacities to allow participants to discover or re-establish meaningful interaction 2. Demonstrates how the richness of physical capacities can open up new opportunities for interaction 3. Uses a statistical analysis of the different designs to evidence how people need different facilitation of technology to utilize their full potential

Paper	Research question addressed	Main relevance and findings
Joshi, S.G (2017) **Using Embodied Experiences to Re-design Enabling Technologies** *Submitted to the Journal of Enabling Technologies, 2017*	RQ3 (RQ1, RQ2)	1. Demonstrates the relationship between the phenomenological theory, the facilitation of design processes, and design results we can produce 2. Presents a statistical analysis of performance to reflect on the relationship between the theoretical underpinning and the produced design results 3. Describes the activities of a design process to exemplify methodic adaptation made to support design for changing bodies

Chapter 2

Empirical context

This study would not be possible without the participants, the support from the municipality, and the various facilities and technologies found within the empirical context. Before I introduce the details of my theoretical lens and the procedure of my methodology in Chapter 3-5, I use this chapter to present the context in which most of my research took place. To understand the reasoning behind the choice of theory as well as the methodological approach I selected, it is important first to recognize who the participants were and what kind of technologies I met. As such, this chapter outlines the details of the Care+ facilities where I defined the scope, finalized my design space, found most of the participants, and conducted most of the research. I start by introducing the idea of the Care+ facilities as envisioned by Oslo Municipality, and then move on to the specifics of services, enabling technologies, and residents found within this context. The chapter ends with an introduction of the various research explorations I have carried out over the past four years and the participants I worked with in these explorations.

I want to open this chapter by thanking the municipality for allowing me and my colleagues to enter this context and systematically look for errors. My description may sound critical at times, but it is not intended as a critique of specific facilities or the people in charge of acquisition. This dissertation concerns the design of enabling technologies and looking for user problems has been the best way to discover opportunities for improvement and to understand challenges with the human-technology relations.

2.1. Care+ facilities

The empirical context of this dissertation is residential communities organized by Oslo Municipality where older citizens live in collocated apartments

complexes alongside various enabling technologies made support them in their everyday life. Since 2012, I have been a part of an established collaboration with Oslo Municipality. Through this cooperation, we have had the opportunity to follow the planning and deployment of multiple facilities in Oslo targeted specifically towards the oldest population who only need partial assistance to remain independent. Per their own descriptions, such facilities are designed for people above 67 with impaired functioning abilities who would still be able to function in a tailored residence and participate in activities and relevant social arenas. Their motivation for applying should be that their current home is either insufficiently physically adapted to their needs, or that they experience insecurity or loneliness in their current residence.

By equipping the apartments with enabling technologies as well as by bringing popular and social services to their common areas (e.g., cafeteria, library, and hairdresser), the idea behind these Care+ facilities is that the residents can prolong the time as independent and self-governing citizens before they move on to traditional nursing homes with full medical care. The goal of the municipality is to use these facilities to provide safety, socializing, health prevention, activity, and voluntary effort as the foundation for remaining independent and functioning optimally on one's own merits.

> *"The target group of Care+ is older citizens, mainly over 67 years, with the need for a suitable accommodation due to medical, social, or physical reasons and need for security with permanent staff and social stimulus to counter isolation. The safety of living in a residence with an activity center and staffing around the clock is essential to the residents." My translation from (Department of Primary Health and Social Services, 2011, p. 3)*

According to the official descriptions provided by the municipality's office, the target demographic for these facilities is people who are unable to live independently at home while still being too healthy to be admitted to a nursing home. I quickly learned through initial field work that many residents – if not the majority of the residents – relied on home care services to help cover all their medical and practical needs, such as delivering and dosing medicine or cleaning the apartment, and that the residents as a group covered a wide range of need for assistance. As the official description states, the

residents are expected to utilize the services provided by themselves, but their need for assistance may range from being practically self-sufficient in terms of daily life to being in need of nursing care most hours of the day (Department of Primary Health and Social Services, 2011, p. 3). I registered a strong discrepancy between the portrayed and expected independence of the residents and the actual experienced independence. To be fair, the requirement specification made by the municipality outlines that all Care+ facilities are meant to serve as a *"base for personnel of the home care service"* (Department of Primary Health and Social Services, 2011, p. 3), so these facilities were always meant to cooperate closely with home care services. However, the managerial staff who had daily interactions with the residents painted a different picture than what their paperwork might say. The assessment of the residents' eligibility for tenancy in these Care+ facilities only described their registered health status at the time of submitting the application. Only over the course of the few years I conducted my research did I register changes to residents' physical and cognitive capacities. Especially among the residents I followed systematically over time did I observe a decline in capacities to a state that was no longer compatible with the assessment made only a few years before. These trends were also confirmed by the managerial staff that had even better insight to their capacities as they had first-hand access to medical records.

It is worth mentioning that in a Nordic context, no similar acquisition has ever before been made by any municipal or governmental unit. When I began my research in 2012, there were no other similar municipal implementations immediately available for comparison, and since then, the most comparable cases are all from either within my empirical context or a similar municipal initiative in Norway.

2.1.1. The smart homes

While the people who are eligible for these Care+ facilities have to leave their homes to move into a facility apartment, the architectural layout and the organizational structure still provide them with their own space (i.e., their apartment) that they can make their own. It is the combination of services and enabling technologies tailored to this oldest generation that constitute the plus-sign of Care+. In a model describing different living situations up until

hospitalization, Care+ facilities fall between two traditional types of living situations, i.e., either residing in their own homes or moving into nursing homes. As such, people evaluated by municipal officials to only be in partial need of help with daily activities can qualify for this care service.

It could be argued that this intermediate phase is an extension of *aging in place* as they are still aging *"in place"*. However, I have seen through my initial field work (**Paper 1**) that this living arrangement is experienced as vastly different from the experiences they had in the homes in which they once lived. First, their original homes contain personal and relational history and memories shaped by ages and generations of aging – for some even a whole lifetime – and many of these situated and circumstantial habits and routines cannot be brought out of the homes. Thus, the people who move into Care+ facilities often part ways with those aspects that define their identity and individuality. One of the most difficult changes with relocation is to reestablish new relations. For instance, one resident had lived her whole life in a family house that her grandfather built almost a century ago and where her children and grandchildren still lived. She was born and raised in a city suburb where she would later also work her whole life. To her, there was only one grocery store, one doctor's office, one school, one bakery, and one library – regardless of whether it was her own story or her children's story she was telling. She knew the people she would encounter in these places; she knew their faces, their names, and their stories. Once relocated, she had to find new replacements for such services as well as establish new relationships with new people.

Second, moving out of a large multistory villa and into a small apartment involved other compromises in terms of remaining independent. While the apartments belong to the resident through tenancy, they are still rented and therefore regulated by municipal governing that dictates rules and restrictions on how people are allowed to live in this *"own"* space. It might sound unreasonable rigorous, but these are mainly general rules of civil and neighborly conduct implemented to maintain communal order, and mostly within the ranges of what one might expect as a tenant in any other apartment complex. However, the rules enforce some restrictions with regards to personalizing the apartment, e.g., painting or decorating walls in desired colors and rearranging white goods and major appliances.

Third, the apartments are designed to be smart homes, i.e., utilizing technology to enhance the living situation. I will later describe the range of these enabling technologies, but more important to the residents is that these technologies are pre-installed and non-optional. These Care+ facilities represent long-term commitments with regards to municipal welfare services, and as such, the apartments are by design meant to outlive the tenants. The enabling technologies that accompany the apartments are not tailored to each resident but to all residents as a whole. Contracts with various vendors cover the entire apartment complex rather than individual apartments, and there was no facilitated dialogue between individual residents and the vendors who made and delivered the various technologies and services. Having to live with these various enabling technologies without any option of opting out and only small options for customization, gave residents almost no autonomy or control over the technologies they had to endure in their own homes. The description might sound exaggerated and colored by negativity bias, but I registered so many ethical and practical issues related to mandatory and non-adaptable technologies that any other narrative would not do justice to the data gathered (**Paper 1**). Regardless of the technical quality or general usability, we as designers are mainly concerned with actual use; if the design result is not interesting to the users, then who are we really designing for? As such, the idea of forced presence of technology only highlights the need for a design process that puts people before the technology and aims at designing enabling technologies that the users actually master and enjoy. I will revisit a few of these issues later in the dissertation, and **Paper 1** outlines the main challenges as seen from the perspective of the residents, e.g., unintended or undesired use, but I want to use two examples to highlight this point.

The first example of unintentional outcomes is the way lighting control is implemented in most rooms of the apartments. Lighting is not controlled with a traditional light switch on the wall, but rather automatically regulated through motion detection. There was an incident involving one resident entering the shower, and when drawing the shower curtains between him and the motion sensor, the sensor would no longer register his presences due to the shower curtain blocking the detection. After a while, the bathroom would suddenly go entirely pitch black. Waving arms would not make any difference because the shower curtain became an obstacle for the motion sensor's

detection. This is not only an example of the technology failing to remain assistive; it simultaneously introduces new serious situations: standing in the dark under running water with one hand on the wall to maintain balance while frantically waving the other. There were no manual light switches to prevent any such scenarios. The consequences of failed cases of implementation can lead to far worse scenarios than non-use; this example demonstrates how the enabling technology – if not designed properly – can introduce not only scenarios of non-use, but also potentially dangerous situations.

The other example I want to highlight is also related to the lighting systems. The motion sensors that failed to detect in the bathroom introduced a different type of problem in the bedroom. While all rooms have nice pockets of light running along the floor to help residents navigate between the bedroom and bathroom during night time, the bed is simultaneously within the range of the motion sensors installed in the room. As such, when lying in bed, turning and tossing by itself can trigger the sensors to flood the bedroom with light at night. This is frustrating by itself as the sudden light can be both surprising and scary, but the real problem is once again a matter of overruling failed instances of smartness. The only way to turn off the lights is to lie still in the bed until the motion sensors decide that no motion has been detected for a long enough time to turn off the light again. As I reported in **Paper 2**, one participant had to cover her sensor with aluminum foil to prevent the sensors from disturbing her sleep.

2.1.2. Services

The apartments of the various Care+ facilities are organized around common areas. These common areas house many basic services that support the underlying goals of the facilities. While the specifics of these services vary, the concrete examples provided in this chapter are mainly gathered from one Care+ facility where I spent most of my time. This facility consists of 91 individual apartments tailored for older adults. The open area offers easy access to a large cafeteria serving warm meals and sitting groups with televisions and games as well as a library with desktop computers and books. Some of these common areas are illustrated in **Figure 2.1**. The front desk faces towards the main entrance and is located between the common areas and

the apartments and serves as a contact point for both residents and visitors. The common area also includes a smart gym where residents can stay active – either with or without the assistance of the in-house physiotherapist (**Figure 2.2**). The gym included novel exercise equipment with opportunities to track and share data from physical activity. In addition, commonly requested services such as hairdresser and cinema are also provided in-house within these common areas, and the managerial staff and volunteers offer a variety of social and cultural activities for the residents. This common area serves as the main social arena at the facility and remains the default meeting place for the residents. Home visits between residents were much rarer than I first expected and the principal reason behind this was the frequent interactions found between residents in these common areas.

Figure 2.1: *Various parts of the common areas in one of the Care+ facilities*

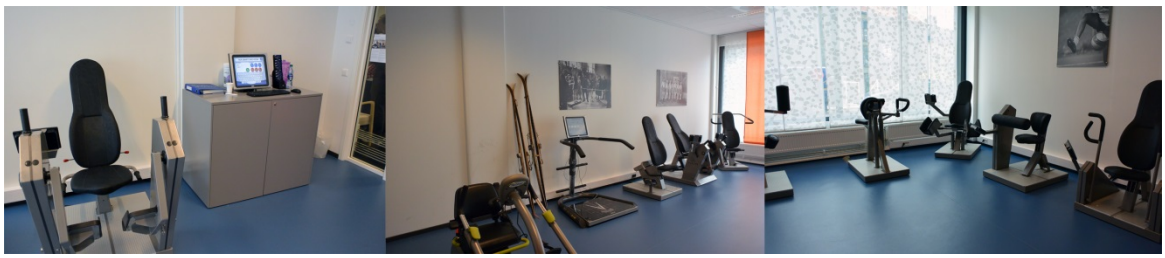

Figure 2.2: *The smart gym at one of the Care+ facilities*

Clustering these services within the same apartment complex eliminates much of the need to travel outside of the facility for most everyday purposes. The functional requirement specification from the municipality also specifies that the facility itself must reside in close vicinity to public transport as well as commercial and public services. Hence, the residents do not have to travel far when leaving the facility to reach most points of interest. With car access all the way to the front entrance of the building, residents who depend on private transport can easily use public taxi services, e.g., to and from the doctor's office. The guidelines provided by the municipality also emphasizes the

importance of staying outdoors; all Care+ facilities should have easy access to green areas with walking paths, and the functional requirements are specified for balconies and terraces to help protect outdoor sitting groups from wind, noise, and privacy (Department of Primary Health and Social Services, 2011, p. 5). The residents considered this to be a highly appreciated part of the architecture. In one facility, two residents even helped to maintain the plants on the roof terrace (see **Figure 2.3**).

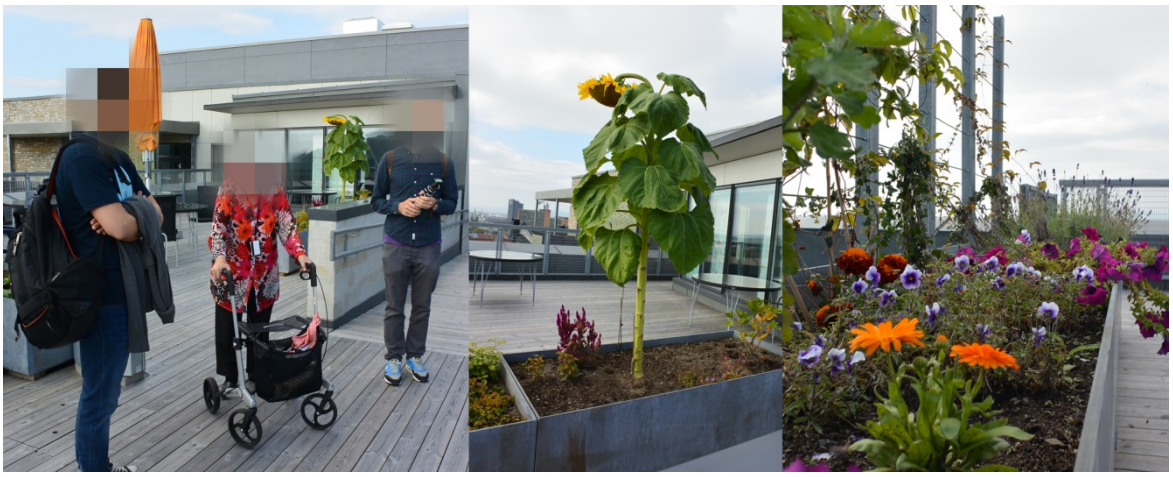

Figure 2.3: *A resident giving an orientation of the roof terrace*

2.1.3. The managerial staff

The last and most important part of the Care+ facility was the managerial staff that provided custodial care. All these Care+ facilities were procured, built, and owned by the municipality, but they hand over the day-to-day management to a third-party with organizational competence and capacity to provide all required services, for instance to a diaconal foundation. This managerial staff – consisting of a small permanent full-time team as well as part-time and volunteer workers on rotation – provided a service desk for the residents 24 hours a day. While their official responses were mostly restricted to basic and mostly janitorial support, e.g., I could not find any member of the staff in any of the multiple Care+ facilities I visited that did not extend their efforts way beyond what one could classify as custodial care; they work around the clock to help residents with all kinds of issues. Their presence and help have also served a vital role to my research in that they have helped me organize activities, recruit participants, coordinated workshops, and been

highly supportive and accepting of my presence in general. I am grateful for their continuous and extended efforts and kindness.

One example of their extended service is monitoring and partially maintaining and supporting the systems running beneath the various enabling technologies. While they are not technical personnel, they still strive to offer technical assistance for the residents; in most cases, they serve as the first-line support for technical issues with pre-installed technology. The residents have little information or knowledge about the vendors behind the various pre-installed technologies and contacting the managerial staff seems to be the first choice for most residence when in need of technical assistance, even in cases where the managerial staff can do nothing but forward their inquiry. As such, the managerial staff constitutes the people standing behind the technology, making sure that the devices and the infrastructure function correctly and coordinating with the vendors in cases of failure.

2.1.4. Apartment 313

As mentioned, the empirical work includes data from several Care+ facilities, but I spent most of my time in one particular facility. The main reason was the excellent communication with both the managerial staff at this facility as well as their past collaboration with the municipality. However, another important reason was that this facility provided me and the rest of the researchers from my department with a dedicated test apartment. One apartment that would otherwise have been rented out was graciously donated by the municipality to our research purposes between 2012 and 2015. This apartment shared the same specifications as the rest of the inhabited apartments, both architecturally and with regards to pre-installed technology.

The residents and employees always referred to it as the test apartment, mainly due to the absence of what one participant labeled as a sense of *"homeliness"*. We did not aim for full furnishing, although it had some basic furniture such as a sofa, an armchair, and a kitchen table to make sure the participants understood the context despite its apparent lack of realistic portrayal of a proper fully-furnished living room. Nevertheless, this apartment allowed me to facilitate activities inside a controllable space that resembled their own home environments, and it gave me my own space where I could experiment with alternative technologies and services without disturbing or

disrupting any existing systems. Moreover, this test apartment gave me unrestricted and non-intrusive access to testing out the technical aspects of all the pre-installed enabling technologies. **Figure 2.4** and **Figure 2.5** show the test apartment both with and without participants.

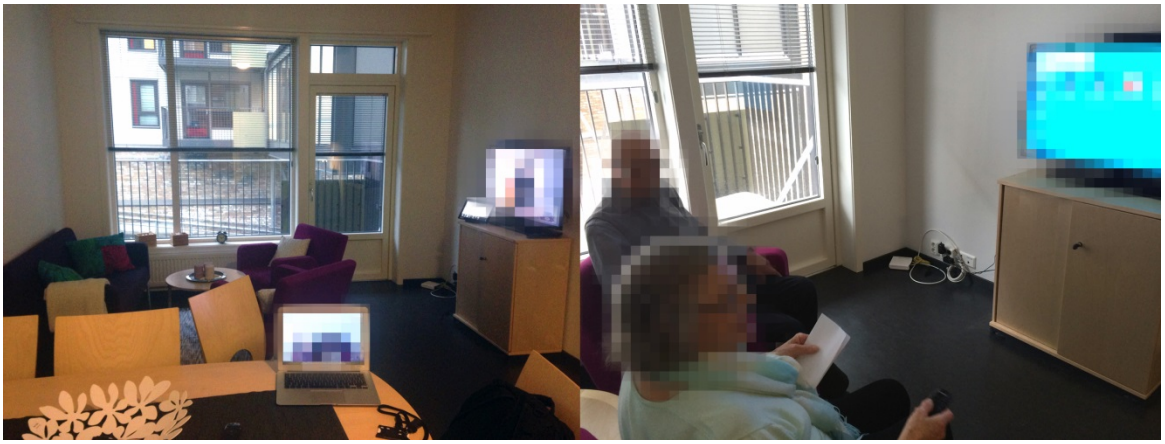

Figure 2.4: *The test apartment 313*

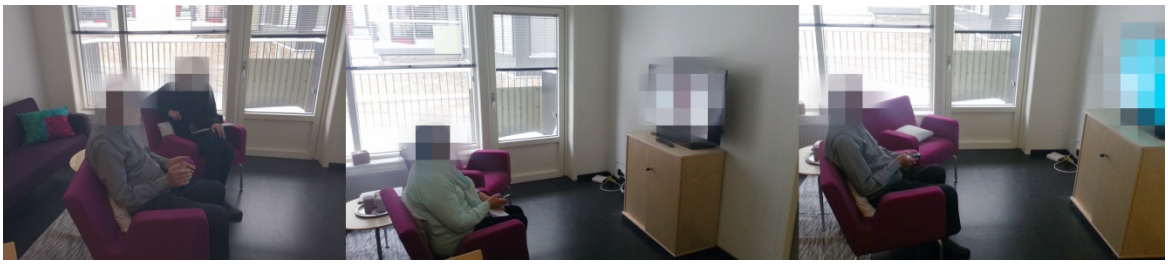

Figure 2.5: *Participants engaged in evaluations activities in the test apartment*

One example of a study that was feasible through our access to this test apartment was a research exploration I will introduce later in this chapter called the Collaborative Change Experiment (Joshi and Woll, 2014). In collaboration with Anita Woll, another Ph.D. candidate within my research group, I established a cooperation with the home care service office responsible for the residents of these apartments. The goal of this study was to offer new ways of delivering home care services through the television and the study focused on the delivery of services that involved people on both sides of the interaction. As we discussed in later papers reporting from this study, see, e.g., (Joshi and Woll, 2015a, 2015b), moving these types of studies into the homes of the residents introduced a whole new range of practical and technical challenges; conducting such experiments from within the apartments of the

participants would not have been possible without first running multiple preliminary iterations from the test apartment. This serves as an example of how this test apartment opened up possibilities for conducting specific types of research. Most research explorations that I refer to later in this dissertation utilized this test apartment at some point, albeit for various purposes.

2.2. Enabling Technology

Before introducing examples of enabling technology found within my empirical context, I will first explain the idea behind the official term in Norway, i.e., welfare technology, and how most people understand and use the term. In general, welfare technology is widely in Norway used to describe a set of technologies designed to help people with various kinds of disabilities (Directorate of Health, 2012). This umbrella term does not include any definitions of age group, specific types of disabilities, intentions, or technologies. From the data gathered in my own empirical work, I have registered 131 different types of technologies that all could fall into this category, and their purpose varies – some are mainly intended for long-term preventive measures, while others are frequently used and serve a vital role in for instance self-medication. There have been various attempts at concretizing the terminology, but I still see alternative terms such as enabling technology, adaptive technology, rehabilitative technology, and assistive technology being used interchangeably with welfare technology. This substitution is usually done in pursuit of a more accurate and contextually-appropriate term. Nevertheless, it is important that I elaborate my understanding of enabling technology and exhibit selected examples that illustrate the types of technologies I refer to from my papers and in the rest of this dissertation.

In my initial research, I relied on the term welfare technology to describe my research interest. When presenting my research internationally, for instance at conferences in the United States, I learned soon enough that there is no common understanding of the term welfare technology and the closest thing to a consensus I observed did not properly describe my understanding. The result became to use the generic term assistive technology and then exemplify what that implied through different kinds of technologies; throughout the work covered in this dissertation, the focus has been on studying different types of technologies, and rather than using various terms

from case to case, I chose to keep the umbrella term and then specify as I learned that this would be necessary for clarification purposes regardless. I will now clarify the understanding and definition of my preferred term, i.e., enabling technologies.

I began my understanding of enabling technology with the definition made by the municipality, i.e., those who oversee the procurement of said technologies. They only define the term welfare technology, and it is contained to the context of smart homes. Thus, the definition is internally and contextually defined:

> *"[...] the new term "Welfare technology" scopes the ICT functions related to the provision of services and utilities that support residents '/users' welfare." (Department of Primary Health and Social Services, 2011, p. 10)*

My research interest does not lie in the broad range of welfare technology that can fall within this general understand from the municipality, nor am I concerned with a specific subset of technologies. The Directorate of Health states that *"welfare technology is not about technology, but about people"* (2012) and as such, I am interested in the people. The types of technology I am interested in are the kinds of technology my target demographic uses – because to them, those technologies are supporting and enabling them in their everyday life. And it is those technologies I refer to as their current technology while the design outcomes of my research are labeled as co-designed or alternative technologies. Thus, my research includes a wide array of technologies, spanning from commercially available assistive equipment to adaptive devices specifically designed for my empirical context. As such, the term enabling technologies that I introduced in Chapter 1 will remain the term I continue to use – both for the rest of this dissertation and in future research. For clarity purposes, all future references to enabling technologies in this dissertation refer to the various kinds of assistive devices present in the empirical context. Later in this section, I will provide concrete examples of such technologies, but they are only intended as illustrative examples of technologies that the municipality understands as welfare technology according to the definition above, but that I chose to see as enabling technologies.

As mentioned, there is no medical service provided, and those in need organize their own arrangements with the district home care services **(Paper 1)**. Returning to the definitions made by the municipality, apartments in Care+ facilities are considered smart houses where physical facilitation and enabling technology is utilized to bring the residents back to a level of self-functioning that they were unable to achieve in their former homes. I use the case of one specific Care+ facility to exemplify what kind of enabling technologies they have made available to their residents.

All apartments are equipped with a broad range of devices and sensors, e.g., automatic light sensors, RFID-based door locks into private homes, motion sensors in the living room and bedrooms, and preinstalled tablet devices in all apartments. The 11-inch tablet (as seen in **Figure 2.6**) is referred to by the municipality as welfare technology, and the tablet is meant to assist residents with their daily tasks, e.g., ordering food from the in-house cantina or providing overviews of internal and external events. It also includes social features that allow the residents to make phone calls, have video conversations, use the Internet, and listen to the radio. While not currently implemented at this facility, the software of the tablet is also intended to serve as a hub for attachable health monitoring equipment, e.g., pulse oximeter, blood glucose meter, and medical thermometer. This tablet illustrates an important aspect of enabling technology, namely that many of the devices provided by the municipality depend on support to fulfill their potential – the managerial staff uses the tablet to communicate information to the residents and much of the content, e.g., overview of food in the cafeteria or list of upcoming events, is added and maintained by this staff.

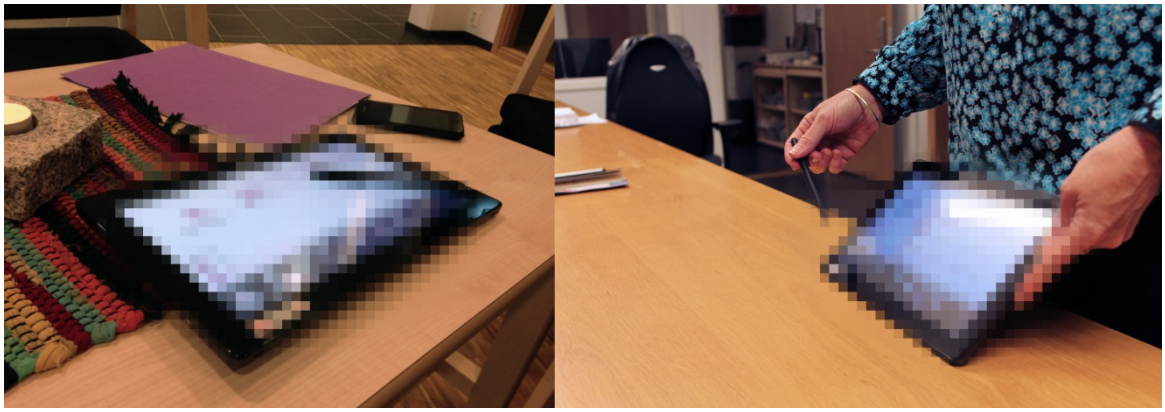

Figure 2.6: *The tablet at one Care+ facility being demonstrated by the managerial staff*

Another part of the home that has been enhanced with technology is the control of heating and ventilation. While most of the other existing enabling technology is mainly focused on activities or tasks related to the dimension of health or socializing, this type of enabling technology intends to assist with daily *"background tasks"*, i.e., tasks that only indirectly contribute towards one of the goals of the Care+ facility, in this case health prevention. As in the case of many public buildings, these devices only allow small deviations from a predetermined temperature – in this case, ± 3.0 degree. The reasons I am mentioning this particular type of technology is to demonstrate how many of the activities in the home have been moved from traditional ways of interaction to newer and *"smarter"* modes of interaction (**Figure 2.7**). Rather than adjusting the heater temperature from the heater itself, it is moved to one centralized control panel on the wall. Another example of this same phenomenon that I previously described was the lighting that has now shifted away from the traditional light switch position and now relies on automated control based on motion detection.

Figure 2.7: *Examples of various technologies installed in the apartments*

These currently implemented technologies have served different roles in the various parts of my research. During my initial research, several technologies were used as the basis for discussions on ethical concerns, including safety alarm, the tablet above, and automated indoor lighting **(Paper 1)**. One revelation from these technology-centric investigations was the lack of privacy by design and the consequences of living with unwanted or unusable technology. In **Paper 2**, I used the tablet to focus a discussion of simplicity and mastery among the participants. In more experimental research explorations, I have used specific types of current technology, e.g., tablet chargers **(Paper 5)** and automated heating systems **(Paper 2)**, as the basis

for the design of concrete alternatives to existing technological solutions or discussions on the implications of current technology.

2.3. The residents

The goal of the Care+ concept is for the inhabitants to maintain their current level of functioning. The target population for such facilities is people above 67 years in search of residential alternatives due to medical, social, or physical challenges with their current living situation. This could, for instance, be citizens who are depending on safety through regular contact with caretakers or social stimuli to counteract loneliness. Thus, the residents constitute a highly heterogeneous group, ranging widely in age and capacities. I consider this part of the target group's composition, i.e., the heterogeneity, to be of great importance, and this is one of the reasons I adopted the term enabling technologies. Nevertheless, all these diverse residents spread across various establishments constitute my target group.

The municipality's main concern when selecting residents through applications is to make sure the applicant can still take advantage of their abilities, i.e., being mostly independent and able to utilize the services offered at the Care+ facility. In the functional requirement specification made by the municipality (Department of Primary Health and Social Services, 2011), it is evident that they expect diversity among the residents by stating that some residents will be almost entirely independent in their daily activities, while others will depend on caretaking almost around the clock. Furthermore, the facilities aim to support residents undergoing the earliest stages of dementia by using familiarity in the architectural design as one of the multiple strategies for postponing the gradual decrease. Once I initiated my field work, I faced a different reality than what I had expected from reading the requirement specifications. Most of the participants were much older than the minimum age requirement of 67 years. The average age at one of the Care+ facilities was 84 years, spanning from below 70 to above 100 years, and as such, these people represented multiple generations. Most residents – despite their heterogeneity – represented a significantly different age group than people who only recently retired from full-time employment. With such a high average age, the gender distribution was also skewed, and women constituted a clear majority.

2.3.1. Health issues

While having a good dialogue with commonly-used medical services as well as providing basic assistance related to everyday concerns, the Care+ facilities do not provide any medical care or assistance directly. All residents had been through a screening process with a medical assessment before taking up residency, and since my initial field work happened during the first months – even before the official opening – there was little development in health status or medical assessment of the residents. However, there were a few common health-related challenges that were more prominent from the very moment I arrived, and to paint a complete picture of the residents I met, I believe it is important to share examples of representative issues.

The description of common health problems in the functional requirement specification highlighted a broad range of challenges where impaired vision, reduced hearing, poor grip and balance, and dementia were stressed (Department of Primary Health and Social Services, 2011, p. 3). These were described as general symptoms of aging rather than being expected as particularly prominent within the group of citizens who qualified for residency at Care+ facilities. All these challenges were present in the various Care+ facilities I visited. However, there were a few other discerning traits among the residents. The first prominent challenges I observed were issues related to movement. When observing movement, orientation, and navigation in daily activities, the number of people relying on mobility aids was higher than anticipated. As I reported with my students in (Källström et al., 2015), the percentage of individuals depending on walkers or other special aids at certain facilities reached a record-level of 90 %. There were multiple reasons behind this observation, but residents reported declining sensory-motor abilities such as atrophy and stiffness as the main reason behind the restricted movement and reduced flexibility. Rigid, fragile, and aching joints and limbs were reason put behind another common issue, i.e., reduced fine motor abilities. Most enabling technologies pre-installed in the Care+ apartments used interfaces that became difficult or inoperable to many residents as they aged. For instance, the tablet relied on interaction mechanisms such as swiping and pinching while control panels for ventilation used small buttons that required precision. A third issue was reduced sensitivity to touch and pressure. This was discovered by observing participants using the enabling

technology that included touch-screen interfaces and alarms with haptic feedback. The residents claimed the cause of this phenomenon to be thinner and drier skin which reduced the sensation during the interaction.

Since the Care+ facility was never intended to be a home for people struggling with cognitive abilities, the municipality's application process guaranteed that the most evident cases of dementia would only be in the beginning stages and not significantly impede on the residents' daily lives. I did not look for cognitive issues, nor did any resident report any such issues themselves; there were common signs of forgetfulness that comes with aging, but nothing I or the residents themselves experienced as severe concerns. That being said, I registered a rapid decline in cognitive abilities over the course of the few years I was present – bear in mind that this was without any training in cognitive assessment. I mainly observed these issues with the residents who were participating in my design process, and since it clearly affected their participation, these changes were evident even to me as non-medical professionals. However, discussing such issues was different from discussions of physical or social challenges; understanding, assessing, and describing cognitive issues and disorders was a challenge – both for the residents and for me. As I will continue on explaining, my work concerns physical changes in aging bodies, but I have briefly discussed some of the issues with changes to functional capacities throughout participation with Anita Woll in (Joshi and Woll, 2015a, 2015b).

2.3.2. Avoiding medical conditions

Despite registering the broad range of present medical conditions among the residents, especially over time (Joshi and Woll, 2015b), these health issues were not of direct interest to me. My main concern has remained on understanding the residents' capacities and includes them as they are without necessarily understanding the medical underpinning of their challenges. I deliberately avoided using medical data for three main reasons. First, I am not a medical professional, and as such, I cannot fully comprehend the entirety or implications of diagnoses, medical terms, and specific types of sicknesses and diseases. If I were to use precise medical terms, it would be a second-hand understanding at best, and it would be a language that could potentially create discrepancy between the expertise I hold and the expertise the reader of

a paper or this dissertation might think I claim – in certain papers, e.g., in **Paper 4**, I have specifically emphasized this point. It is an undesired consequence of applying medical terms in parts of my research that readers with a medical background might expect associated medical aspects, e.g., adverse effects and complications, to be more prominent in any discussions regarding diagnosed health issues.

Second, as the next chapter will introduce, my theoretical concern is about how people experience the nature of aging and changes to own capabilities. I believe that this includes factors extending beyond those which can be described with medical assessments alone, for instance, embodied routines and potentials for interaction. In the spirit of putting capabilities before disabilities, I want to avoid a co-design process where the language I use to describe and determine participation revolves around medical assessments unable to appreciate all the qualities I believe the body to hold. As such, I am more concerned with their reiteration of own health status as I consider that input to be of higher value to the design process than any medical record.

Third, all kinds of medical assessments were handled by regular physicians outside of the facility or in some cases by home care nurses visiting residents. Different residents used different medical practitioners, often physicians with whom they had long-standing relations. As such, I did not have direct access to medical personnel who diagnosed the residents, nor did I have access to any central list of resident doctor relations. Spending time tracking down all these physicians as well as applying for data gathering of health sensitive data material without violating the residents' privacy concerns, would be so time-consuming that it would shift the focus away from the main scope of this dissertation.

It is also important to me to not provoke or tense residents or participants with my study. Several participants reported that they did not always share their medical diagnoses with friends in fear of being associated with a specific condition or diagnose. For instance, one participant claimed that her friend was often referred to as *"the one with diabetes"* (woman, 81). She emphasized that the people saying this did not have any ill intentions, yet it still bothered her because it sounded like a much more defining aspect of her person – including personality and capabilities – than she herself would

attribute. In extreme cases, trivial diagnoses would take precedence and overshadow the positive and more important qualities, something I saw led to stigmatization and uninformed design choices in existing enabling technologies **(Paper 1)**. The managerial staff had a very professional approach to this aspect as they had systems and routines for registering and sharing resident information between the various employees, including sensitive issues such as health states. The same could not be said about the inhabitants – neither their expertise nor their discretion. I registered a divided behavioral pattern with regards to sharing such sensitive information; many residents openly shared their health challenges while others were cautious with disclosing anything, even with the managerial staff. Since people talked about their own health challenges with varying degrees of openness, it was difficult for both the residents as well as the managerial staff to keep track of what issues they could disclose to others and which matters that the person in question did not want to share. As such, there were also practical concerns with relying too much on health data in this study.

2.4. Research explorations

I have spent a lot of time within this empirical context due to my methodological approach, which I introduce in Chapter 5. The field work in my initial studies and the time spent conducting various research and design activities at different Care+ facilities over the years amounts to four months of presence in the field. I have carried out 14 research explorations between 2012 and 2016 including a total of 542 participants all from within my empirical context. Before I present a timeline over the 14 research exploration in **Figure 2.8**, I want to introduce them briefly. All these research explorations demonstrate different inquiries I have made into the same design space; the various explorations aims to explore different problem areas, different technologies, and different design considerations all framed inside the same design space of enabling interaction. Due to the different types of investigations, the contents and findings from these explorations include many interesting issues extending beyond the three specific research questions of this dissertation, and in retrospect, not all explorations are equally relevant to help clarify the contribution of this dissertation. For instance, the *Collaborative*

Change Experiment (RE #2) carried out with Anita Woll was one of my first explorations and brought important insight into existing challenges with current technologies, yet it falls outside of the theoretical perspective of this dissertation. The data gathered from this exploration serves as important empirical data for Woll's own Ph.D. dissertation, and we have reported on this project in multiple papers. However, as I have other examples that I believe better highlight the points I am trying to make in my earlier chapters, it will mainly contribute to the reflection on building fully-functional systems in my analysis of design outcomes as PD results in Chapter 6 of this dissertation. As I have already reported from 12 of these 14 research explorations in previously published papers (see **Table 2.1**), I confine myself to only bringing in findings and experiences from these 14 research explorations throughout this dissertation to support the points I am trying to make. Whenever I make a reference to any of these 14 research exploration, I add the notation *RE #X* behind to make it clear that this is a reference to this section.

The range and depth of these studies would not have been possible without the collaboration with students and other researchers, and my role in these explorations have ranged from principal designers to mainly supporting or supervising roles. Common for all these explorations is that they were initiated by me and carried out within my empirical context. Nevertheless, the notation *"w/"* in **Figure 2.8** indicates that the work was carried out in collaboration with others without whom the exploration would be impossible. It should be mentioned that two of the explorations, HomeCare Expected and Magnetic Radio, were led by the master and Ph.D. students from my courses, hence the notation *"by"*; my role has been supervisors and not principal designers in these research explorations. The reason I still include them in my research exploration overview is that I have – on my own but with permission granted – continued to use the design outcomes from these explorations in later studies and extended the research beyond the work of the students. For instance, the Magnetic Radio was prototyped and finished by students in five weeks at which point they concluded their work, but the design outcome remained subject to later PD activities such as workshops and evaluations. None of the students were involved in the data gathering presented in **Paper 4**.

2.4.1. The 14 research explorations

The rest of this section will describe the research exploration and summarize them in a timeline overview (**Figure 2.8**) and a list (**Table 2.1**) at the end on this section.

Research Exploration 1: Leap
Research objective: Exploring various methods and techniques for registering and understanding information of the body
Collaborators: *(none)*

Leap was an early inquiry into the world of changing bodies. The goal was to come up with ways to capture the embodied nature of the participants during the interaction. This exploration was my first collaboration with older adults that specifically targeted their physical capabilities. As such, this exploration included experimentation of various tools, techniques, and methods along with 10 participants. One of the aspects I studied was the relevance and applicability of data gathered from different methods, and this exploration mainly contributes to my dissertation by informing the data gathering procedure. For instance, the exploration of video recording using of glasses with the hidden built-in camera is something I will bring up in Chapter 5 to demonstrate how I brought attention to the bodily capabilities. Along with participants, I developed prototypes for measuring bodily aspects such as dexterity, flexibility, and movement. The name comes from the technology mainly applied in my exploration, i.e., the Leap Motion. I also explored standardized testing procedures for assessing physical abilities, e.g., rotary pursuit test, Minnesota manual dexterity test, and Purdue pegboard, that resurfaced two years later when I needed to assess psychomotor abilities (**Paper 4**).

Research Exploration 2: Collaborative Change Experiment
Research objective: Exploring how moving service tasks over to technology affects the quality from the perspective of the users

Collaborators: Anita Woll

This research exploration resulted in three papers co-written with Anita Woll (Joshi and Woll, 2014, 2015a, 2015a), and spanned over three years by the time we had concluded the work. The goal of this exploration was to study how the introduction of telecare as a means for delivering services was experienced by the participants. 78 participants contributed to the various design and evaluation activities. We used a self-made system for telecare to capture and assess challenges related to the interaction. The main long-term contribution of this exploration for my own later work was the establishment of cooperation – both with participants and the municipality; the access to participants, expertise, and facilities that were made available from this collaboration has allowed me to include a number of participants I could never imagine before this exploration. The design outcome of this system will be used in Chapter 6 to describe some of the benefits of building functional systems with regards to my PD process. With regards to research outcomes, the application of certain methods in this exploration, mainly the usability testing and workshops, also revealed important practical concerns that I later needed to address. For instance, the way we prepared for activities in the test apartment began in this study and remained an important way of facilitating flexibility in later design activities.

Research Exploration 3: PiRadio
Research objective: Exploring how familiar habits and past experiences can influence design of newer interaction mechanisms
Collaborators: Espen Johnsson, Magnus Ofstad, and Sarujanthan Subaschandran

The PiRadio began as a student project under my supervision. The design outcome and the evaluation of performance also demonstrated the benefit of producing research products (Odom et al., 2016) rather than only prototypes. The radio also served as an important generative function in the exploratory design of the other radios in later explorations. 20 participants contributed to

this study. This was the first exploration that pursued phenomenological concerns in collaboration with users, and this exploration is one of the PD projects I describe in **Paper 3**. As also described in (Joshi and Bratteteig, 2015), the co-construction activities attempted to use embodied perspectives in the co-design and emphasized mutual learning and co-construction. One of the concrete facilitations we made was the exploration of how various materials (e.g., plastic versus wood), as well as different shapes, sizes, and materials affected the interaction. The early work on material testing inspired the development of more focused methods of investigating and evaluating the role of materials in enabling interaction, such as the work I did in *Materiality (RE #13)* over two years later.

Research Exploration 4: HomeCare Expected
Research objective: Exploring how technology-assisted means of delivering services can provide users with better experiences
Collaborators: Tina Vedal, Rebecca Louise Clements, Abdimaalik Abdirhmaan, Suzanne Sannes, and Haris Ali

This research exploration was carried out by students at one of the Care+ facilities within my empirical context and is also a part of **Paper 3**. The exploration involved 10 participants and yielded important perspectives on how to involve participants in imagining and designing enabling technology. Furthermore, the use of low-fidelity research prototypes demonstrated the role prototypes could have as communicative tools when facilitating dialogue between different groups of people in design activities, in this case, residents at the Care+ facility and the home care nurses. I draw on these experiences when describing the role of design results as a way of communicating when I describe my methodology. Moreover, the procedure for involving participants without disrupting their daily activities, such as making home visits and attending during coffee meetings, was informed by past explorations and extended the ongoing facilitations done to involve participants as they are and where they are. Nevertheless, my involvement in this research exploration was

minimal, and this exploration is less relevant to the main scope of this dissertation.

Research Exploration 5: Simplicity
Research objective: Exploring challenges with current technology and whether the experience of users matches the expectations of the designers
Collaborators: *(none)*

This research was motivated by the case of an 84-year-old lady in one of the Care+ facilities having to cover up her light sensors with tinfoil to avoid false triggering of lighting. This exploration did not aim to generate any design suggestions, but rather strengthen the understanding of the various types of challenges the resident at the facility experienced with current enabling technology. The title Simplicity reflects one of the main foci of this exploration, i.e., how the sense of simplicity, along with mastery and attitude towards technology, evolved over time and continuously affected the user-technology relationship. Three different evaluation methods were used to study how the 45 participants' relationship with technology evolved over the course of 13 months. This exploration is presented in its entirety in **Paper 2**, including the statistical analysis that confirmed assumptions on how central values of my phenomenological perspective such as familiarity and adaptation were indeed a concern for the participants. The findings have helped to inform my methodology, namely through the five key implications presented and discussed in the paper.

Research Exploration 6: Tangible Alternatives
Research objective: Exploring alternative interfaces and interaction for enabling technologies
Collaborators: Thomas Iversen

The work in this exploration was carried out with a former master student of mine, Thomas Iversen. Four concrete design outcomes were generated in co-

design activities with 52 participants. These outcomes demonstrated ways of reconfiguring existing solutions or designing entirely new alternatives to enable interaction for older adults. The way we explored opportunities for alternative configuration of interaction in the spatial dimension is described in the paper (Iversen and Joshi, 2015), and the T-Radio developed in this exploration was a part of the investigation into psychomotor abilities in *Motor Radio (RE #7)*. I will bring up the T-Radio, as well as the conceptual prototype LightUp, when presenting the design outcomes in Chapter 6 and Chapter 7. The exploration of the bodily and spatial configuration of the chargers found within the empirical context served as a stepping stone for the continued emphasis on body-technology relations in *Induction Charge (RE #10)*. Finally, this work also included the use of relevant literature from TI, e.g., the framework of Cho et al. (2013), that helped us understand the relationship between bodily changes and opportunities for interaction.

Research Exploration 7: Motor Radio
Research objective: Exploring whether the various design results did indeed re-enable interaction
Collaborators: *(none)*

This exploration used the fully-functional radios as they became continuously available in the various research explorations to assess their ability to help participants who were unable to use traditional radios with re-enabling interaction. After evaluating the performance of the four first radios, I wrote **Paper 4** where I explained how these design results were all different examples of the tailoring I am suggesting with my design approach, i.e., building on what people can do rather than cannot do as a strategy for opening up new opportunities for interaction. 65 participants were involved in this exploration, and the goal was to statistically analyze whether the performance with these four alternative designs could re-enable interaction and if there existed anything as *"one solution for all"*. I will draw on these design outcomes, as well as the statistical analysis from the paper, in Chapter 7 and 8.

Research Exploration 8: Motus
Research objective: Exploring gesture-based and wearable interactions to design for increased autonomy
Collaborators: Mathias Stang, Andreas Truchs, Torkild Kjevik, and Vegard Søyseth

This was another research exploration where my contribution was limited to supervision, but where the empirical context and design space was introduced by me. The exploration focused on the use of gesture-based and wearable interactions to stimulate activity and exercise among older adults by tailoring technology after their capabilities. The exploration engaged physiotherapists and domain experts, as well as 17 older adults. One of the ideas the students brought to the exploration was a gesture based glove that was used to both help train fine motor skills in fingers as well as serve as a device for input. The exploration aimed at designing for increased autonomy, as well as continuous adaptation based on changes in capabilities, both in a positive and in a negative sense. A Kinect-based movement analysis allowed the system to adapt to performance and adapt accordingly. While this exploration yielded interesting design concepts, the relevance of this work is limited to this dissertation. This exploration also serves as one of the four projects described in **Paper 3**.

Research Exploration 9: SmartWalker
Research objective: Exploring how positioning and recognizable aids can help older adults with navigation
Collaborators: Mathias Källström, Axel Boix, Stian Sørhagen, and Sondre Berdal

Observation in this exploration revealed that certain facilities had 90 % of the residents using mobility aids and the results demonstrated how the mobility aid itself could be enhanced to help with indoor navigation. The importance of

familiar abstractions and extended use of pre-existing aids was emphasized in the implications of the paper (Källström et al., 2015) that reported from this exploration. The work focused on designing for cognitive impairment, i.e., outside of the target group of this dissertation, yet the part I bring with me is the methodic facilitation; the methodic concerns with involving the 23 participants in exploration of spatial aspects such as movement and the use of familiar equipment as the basis for new interaction opportunities were the two most relevant parts concerning this dissertation. I draw on experiences from this e when describing the methodological adaptation in Chapter 5, and the idea of anchoring the design activities in familiar aids and activities. This is the fourth and final exploration mentioned in **Paper 3** where it is used to demonstrate how I facilitated design activities to ensure decision making in the development of more abstract concepts.

Research Exploration 10: Induction Charge
Research objective: Exploring the human-technology relationship through a design process building on embodied knowledge
Collaborators: *(none)*

This research exploration was a continuation of the Natural Charge prototype from *Tangible Alternatives (RE #6)*. I continued the exploration of how designing new wireless chargers could reconfigure the human-technology relationship between residents and their existing technology. Before the co-design activities took place, many of the conceptual and underlying ideas were explored in collaboration with Heidi Bråthen as preparation. 31 participants contributed to this research, some of which had previously participated in *Tangible Alternatives (RE #6)*. The focus was on methodic adaptations made to support the focus on embodied human-technology relationship by designing for reinforcement of life-long habits, familiar gestures, and embodied knowledge. **Paper 5** describes the methodic adaptations made to support my focus on embodied human-technology relationship in detail and also presents and analyses the design outcomes. Since these outcomes will be central in my

analyses of outcomes in Chapter 7, I will not elaborate further on the details in this section.

Research Exploration 11: GLiMT
Research objective: Exploring how the use of tangible artifacts can re-enable interaction
Collaborators: Heidi Bråthen, Oskar Galewicz, Sondre Sæther, and Petter Holt Juliussen

This research exploration focused on transferring available assistive tasks and services from the pre-installed touch-screen devices to tangible alternatives. The goal was to study whether participants who were unable to operate the touch-screen devices (regardless of medical reasoning), or just experiencing difficulties with the interface, could establish new and more positive experiences if the interaction was situated in the physical world. The work in this exploration involved 42 participants, and the strategy was to build technically sophisticated research products that could function independent of researchers' presence and guiding. Some of the methodic issues related to this approach were discussed in the paper (Joshi and Bråthen, 2016a). Nevertheless, the emphasis on the role of materials and physical aspects in this exploration was the main inspiration for the related exploration named *Materiality (RE #13)*.

Research Exploration 12: Magnetic Radio
Research objective: Exploring how interaction mechanisms can build on capabilities rather than disabilities
Collaborators: Jorun Børsting, Espen Johnsson, Lena Drevsjø, and Vegard Søyseth

This research exploration did not involve users during the construction but rather afterward. This radio was originally constructed by Ph.D. and graduate students in a course I taught on TI. The design was guided by Fleishman's

taxonomy on psychomotor abilities (see **Paper 4**) and design critique to find opportunities for tailored design. The radio was built to allow users challenged with tremors, involuntary twitching, and reduced fine motor skills to operate it. As such, the radio draws on the same ideas as the past exploration where building on existing capabilities was used to counter interaction challenges due to disabilities. However, once finished, I used this radio as another design outcome that could contribute to the co-design activities in *Motor Radio (RE #7)*. As such, this radio is also part of the outcomes I present and analyze in Chapter 7. It should be mentioned that while the number of participants was indeed 0 during the actual construction, the number of participants indicated for *Motor Radio (RE #7)* also includes the participants that worked with this radio as an exploratory tool.

Research Exploration 13: Materiality
Research objective: Exploring the role of material/physical attributes within the design space
Collaborators: Heidi Bråthen

This research exploration was carried out with Heidi Bråthen who previously also participated in *GLiMT (RE #11)*. The focus was on exploring and discussing which role materials had or could have in tailoring interaction to the design space. The goal was on investigating how materials related to the experience and competence of older people and whether this dimension could be used to suggest any natural actions, moves, or gestures. 59 participants contributed to this study. The discussion revolved around the link between material/physical aspects on the one hand, and its influence on the perceived familiarity, context-suitability, and intuitiveness on the other. We have reported from this exploration in the two research papers (Joshi and Bråthen, 2016b, 2016c). The most relevant part of this work, which we later return to in Chapter 5, was the use of self-developed methods that incorporates a phenomenological lens to situate and interpret the generated results within the design context.

Research Exploration 14: Elbø
Research objective: Exploring various interaction mechanisms for controlling radios
Collaborators: Sigrid Bakås, Martin Bjerkeengen, Kai Chen, and Anna Finstad

This was the final exploration and involved 35 participants in the co-design of a final radio. I served as a supervisor and facilitator rather than a designer. Similar to past exploration of radios, Elbø aimed at building a fully-function device that allowed both testing and reflection based on realistic use experience rather than imagined use scenarios. The participants expressed strong desires for designs that supported autonomy and once again the goal was to design for participants without requiring them to learn new interaction mechanism but rather build on familiar ones. Throughout the process, the focus remained on exploring the specifics on various interaction mechanisms and the process of involving participants in decision-making, and that was the two most relevant aspects for this dissertation. The way design activities emphasized the importance of embodied knowledge by studying various physical attributes, e.g., sizes, shapes, and colors, and how the process was adapted to engage participants from within their everyday context.

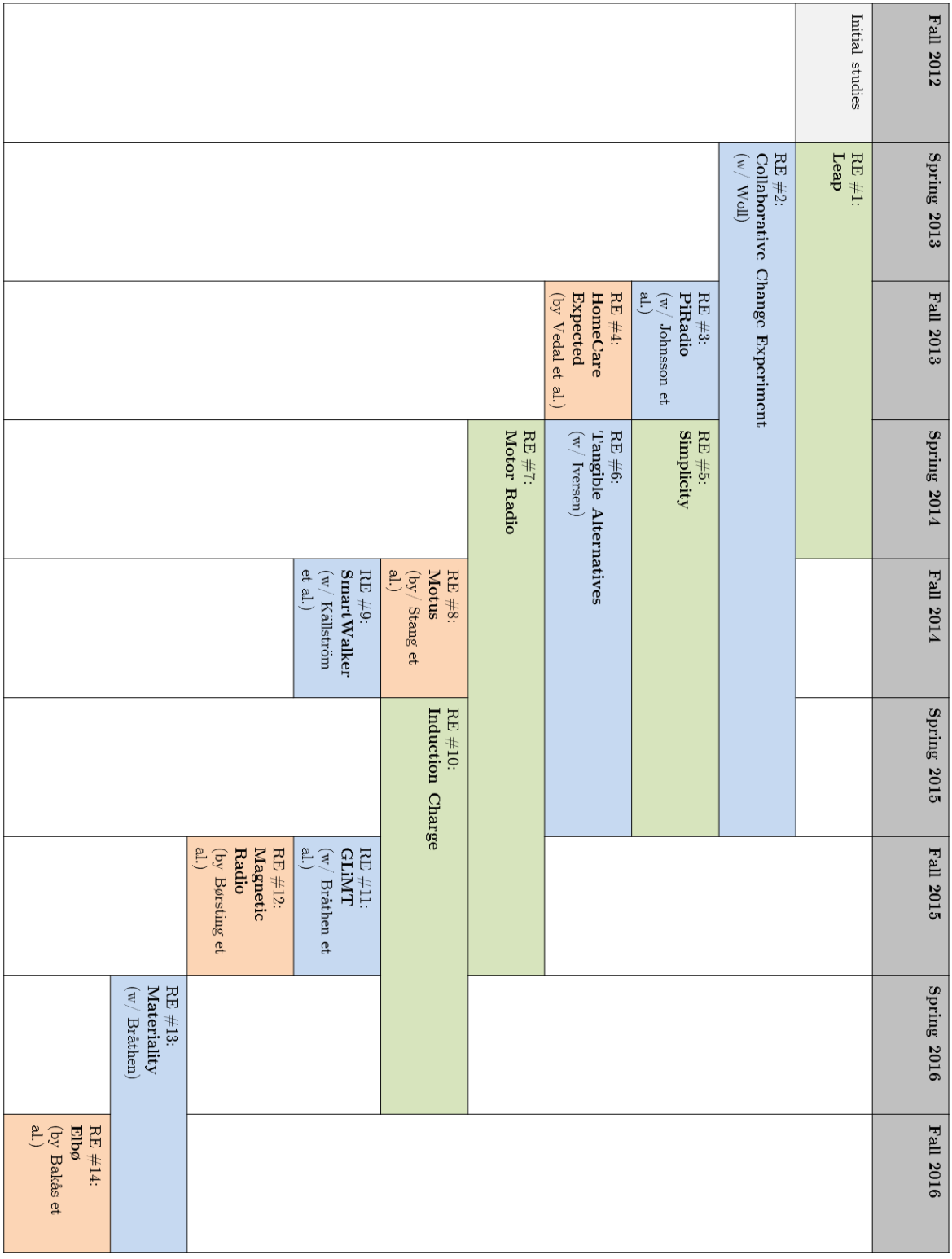

Figure 2.8: Timeline overview of the 14 research explorations

Table 2.1 provides an overview of all 14 research explorations, the number of participants in each exploration, and relevant papers. I am a co-author or only author on all the 11 papers mentioned in the table beside the five papers already introduced in Chapter 1.

Table 2.1: *Overview of the 14 research explorations, number of participants, and publication*

#	Research exploration	N	Paper
0	**Initial studies**	93	(**Paper 1**)
1	**Leap**	10	-
2	**Collaborative Change Experiment**	78	(Joshi and Woll, 2014, 2015a, 2015b)
3	**PiRadio**	20	(Joshi and Bratteteig, 2015; **Paper 3**)
4	**HomeCare Expected**	10	(**Paper 3**)
5	**Simplicity**	37	(Joshi, 2015; **Paper 2**)
6	**Tangible Alternatives**	52	(Iversen and Joshi, 2015)
7	**Motor Radio**	39	(Joshi, 2016, **Paper 4**)
8	**Motus**	17	(Joshi and Bratteteig, 2015; **Paper 3**)
9	**SmartWalker**	23	(Källström et al., 2015)
10	**Induction Charge**	27	(**Paper 5**)
11	**GLiMT**	42	(Joshi and Bråthen, 2016a)
12	**Magnetic Radio**	0	(**Paper 4**)
13	**Materiality**	59	(Joshi and Bråthen, 2016b, 2016c)
14	**Elbø**	35	-

2.4.2. Participants

In the previous section, I described the target group of my research. I will now give a brief description of the participants that contributed to the various

research explorations. This dissertation heavily emphasizes the involvement of participants and their role will be further elaborated in later chapters, particularly in Chapter 5. With regards to participation, there were other issues that I could have discussed more in-depth, for instance, recruitment or representativeness. However, these issues are not central to the main concern of this dissertation, and I have chosen to omit a mere description of procedures and challenges in this chapter as many issues have already been discussed in published papers, e.g., **Paper 3**. Other issues will be part of later discussions in this dissertation, e.g., the capabilities of the participants. The issues will be further explained as they are introduced as some are of methodological concerns while others are brought up to shed light on theoretical aspects.

The 14 research explorations have involved 542 participants in total over four years. Not all of them were potential end-users, some were domain experts, care providers, and family members, but the majority of the participants remained within the target demographic. It should also be mentioned that many of the participants that contributed to earlier explorations returned later to join related explorations. As such, the exact number is not specific or significant. What matters is that it is a sufficient amount of participants for me to demonstrate how my design approach is relevant to different people participating in different types of explorations following different paths and lines of inquiry. The emphasis on the subjective nature of the interaction is maintained throughout all 14 explorations, and I believe it demonstrates that individual perspectives and capabilities do not have to automatically conflict with a large number of participants.

In the very beginning, the only thing I knew for certain was that I wanted to include participants in as many design activities as possible. I had not matured the phenomenological lens enough to know exactly what kind of participants that would be more relevant to my work and the experience I had with recruiting at the time did not suggest that I could pick and chooses participants based on their characteristics. I knew that I wanted to design for changing bodies, but it was not clear to me what that entailed with regards to recruitment; as I discussed in my earlier work, see, e.g., (Joshi and Woll, 2014), the emphasis when recruiting participants was based on general methodic aspects such as avoiding skewed representation of participants by

balancing gender, experience, as well as acquaintance with various technologies and interfaces.

The majority of participants falling into the category of older adults in my empirical context were either residents at one of the Care+ facilities I visited, or other senior citizens frequenting senior centers, retirement homes, and activity centers where I could recruit participants and facilitate design activities. As mentioned in **Paper 2**, the participants represented a broad range of physical and social difficulties, and it was hard to find a common description. To understand and learn from the lived experiences of the participants, the framing of the participants had to align with my *"understanding of user experience and the epistemologies, methodologies and research practices it entails"* (Wright and McCarthy, 2008, p. 637). To that end, I avoided generalizations that would move me too far away from the human-technology relation that lies at heart of this dissertation. As such, the age of the participants was never an important indicator for me, neither of capabilities or challenges. The average age varied from one research exploration to the next; in *Simplicity (RE #5)* the average age was 86 years, while in *Materiality (RE #12)* it was 79 years. The mean age of all participants was 83 years old, and while there was a sincere attempt at balancing the gender distribution, the proportion of female participants was higher than men (Joshi and Bråthen, 2016b). The best way to summarize the characteristics of the participants would be that **they all experienced bodily changes independent of medical assessments that affected their interaction with digital artifacts in their everyday life**. The goal was to find a definition that would allow people to decide their participation on their own experiences rather than their age or medical assessment. As mentioned in the previous section, I wanted to focus on physical issues rather than cognitive matters, and as such, I did not specifically recruit participants from residential units and institutions specifically tailored for people with cognitive challenges, despite having access and established cooperation with such facilities. The notion of physical changes was intentionally kept vague to allow participants to decide their own eligibility. However, within the concrete research exploration, I would usually explore different types of technologies, tasks, or contexts that would automatically yield a participation pool where I could work with more accurate terminology. For instance, in both *Motor*

Radio (RE #7) and *Magnetic Radio (RE #12)*, it was Fleishman's taxonomy on skills and abilities describing the human performance that was used to define and understand the types of psychomotor abilities I addressed. This taxonomy is described in **Paper 4**. Similarly, I use categories of extant sensory-motor challenges of aging described by K.M. Newell et al. (2006) in Chapter 4 to help me build my design framework.

There are some brief descriptions of the participants and their background in selected papers, e.g., in **Paper 1**. However, this only demonstrates how it is hard to generalize such information about the participants without losing touch with all the qualities and capabilities that are central to my design space. However, I do believe the five user stories from **Paper 3** provide representative illustrations of the *"typical"* participants and discusses their participation pattern and influence in the design activities. I did not reject any participants who wanted to join any of the design activities. That being said, it was only on rare occasions that anyone volunteered – I would usually have to recruit participants. The established cooperation in *Collaborative Change Experiment (RE #2)* contributed significantly to recruiting participants in future studies. At times, we would even have residents joining the design activities not for the content of the activity, but rather the social companionship that followed. The design activities were open for all and held in common spaces where they resided. The methodological reasoning behind situating the design activities to their context is further described in Chapter 5.

Older people

My work grows out of motivation to include older people in design activities in a respectful way where they as end-users can contribute as fully-capable co-designers. As such, there should be no doubt of the intentions behind my way of conducting my research. In my earliest papers, e.g., **Paper 1**, I would use the term elderly to describe the people I was designing for and with, as this is a valid noun in both Norwegian and English that was used as a synonym to old adults. However, I was made aware that it might hold negative or demeaning connotations for some, and one reviewer of a paper pointed to social gerontology to demonstrate why this was now mostly considered a pejorative term. Since then, all my following papers have used the term older

people or older adults, and I have followed the SIGACCESS Accessible Writing Guide (Cavender et al., 2015) on which terms to avoid.

Within the research community, there seems to be a shared understanding that older people constitute a heterogeneous group with various challenges and abilities, independent of age. Aarhus et al. (2010) exemplify how similar-aged people might have different attitudes and perspectives towards technology. This understanding has led to relevant discussions on what constitutes as old participants and appropriate participants, and how we should address them. Vines et al. (2012a) choose to use the term eighty something to describe the age group rather than old or oldest old, while Huldtgren et al. (2013) discuss how age is not bound to our biological age, but rather to the individual perception of age. Malmborg et al. (2010) discuss difficulties finding characteristics for older participants that are not grounded in age and simultaneously avoiding stigmatizing their self-image. Their studies suggest different approaches, e.g., the concept of situated elderliness as a way of addressing the older adults and simultaneously acknowledging context-specific challenges (Brandt et al., 2010). Vines et al. (2012b) claim that the meaning of the term *"participant"* has evolved, and argue that many research projects now aim at recruiting people just because they happen to be old, rather than a selection based on other criteria.

As such, it is also important for me to provide a description of what I consider an *old adult*, and how I choose to understand and frame what it means to be old (Vines et al., 2015a, p. 18). The government uses the retirement age of 67 years as the dividing line, and everyone above that is considered old. As briefly discussed in **Paper 3**, the use of the term old ranges and the age-wise qualifying threshold varies widely. My youngest participant was 64 years old and the oldest 101 years old, i.e., an age range spanning over almost two generations. The average age of my participants was 83 years old. They were closer to the term *"oldest old"* rather than just *"old"* (Lindsay et al., 2012), i.e., over 85 years old, and attributing them as old did not do them justice, nor did it provide me with a precise description or input to use when understanding the changing body. Some of the related work mentioned in **Paper 2** reports on work from Asia involving older citizens where the definitions of old do not relate to the age ranges of my participants.

When I refer to the older adults in this dissertation, it is not an age-related concern, nor is it medically defined; I refer simply to the people that have qualified in the municipality's assessment of eligibility and that are now residing in a municipal care facility providing enabling technologies. I am designing for and with these residents. I am not using the term old when talking to them as I am more interested in how they feel rather than how old their age suggests they should feel. I simply refer to them as what they are – participants and co-designers. No participant has been recruited for "*just being old*".

Chapter 3

The theory of the lived body

This chapter introduces the phenomenal lived body as the foundation for the theory that I use in this dissertation. I present the underlying ideas from Merleau-Ponty's lived body to help clarify how the theoretical concepts introduced in Chapter 4 are well suited to understand the potentials, opportunities, and challenges involved in the design of enabling technology for older people.

3.1. Phenomenology as theory

Phenomenology concerns experience through the eyes of the first-person. Experiences always belong to someone, but how do we subjectively experience a phenomenon and what is the structure of how a phenomenon appears to us? In its broadest sense, from early Husserlian phenomenology to modernize post-phenomenology, the term phenomenology refers to the study of the structures of a number of different types of experiences such as perception, thought, memory, imagination, emotion, desire, and volition to bodily awareness, embodied action, and social activity, including linguistic activity (Smith, 2016). Phenomenology has a natural and vigorous relationship with design practice as it relates our presence and experiences towards our immediate environment and the world around us, which includes everything from people to objects, as well as the relationship between them.

The theoretical foundation of this dissertation finds its roots in the French philosopher Maurice Merleau-Ponty's work, mainly derived from his most famous creation – *"Phenomenology of Perception"* (1945; 2002). Merleau-Ponty's vivid use of bodily phenomena tied to changing bodies such as injuries, pain, and suffering helps me contextualize and apply the philosophy as a theory in a design context. The role of embodiment in perception and cognition provides a grounding for understanding interaction through the relationship between the body and the world; it allows me to study interaction

through a phenomenological lens where we perceive the world through bodily senses and therewith how interpretations, experiences, and intentions revolves around how the human body immerses itself in the world.

I have also brought in literature from the more recent application of Merleau-Ponty's phenomenology to complement my own interpretation. The next chapter refers to the contemporary use of phenomenology within HCI and ID, as well as the use of phenomenology in relating disciplines, e.g., nursing and aging, to build this dissertation on a phenomenological understanding of both classical phenomenology as well as modern interpretation. The phenomenological approach of this dissertation partly ignores the ontological concern with the world that is, and rather shift from reality to appearance, i.e., to the *"world we experience"*. By understanding objects such as artifacts, tools, and technologies as elements that influence our experience of the immediate surroundings, this dissertation focuses on objects as they appear rather than that which the objects themselves might be – which would require a separate philosophical and existential endeavor.

However, studying the world through the eyes of conscious experiences carries both a phenomenological and ontological dimension, something I will show that Martin Heidegger, another phenomenologist, paid particular attention to in his work. While phenomenology can be labeled as the study of, among other things, structures of conscious experience and what it means that experiences are experienced, it still raises the ontological question of what our experiences, i.e., the nature of the structures of conscious experiences, actually are (Smith, 2016). This dissertation will not aim to undertake an ontological exploration; it returns to the root meaning of the word phenomenology that directs us towards the phenomena, i.e., the appearance, rather than the objective reality.

3.2. The preceding phenomenology

Merleau-Ponty's work was influenced by and critical of many central philosophical figures, both historical and contemporary. Much of Merleau-Ponty's work was intended as a rebuttal of established philosophical axioms and fundamental theories but mainly directs its offense towards Cartesianism. René Descartes carefully represents the scientific antagonist of Merleau-Ponty, and his postulates about body-mind are used as the philosophical

counterweight. Beyond the direct influence of the systematic and philosophical systems described in Cartesian philosophy that had established itself throughout the last several centuries, his work was also inspired by and critical of his philosophical contemporaries, mainly other German and French phenomenologist who lived closer to his own time. Merleau-Ponty allowed himself to be directly inspired by both Edmund Husserl and Martin Heidegger, and to properly understand and reflect on Merleau-Ponty's phenomenology, I need to briefly introduce their work before diving into this dissertation's theoretical core, i.e., the phenomenology of the lived body.

The first building blocks of what would eventually become the philosophical tradition of phenomenology were laid down in the early 20th century. Notable figures included Husserl, widely considered the founder, as well as important later philosophers such as Heidegger, Jean-Paul Sartre, and Merleau-Ponty. Husserl's "*Logical Investigations*" (1900-1901) bears witness of how Husserl melted his mathematical-logical background with established psychological theory in that which must be regarded as the very starting point of the phenomenology of the 20th century.

Disagreeing with the historical mathematized truth described in Cartesianism, Husserl distanced himself from established dichotomies in search of a new epistemology, most notably subject/object and empiricism/idealism. One of his critiques of the current metaphysical and epistemological literature was its failed attempt to explain the lifeworld that must precede any objective world. Before any objectivity or objective knowledge, there must exist life which in turn would mean that knowledge finds its origins in experience (Sadala and Adorno, 2002, p. 283). Husserl's epistemology described a symbiosis of being and experiencing that contrasted the positivistic science which did not properly address important aspects of the world of experiences. One such shortcoming of natural sciences, as well as positivistic psychological science, was that it neglected the animate dimension of the body, i.e., the unique manner in which we experience our bodies as something subjective and categorically different from other people's experience of embodiment. The body was neither internal to the consciousness nor external to oneself in the environment but would appear as phenomenological anomalies caught between the rest of a materialized world and the subject's personal sphere (Carman, 1999, p. 206).

According to Husserl, we have to include all preconceived notions in the examination of a phenomenon, i.e., everything we take for granted. Our embodiment in the world permits orientation, and before experiencing objects, we have to begin by acknowledging our presence as the subjects who are experiencing. Objects in the world carried their meaning through first-hand embodied lived experiences rather than through casual explanations anchored in natural science. Husserl chose to focus on the coherent relationship between consciousness and appearance by studying basic structures of consciousness through intentionality. Husserlarian intentionality of consciousness describes our connectedness with the world, i.e., one's directed awareness or consciousness of an object or event (Reiners, 2012). Phenomenology was to Husserl a descriptive understanding of various forms of individual conscious experience such as perception, emotion, and memory rather than preconceived notions (Reiners, 2012). All consciousness is categorized by intentionality, i.e., all our consciousness is directed at something, or is about something. There would be no consciousness without the world, nor a world without consciousness as all gestures and habits find their meaning in the intentionality of consciousness (Sadala and Adorno, 2002).

Husserl's transcendental-phenomenological epoché challenged the idea of reality and the nature of objects in the world. The ontological questions of why and how objects existed were set aside (bracketed) to bring sole attention to the intentional constitution of things, i.e., their sense of existing. This epistemological reduction allowed Husserl to bracket out all judgment imposed on the natural world and focus on analyzing and building valid descriptions of the phenomenon. This way of peeling away layers of a phenomenon like an onion has been illustrated by (Sadala and Adorno, 2002, p. 284) through Pablo Picasso's *"Metamorphosis of a bull"* where unessential elements are discarded piece by piece until only the very essence remain, and the principle of the intentionality is unveiled. Thus, Husserl's concern with *returning to the things themselves* paved the way for Heidegger and later Merleau-Ponty to further ontologically explore his work on lived embodiment.

Heidegger, who began his academic career under Husserl's guidance, continued his master's work but was simultaneously more concerned with ontology and human existence. While Husserl would see phenomenology as a reduced and methodic inquiry where we would stand back from involvement

with the world, Heidegger built his ontological phenomenology around the very existence of human beings in the world. His main work *"Being and Time"* (1927) emphasized the development of hermeneutics through exploration of *"being"* in the context of *"being-in-the-world"*. His work shifted away from Husserl's descriptive style to what he labeled a *"fundamental ontology"* – examined through an analytical and interpretative investigation of what it meant to the existing world.

Heidegger had in his inquiry of the nature of being also distanced himself from the Cartesian mind-body dualism and explored the existence and role of embodiment in a contextualized lifeworld. He revitalized the term Dasein (*"being there"*), previously used by philosophers such as the idealist Georg Wilhelm Friedrich Hegel, to anchor his existential philosophy. With this term, he continued the Husserlian understanding of the human-world connection and the manner in which we exist and live in the immediate world. Following Franz Brentano and Husserl's intentionalism, the term Dasein and the concept of Being-in-the-world (German: In-der-Welt-sein) allowed Heidegger to ontologically frame established yet separated concepts such as subject, object, consciousness, and world into an interconnected and co-existing structure. According to Heidegger, we do not exist in a subject world or object world alone; it is the continuous and never-ending being-in-the-world that transcends being into meaning. Our embodiment and its presence in the world define and hold all aspects of social and historical meaning.

However, Dasein did not provide an explanation or acknowledgment of the role of the body, and for the sake of not diverging away from the core theoretical theme of this dissertation, the emphasis on Heidegger's work in this dissertation is placed on his later writings. Dermot Moran (2000, p. 412) states that Merleau-Ponty was not influenced by Heidegger at the time of writing *"Phenomenology of Perception"*, although it would gradually come to be later. While he received critique for the reluctance to address the body in Being and Time, including from Merleau-Ponty, later interpretation of his work has argued that while Merleau-Ponty and succeeding phenomenologist paying particular attention to the lived-body had already inherently assumed parts of Heidegger's phenomenology, e.g., his account of spatiality (Aho, 2010, p. 33). Heidegger would in his later work return to the phenomenon of the body, most notably in his *"Zollikon Seminars"* (1959-69) where the body would

be surprisingly prominent despite its absence in Being and Time. During these seminars that took place three decades after Being and Time, Heidegger would raise interesting points during medical discussions by addressing medical issues such as back pains through a phenomenological lens applying concepts such as spatiality.

Heidegger would also rely on Husserl's description of the lived, experienced body to further problematize and discuss embodiment. He revisits Husserl's example of the hand's double touch, i.e., that my right hand touching the left hand can feel both the touching and being touched to explore how reversibility of tactility would be impossible in the act of seeing (Ciocan, 2015, p. 466). A similar issue of reversibility of the body as simultaneously sentient and sensible described as *"double sensations"* would later be raised by Merleau-Ponty in both *"Phenomenology of Perception"* and his last work *"The Visible and the Invisible"* (1964). Aho (2010, p. 37) argues that this agreement on the interwoven and active directedness with the world suggests a much closer philosophical relation between Heidegger and Merleau-Ponty than critiques such as Sartre would acknowledge. For instance, the manner in which Heidegger describes embodied social habits as well as bodily movement, gestures, and expressions in his later work shares fundamental similarities between Heidegger and Merleau-Ponty (Aho, 2010, p. 41).

In his phenomenological structure of perception, Merleau-Ponty relies on established conceptions from the work of both Husserl and Heidegger such as intentionality, Dasein, and being-in-the-world, albeit redefined and polished through his own dialectic. Similar to Merleau-Ponty, the work of these two aforementioned philosophers touched upon many concepts later applied as theoretical grounding within HCI and ID research – one prominent example being Heidegger's notations of ready-at-hand and present-at-hand. However, this dissertation scopes the theoretical basis to the lived body as asserted by Merleau-Ponty, and only momentarily introduced these adjacent concepts to help understand the origins and dialectics behind the historical development of the concept of the lived body which precedes the work of Merleau-Ponty.

3.3. The phenomenological lens of Merleau-Ponty

This section on Merleau-Ponty does not attempt to explain the entirety of Merleau-Ponty's phenomenology. It only touches upon a fraction of his work

intended as an introduction to his perspective on fundamental components and concepts such as subjects, objects, surroundings, intentions, habits, and space. It is within these ideas the theoretical concepts presented in the next chapter find their epistemological grounding. The main body for the theoretical part of this dissertation draws upon the work of Merleau-Ponty presented in his magnum opus, *"Phenomenology of Perception"*. It addresses a number of existential themes such as the self, consciousness, truth, and time. The book attempts to give phenomenology a position by revisiting established axioms and theories found in empirical and natural sciences as well as arguing against concepts from the phenomenology of his contemporaries, e.g., Heidegger and Sartre. The entirety of Merleau-Ponty's philosophical writings, especially considering his posthumous work, is layered and complicated, and G. J. Marshall (2008, p. 7) opens his analysis of *"Phenomenology of Perception"* by stating that it *"is written in such a way as to make the first time reader cry out for help"*. This dissertation builds its main theoretical component around central themes discussed throughout all three parts of *"Phenomenology of Perception"*, yet still does not touch most of the concepts that Merleau-Ponty explores in these writings.

Hopefully, readers of this dissertation will see the significance of connecting concepts derived from Merleau-Ponty's phenomenology to my design space. It was through this phenomenological lens I began to discover theoretical concepts that later were operationalized to guide the design process of enabling technology. To succeed with designing enabling technology for changing bodies, I needed a solid understanding of the entirety of the users' experience during interaction with technology. Throughout his work, Merleau-Ponty would criticize established notions from natural science, as well as traditional disciplines such as psychology and physiology, for failing to acknowledge and capture the wholeness of our embodied experience in the world, including our relationship with the environment and surrounding objects. His emphasis on experiences related to bodily discomfort and change such as illness, pain, fatigue, and amputation positions the theoretical grounding closer to studies such as this one revolving around aging and changing bodies. This strong link contributes to operationalize theoretical concepts within my empirical context. This could also explain the presence of Merleau-Ponty's theory found in studies on topics related to changing bodies

such as disabilities and body dysmorphic disorders (see, e.g., Fuchs (2002), Gonzalez-Arnal et al. (2012), and Kristiansen et al. (2008)). The approach of Merleau-Ponty is not flawless and has been both praised and criticized. For instance, the absence of neurological knowledge during his time has raised some critique in modern times of his theory of the body but simultaneously contributed to the development of new scientific disciplines such as neurophenomenology. Scully (2012, p. 143) argues that the theories of Merleau-Ponty do not explain the epistemic consequences of bodily variations in a satisfying manner, but also finds some conforming links between his philosophy and modern neuroscience. Nevertheless, the overarching purpose of this chapter is to explain and justify why building on the phenomenology of the lived experience helps me understand human-object interactions as well as through theoretical concepts facilitate an inclusive design process that offers a respectful and meaningful attitude towards the users – despite its neuroscientific or medical non-significance. As stated at the beginning of this chapter, I am not attempting to discover that what is in a medical or neuroscientific manner of speaking, but rather how things, in this case, the interaction with enabling technology, appears to the users, as well as how they experience it themselves. The goal of applying such a theory – as with any theory – is to ultimately end up with a body of knowledge that informs the facilitation of both the design process and the end-use experience itself when designing enabling technology for changing bodies.

3.4. Merleau-Ponty's lived body

Merleau-Ponty begins his journey from the lifeworld described by Husserl (Lebenswelt) and guides the reader through his own understanding of the world by systematically challenging established theories from realism and idealism (empiricism and intellectualism respectively) as well as the work of his peers. Despite earlier philosophers' work on embodiment, it is Merleau-Ponty who is widely known for holding the heaviest emphasis on the lived body and its primacy as the anchor of epistemological reasoning. His emphasis on the perceiving body as the medium through which a phenomenon was experienced has been described by one later interpretation as more like *"being-in-the-body-in-the-world"* rather than conforming to his predecessors' notion of being-in-the-world (Scully, 2012, p. 143). Nevertheless, the notion of the living

body served as Merleau-Ponty's justification of how our subjective perspective finds its place in and connects with the world.

> *"I can clearly distinguish from myself the world and things, since I certainly do not exist in the way in which things exist." (Merleau-Ponty, 2002, p. xiv)*

Before introducing the subjective body, I first introduce Merleau-Ponty's perspective on objectivity; as the body itself is the epistemological center of being, it plays an equally vital part as I turn to objectivity. Objectivity was to Merleau-Ponty an inaccessible perspective tied to scientific knowledge and independent of the observers. Objectivity did not concern itself with how people were experiencing something (e.g., distance, time, size) from their own perspective. It was the mere factual description as seen from an all-perceiving position where it could capture *the "geometrized projection of these perspectives and of all possible perspectives"* (Merleau-Ponty, 2002, p. 77). But as objectivity carried no perspective, it could not have been seen from anyone's perspective, and accordingly, there would be nobody to see it. Thus, Merleau-Ponty argued that if no one sees something from somewhere, it must surely then be invisible. The term *"seen from nowhere"* was applied to explain how the scientists would need to detach all human experience from an object and capture all perspectives at ones in order to study it in a scientific way. The most important aspect of his argument relevant to my focus was that the objective and scientific perspective did not attribute any inhabiting value or meanings to objects; intrinsic value does not belong to the object, but rather the phenomenon. It was the relationship between the object and our being in the world that provided any and all attributes to objects, and he would argue that science needed to be more concerned with how the world was experienced from our perspectives rather than how it was wh*en "seen from nowhere"*. Matthews explains how Merleau-Ponty also used this train of thought to refute Descartes methods of doubt – as we cannot extract ourselves entirely from the world, we will always be situated in the world and can never truly see the world as seen *"from nowhere"* (2006, p. 43).

3.4.1. The body I live

Merleau-Ponty dedicates a significant portion of *"Phenomenology of Perception"* to rationalize the rejection of the objective and deterministic body. He initiates his discussion of the body as a continuation of Husserl's definition of the duality of the body as both an *"inanimate physical body"* as well as the *"living animate body"*. The body cannot be understood only as an isolated object in a multitude of co-existing objects but as something more meaningful and transcendental. The body we inhabit is never ontologically separated from the *"self"* or *"I"*. Moran (2000, p. 423) uses two quotes by the philosopher and friend of Merleau-Ponty, Jean-Paul Sartre, namely *"I exist my body"* and *"I live my body"*, to emphasize how Merleau-Ponty builds on preceding and existing philosophers' rejection of the classical Cartesian separation of existence and embodiment. According to Merleau-Ponty, the mind and all higher-order representations and thoughts were not primary functions, but rather the result of our sensory body-world relationship.

> *"Similarly my whole body for me is not an assemblage of organs juxtaposed in space. I am in undivided possession of it and I know where each of my limbs is through a body image in which all are included." (Merleau-Ponty, 2002, pp. 112–113)*

Another central concept from Merleau-Ponty's phenomenology is his understanding of how we live through experiences. He used the term *"lived body"* (le corps propre/vivant) to explicitly state how we – by living in our body, and thereby living through our body – experienced the world. Our body was not only a physical entity surrounded by other objects in the world, but it served as the anchor and reference point to how we perceive the world around us. To understand the origin of the term lived body, I once again return to the German phenomenologist Edmund Husserl. He was strongly influenced by Rene Descartes' dualism of body and mind and spent the time to form a strong position against the distinct separation of humans and minds. One of his key concepts was the important distinction between *Körper* and *Leib*. These two words are both usually translated to *"body"*, yet hold very dissimilar meanings. *Körper* is the organic, anatomical, and corporeal body, what we are as physiological, neurological and skeletal beings (Aho and Aho,

2008). Körper, based on the Latin word *corpus*, refers to the structural and objectified body as the sum of our DNA and all the vital body parts that enable our presence as a physical system; it is the body as an object of scientific investigation. Körper describes our body-object independent of our living and comprises both a living body as well as a dead body, i.e., a corpse. On the other hand, *Leib* contrasts the objective Körper by referring to the living body. It encompasses the personal self and all the qualities of being a-life (a-Leib), i.e., feelings, sensations, perceptions, and emotions (Csordas, 1994). Where Körper would refer to the sum of our physical-structural components, Leib reflects the immediate self-consciousness stemming from life-long and non-interrupted waves of personal experiences of being one's own body. What we remember and feel about our own skin and bones as volitional and sensing individuals gives our body a life here and now (Aho and Aho, 2008).

However, while the notion of Körper can be isolated in the sense of seeing a body as merely a thing, Leib does not exist apart from the experience of the Körper as Leib and Körper are inseparable (Slatman, 2016, p. 74). Nevertheless, the notion of the lived body was a way for phenomenologist to distance themselves from the objectified *"foreign body"* which was subject to most scientific investigations of the time. Fuchs (2002) raises some interesting perspectives on how the corporeal body emerges during reactions or resistance to the lived body such as disturbing, blocking, or objectifying, demonstrated through three examples: (1) experiences of heaviness, fatigue, injury or illness could shift the perspective of one's body to something *"I have"* rather than *"taken for granted"*; (2) clumsiness while learning new bodily movements can yield a tool-perspective on the body as being difficult to master; (3) exposed situations where our body becomes objectified in the view and judgment of others, e.g., during a medical examination (Fuchs, 2002, p. 224).

3.4.2. The living body

For Merleau-Ponty, perceptual experience is divided into three elements: the subject, the object, and their relationship. The body represents the subject, the world is the object, and their relationship manifests itself through the consciousness. From the very beginning, the body as explained by Merleau-Ponty takes on the form of a lived body, immediately present to us because

we are our body. Rather than considering the body as an assemblage of interconnected body parts, we experience a wholeness of our body through a body image. The two modes of being, namely in-itself and simultaneously for oneself, highlights a contrasting nature, i.e., the contradictory operation (Merleau-Ponty, 2002, p. 407), between how we experience our own bodies as opposed to other bodies. Merleau-Ponty spends time criticizing the isolated understanding of body image, or body schema, found in the science of physiology and psychology by presenting the case of phantom limbs, i.e., sensation stemming from missing or amputated limbs as if still attached. He argues that phantom limbs are not only a matter of physiology, psychology, or even their intersection; there is also an apparent presence of an awareness of one's body that implies that the body is experienced rather than objectively defined. I will return to the case of the phantom limb later in this chapter to further investigate the body-world relationship.

The living body presented by Merleau-Ponty is a phenomenal body – a natural system by itself, independent of mental representations. This allows a bodily sensation where movement and actions never enter the objective domain. Once scratched by a mosquito, we do not need to enter an objective space to search for the spot that has been stung. Our phenomenal body is always aware of the subjective bodily space through which we will always know where we feel the itch and where our phenomenal hand is in its relation (Merleau-Ponty, 2002, p. 121). Merleau-Ponty transfers this analogy of proprioception to objects, and more precisely interaction with tools such as scissors and needles. When operating scissors, we do not look for our fingers because they are, along with all our body parts, not in the same space as the scissor. Nor are children learning to grasp objects for the first time ever looking at their own hands, but focused entirely on the object (Merleau-Ponty, 2002, p. 172). The living body provides a subjective space while the scissor remains in the objective space. However, as our phenomenal body perceives the scissor, our fingers are immediately presented with a potential for mobilization. Merleau-Ponty explains this as being linked to objects such as the scissor through *"intentional threads"* that present themselves as poles for actions (Merleau-Ponty, 2002, pp. 121–122). The movement performed when the hand grasps the scissor seem natural to us only in response to the space given to us by the world, i.e., the setting in which we have a scissor in front of

us. We know, without any calculations, how to make use of it. Now, without the scissor, the movement would seem *"out of place"* because there is no longer an element in the subject-world system to solicit any movement. Merleau-Ponty uses the case of leatherwork as an example of the relationship between movements and the actions afforded by the circumstances. As we are placed in a context of a working bench, scissors, and pieces of leather, the particularity of that situation *"calls for a certain mode of resolution, a certain kind of work"* (Merleau-Ponty, 2002, p. 122).

3.4.3. The intentional body

To further elaborate on the body-world connection, Merleau-Ponty spends the time to polish the concept of intentionality by introducing the term intentional arc. He credited Husserl with introducing intentional acts and consciousness but spends no time theorizing intentionality. Intentionality of consciousness had already – by both Brentano and Husserl – been attributed with a directedness towards objects, i.e., that consciousness was consciousness of something. Merleau-Ponty quickly placed intentionality within the body itself and argued that it was the body itself that understood the world and directed us towards it. According to Merleau-Ponty, we carry a pre-reflective bodily purpose – a motor intentionality *(l'intentionnalité motrice)* – that precede any conscious intentionality. He labeled this the intentional arc. It is not a conscious motivation such as pleasure that directs our rational; it is the primordial tendency that arises as our body co-exists in a symbiotic and circular relationship with the world around us.

> *"Let us therefore say rather, borrowing a term from other works, that the life of consciousness—cognitive life, the life of desire or perceptual life—is subtended by an 'intentional arc' which projects round about us our past, our future, our human setting, our physical, ideological and moral situation, or rather which results in our being situated in all these respects. It is this intentional arc which brings about the unity of the senses, of intelligence, of sensibility and motility. And it is this which 'goes limp' in illness." (Merleau-Ponty, 2002, p. 157)*

It is also with this international arc that he builds his argument of why past learning informs present and future actions. We are guided by intentions that might not be formulated in the moment of action. Our body offers a

perspective on the world, which pre-reflectively, in turn, affords certain bodily actions. Hubert Dreyfus, one of the modern voices responsible for revitalizing Merleau-Ponty's phenomenology has remained a strong advocator of this particular part of Merleau-Ponty's philosophy. In (Dreyfus, 2002), he argues that according to Merleau-Ponty, old experiences are not stored as representations in the mind but present themselves to an agent as more and more refined response (p. 373). Our intentional arc is the continuously refined feedback structure that projects past experience as solicited response as we repeatedly deal with similar situations.

Similar to Sartre, Merleau-Ponty attempted to distance himself from the rational principle of Husserl, and common to both of them was a desire to bring philosophy back to the world of *"lived"* experience (Stewart, 1998). However, while their inspiration may have bloomed from similar critiques of Husserl and Heidegger, their perspectives diverged in their purpose of reshaping phenomenology. Both being phenomenologists (although Merleau-Ponty would at times dispute Sartre's status as a phenomenologist), their common underlying objective was to define the relationship between consciousness and its world. And it is within their dialectic disparity we find another fundamental aspect of Merleau-Ponty's phenomenology. Where Sartre would use the relationship between consciousness and its world to explain a philosophy of *actions*, Merleau-Ponty attempted to define limits of our *understanding* of the world (Stewart, 1998, p. 49). To further elaborate, Merleau-Ponty devotes significant space to describe the nature of *"objects"* to help us contextualize his main emphasis, namely the nature of the *"subject"*. Sartre defined boundaries, although sometimes overlapping, between the subjective Consciousness and Being on the on hand, and the fathomless objectivity on the other. Merleau-Ponty explained the lived experience as the manifestation of a reunited subjective and objective in the primary phenomenon of the world (Spiegelberg, 2012, p. 522), and would along with Heidegger often position Sartre's explanation as caught within a Cartesian/Newtonian tradition (Aho, 2010, p. 37).

3.4.4. The ill body

Merleau-Ponty introduces and explains several noteworthy concepts through the story of the brain-damaged war patient named Schneider. Through

Schneider's tale, Merleau-Ponty makes interesting observations about the body and illness from the perspective of someone experiencing *"psychic blindness*" (Merleau-Ponty, 2002, p. 118). Most notably, the issues of phantom limb and anosognosia (unawareness of one's own disability) demonstrate how Merleau-Ponty suggests that illness alters our access and intentionality towards the world. Illness culminates in a modified perception of the world. To Merleau-Ponty, illness cannot be reduced to a biological change of an objective body as it entails more than an absence of functionality in an objective healthy body. It disrupts the self-awareness and self-sense which in turn may influence our hopes, ambitions, and opportunities. The story about the phantom limb highlights how we can sense and experience amputated limbs as if they were still present if stimulus is applied. Once again, he repudiates the ability of intellectualism and empiricism to explain this phenomenon properly.

> *"It then becomes understandable that doctors and psychologists should decline the invitation to intellectualism and fall back, for want of anything better, on the attempts at causal explanation which at least have the merit of taking into account what is peculiar to illness, and to each form of it, and which by this means give at any rate the illusion of possessing actual knowledge." (Merleau-Ponty, 2002, p. 144)*

According to Merleau-Ponty, the world continues to communicate with the missing limb and constantly reminds the body of its prior established relationship between the lost limb and the world, for instance, illustrated with the missing hand and the piano. If the piano calls out to our hands' past experience of playing the piano (Merleau-Ponty, 2002, p. 94), we will still experience a sensation of the missing limb as the world instills sedimented knowledge, i.e., knowledge belonging to the habitual body. Somewhat controversial, Merleau-Ponty *"solves"* the phenomenon of the phantom limb as well as with anosognosia by diving into a deeper and subconscious level where we find the rationale to either refuse to acknowledge missing limbs, as in the case with the phantom limb, or ignore the awareness of our existing limbs which is the example used in the case of anosognosia. Nevertheless, the two cases demonstrate how stimuli and reflexes are connected to self-awareness and knowledge of one's body, and that we through a subconscious inducement

allow ourselves to forget dead and existing limbs or remembering missing limbs, which in turn decide how we experience the bodily handicap.

3.4.5. The habitual body

The habitual body is central to Merleau-Ponty's further investigation of habits and the relation between past experiences and current situations. The body adapts to environmental signals and acts through past experiences manifested as motor intentionality that helps understand and react to the affordance of a given situation. Following his idea of an intentional arc, all past experiences, i.e., all former interactions between the subject and its environments, were stored as operational intentionality within the body. To Merleau-Ponty, habits are the repertoire with potentials for action based on a given environment's invitation. Readers of Merleau-Ponty's phenomenology often use the terms habits and skills interchangeably (see, e.g., Brey (2000) and Dreyfus (2002)) because they both alters the body schema's potential for action.

> *"Habit expresses our power of dilating our being-in-the-world, or changing our existence by appropriating fresh instruments" (Merleau-Ponty, 2002, p. 166)*

It is the habitual nature of the experience that offers value by repeatedly exposing us to a given situation that slowly adds yet another layer to our sedimented body, i.e., our habitual body *(le corps habituel)*. The blind man's stick gradually becomes a part of his bodily awareness – his sentient being – allowing him to extend his space of action over time by incorporating with his body (Merleau-Ponty, 2002, p. 165).

In *"The Coming of Age"* (1970), another French philosopher, Simone de Beauvoir, shared some similarities with Merleau-Ponty on that she argued for a strong connection between our younger years and the current present. Merleau-Ponty claimed that we always carried our past with us as something un-detachable, and regardless of its value or significance to us, it would always be part of how we manifest ourselves in the present. Beauvoir seemingly agreed to the presence of a lived experience, albeit in a discussion of the future outlook as seen from the present rather than for the sake of the past-present connection itself. When reflecting on past experience, her attitude towards aging did not reflect a positive and salutogenic approach like I am attempting

to advocate in this dissertation. She found this relationship remarkably negative in the sense that older people would by haunted by their childhood and be fixated and captured in the past, and furthermore describes old age as boring and filled with deteriorating passion and gradually more pessimistic outlook on the future (Stoller, 2014, pp. 206–209). Nevertheless, they both shared a common understanding of the strong relationship between former and present self, and in a deeper theoretical investigation, this comparison of how past experiences manifest themselves in the current would be highly interesting.

3.4.6. The moving body

To understand Merleau-Ponty's perspectives on movement, one has to first visit his understanding of space. Space is to Merleau-Ponty not the conditioning for bodies; it is enabled through the body. The body inhabits space and time, and movement of the body does not take place in an objective space; it takes place in a space as it is experienced as opposed to a Cartesian space. Movement of the lived body is the producer and enabler of spatial meanings and spatiality come from the lived experience. Following this line of though, Merleau-Ponty argued that when describing a phenomenological body in a phenomenological space, we were no longer in an objective realm. When Merleau-Ponty said that it was the movement that produced existential space, it was not the corporeal and *"objective"* movement where body parts would shift from one position to another that resulted in the space; it was the lived experience of performing the movement that allowed us to experience our body connecting with the surrounding world and in so doing access the *"primary world"*.

Merleau-Ponty refers to habituated actions towards external stimuli from the surrounding world as concrete movements, i.e., self-executing actions that do not require any thinking. Such non-representational intentionality manifests itself as potentials for actions in our present body. Hence, the present body can carry out learned skills because they are sedimented into our habitual body, and the repertoire of habituated skills gradually turns into unobtrusive and primordial reflexes to the solicitations offered by the world.

> *"I can therefore take my place, through the medium of my body as the potential source of a certain number of familiar actions, in my environment conceived as a set of manipulanda and without, moreover, envisaging my body or my surrounding as objects in the Kantian sense, that is, as systems of qualities linked by some intelligible law, as transparent entities, free from any attachment to a specific place or time, and ready to be named or at least pointed out." (Merleau-Ponty, 2002, pp. 120–121)*

However, if we once again return to the phenomenon of illness or bodily disruption, this symbiotic relationship between the habitual and the present body does not guarantee eternal harmony. This is especially important to my design space. Changes to the present body such as amputation may disturb or even disrupt the present-habitual body equilibrium; the reflexes suggested by the habitual body may suddenly not align with the capabilities of the present body. The hand might be amputated, but the piano may still invoke a sensation in the present body that makes it reach out to play as a reflex, even with the hand missing. This is one of the points Merleau-Ponty attempts to demonstrate through the case of Schneider. Schneider also serves as the exemplary anchor when explaining abstract movements. The damage to Schneider's brain rendered him, while still able to perform concrete movements, unable to make abstract movements with his eyes closed. Abstract movements are not tied to any particular situation and require a different kind of spatial awareness of the objective space as the body has to perform arbitrary movements on request rather than as primordial reflexes. While the concrete movement finds it contextualized background in the given world and allows us to act solely within our phenomenal space, the background of the abstract movement is constructed (Merleau-Ponty, 2002, p. 127). Failure to construct a horizon to fill the missing background, such as in the case of Schneider, may render us unable to perform abstract movements. Nevertheless, this connection between the past and the current experience has been challenged by recent work, e.g., by Ungureanu and Rotaru (2014) who question the concept of motor intentionality in Dreyfus' interpretation of Merleau-Ponty's work when dealing with complicated object requiring timing and spatiotemporal coordination of movements.

In this chapter, I have introduced the phenomenological foundation that lies beneath the theories introduced this dissertation. The theoretical concepts

that I present in the next chapter are all related to this phenomenology of the lived body.

Chapter 4

A design framework for enabling interaction

In this chapter, I construct my design framework. This design framework constitutes the beginning of my answer to the first research question and scaffolds my research by guiding considerations and opportunities. The design framework draws on two main bodies of work, namely phenomenology of the lived body and TI. Rather than having the nature of aging introduced as a separate entity, I reflect on phenomenology and TI with an understanding of how aging manifests itself to clarify how aging can be seen from both a phenomenological and physical perspective. This cross-section helps me combine perspectives about the world, the user, and the interaction.

Instead of introducing the different layers in parallel, I introduce them in sequential order to easier narrate the rationale behind building a framework as an intertwining of concepts and related work from these particular fields of research. I begin the chapter by scoping down the relevant physical aspects of aging I consider most appropriate to incorporate into the following sections. After introducing the relevance and applicability of Merleau-Ponty's phenomenology within the fields of HCI and ID, I then present eight theoretical concepts from his work. These theoretical concepts describe the different pieces that in combination describe the holistic nature of changing bodies as I see it. To operationalize these theoretical concepts, I begin by identifying some appropriate design considerations that can later guide my research, mainly by infusing phenomenological concerns into my PD methodology. I am designing enabling interaction that will take place in the physical world, and I use TI to address the physical nature of my design space. TI literature holds multiple generic frameworks and principles that may apply to my context, e.g., (Cho et al., 2013; Criel et al., 2011; Guía et al., 2013; Ijsselsteijn et al., 2007; Veldhoven et al., 2008; Warpenius et al., 2015).

However, I am looking to bridge the gap between my specific phenomenological backdrop and design practice by introducing my own framework that is built on a reasoning starting with the phenomenology of the lived body and ending in concrete design opportunities. I use literature on how aging bodies experience changes in sensory-motor abilities to systematize an analysis of a popular generic framework found within TI literature. This analysis contains a reflection on the capabilities and opportunities for interaction within my empirical context and elicits some concrete design opportunities that I bring to the framework. I end the chapter by combining the phenomenological concepts and design considerations with elicited design opportunities into a theoretically informed design framework.

4.1. Sensory-motor changes in the changing body

Older people, and in particular the oldest old, i.e., those over 85 years, usually experience disabilities or chronic diseases as they undergo psychological and physiological changes. In addition, changes to related factors, e.g., social aspects and self-perception, also tend to affect how people experience aging. The goal of the enabling technology I aim to design is to delay the institutionalization of old people by allowing them to stay in their home for as long as possible. In order to maximize the delay, the technology must actively compensate for gradually declining capabilities. Prior studies such as (Marques et al., 2011) and (Häikiö et al., 2007) have demonstrated how careful and tailored facilitation may trivialize for instance motor challenges. My way of achieving something similar is to bring attention to capabilities as I believe reduced individual bodily capabilities does not automatically prevent us from enabling users to continue a purposeful relationship with technology. The changing nature of older bodies will close some design spaces as we have fewer opportunities to act in the world, but my claim is that we can still find capabilities in which we can anchor the design by rearranging the circumstances, i.e., either the technology or the context.

To allow users to focus on their capabilities rather than disabilities, we can use commonly experienced changes to look for windows of opportunity for building on capabilities. As such, the focus on disabilities in this section should not be considered in an isolated manner; I am describing challenges with aging to identify concepts, variables, and opportunities for my design

framework that can that inform a more salutogenic approach. As mentioned in Chapter 2, I am mainly concerned with users experiencing physical disabilities. I am not defining eligibility for participation through medical assessment but rather based on open invitations where everyone who can identify with this concern is welcome to join. However, it is still important for me to address some of the prominent challenges I describe later in this chapter. As such, I have looked at different alternatives for understanding physical change – for instance through the use of Fleishman's taxonomy in **Paper 4** (Fleishman and Reilly, 1992). I needed literature that would allow me to understand change, the physical manifestation of a change in the body, and what types of restrictions it introduce to the body-space relationship. I believe the three categories of sensory-motor challenges of aging described by K.M. Newell et al. (2006), i.e., physical fitness, information processing activities, and neurophysiological control, captures the scope of physical change that mainly concerns me, and I will later use these categories to help me build my design framework. But before I get to that part, I still need to provide a description of the sensory-motor aspects of aging that I am mainly concerned with in my research.

4.1.1. Change in capabilities

Old people usually undergo major circumstantial changes in their life as a result of bodily weakening. The weakening may manifest itself as a steady, long-term effect, or more abruptly through one-time incidents. A natural part of the aging process involves a deterioration of bodily functions; as the muscles in limbs slowly decrease due to atrophy, the stiffness of the joints may restrict movement and flexibility. We often tend to lose some height as the bones and muscles age, even with physical activity and a healthy diet. This usually alters our agency. For instance, our intentionally assumed positioning of limbs, i.e., our posture, is considered the interplay between our central and peripheral system and is therefore fundamental to human action (Birren and Schaie, 2011, p. 166). Similarly, poor sitting positions related to interacting with digital devices such as anterior sitting postures, i.e., forward leaning, remains a longtime struggle among caretakers of older people (Herzberg, 1993). The important lesson should be that it is not necessarily the digital device itself – or the interface involved for that matter – that produces adverse effects; it

may just as well be the configuration of the technology in relation to the body, i.e., the way we facilitate the interaction. For instance, by allowing users to assume a posterior type of sitting posture (i.e., backward leaning) that enables resting, we can avoid distraction in the form of maintaining balance, posture or neck straining, or discomfort during the interaction. As such, physical and spatial considerations such as weight, size, material, as well as how the device is placed relative to our body, all play an important role in minimizing postural strain, fidgeting, and chances of pressure sores.

Diminished mobility and flexibility may greatly reduce our independence, especially in combination with other disabilities. Exercise helps the body strengthen and maintain muscular capabilities, including flexibility and mobility. Birren and Schaie (2011, p. 90) point out that aerobic exercise may also provide positive effects on the overall health and aging process of older adults as it improves cardiovascular function, strengthens the heart muscle, and lowers the cholesterol level. Thus, encouraging interaction that requires activity, even in small doses, may produce positive side effects by situating movement. However, reduced mobility also introduces some new challenges to the design space. For instance, interactions depending on large movements or the whole-body interaction are significantly harder for people with motor impairments or muscle weakness to perform – something which in turn may increase the risk for falls (Rubenstein and Josephson, 2006).

General declines in motor control or psychomotor abilities can make interaction with objects difficult as we experience necessary interaction mechanisms such as grabbing, lifting, or holding differently (Huppert, 2003). Challenges with interaction may manifest themselves as movement-related, such as smoothness, pace (Morgan et al., 1994), accuracy, and nonlinearity (Riviere and Thakor, 1996), or as general sensitivity-related issues, such as reduced reaction, dexterity (Fingerspitzengefühl), and skin sensation (Cheong, 2007).

Finally, the ontology of phenomenology suggests that all people experience a continuous dynamic interaction between themselves and their surroundings, and this interconnectedness between aging bodies and the environment has also been emphasized by others, for instance by Fausset et al. (2011). Previous studies have also suggested that environmental changes can help the interaction on an individual level: Tse (2005) apply

environmental modification as a strategy to prevent and reduce issues with movements, specifically falls and fall injuries. The work of Wahl et al. (2009) also discusses the person-environment dynamics and its impact on aging individuals; result from their trials also support that modifications to the home environment may enhance functional ability outcomes. Another prominent example of following a similar rationale is the *"general ecological model of aging"* developed by Lawton and Nahemow (1973) which has been used to explain how the interaction or adaptation of the environment affects the human behavior. As aging bodies experience a reduction in individual competence, we can re-arrange or reduce environmental pressure accordingly to avoid a negative effect, and in turn a maladaptive behavior, on the person's functional abilities (Satariano, 2006). As I have demonstrated in a prior paper (Joshi and Woll, 2015a), there are many challenges with interaction that are direct consequences of how the technology is arranged in the space rather than matters of bodily disability. For instance, relative positioning between users and technology within a context may also change the experience. In my case, it was the hearing aids that sometimes would yield impaired sound experiences due to room acoustics and reverberation if positioned wrong. Similarly, the introduction of certain technologies within a space, e.g., a telephone, may impact how we perceive and live through space.

As I have briefly described in this section, the physical nature of aging is a complex combination of multiple bodily sensations. To address my main concern with aging, i.e., the sensory-motor challenges, I will blend in two different types of literature in rest of this chapter. In the theoretical section on the lived body's experience of aging, I rely on phenomenological-driven issues of aging such as manifestation of illness (Aho and Aho, 2008), altered bodily range (Toombs, 2001), new experiences of objects (Brereton, 2013), and the changing embodied relations (Brey, 2000). In the section on TI, I bring in the work of K.M. Newell et al. (2006) to study how changes to bodily capabilities affect the different dimensions interaction in the physical world. Their work describes three distinct areas of studies in extant sensory-motor literature all concerned with how the ability of aging bodies to interact with technology is reduced: the three areas are physical fitness, information processing activities, and neurophysiological control. I also use related work on TI to reflect on

opportunities to tailor interaction to changing bodies, e.g., (Brox et al., 2011; Ciolfi and McLoughlin, 2011; Naumann et al., 2010).

4.2. Phenomenology and the changing body

Chapter 3 introduced Merleau-Ponty's phenomenology of the lived body. In this section, eight concepts are elicited from his phenomenology to help me bring the phenomenology to action by theorizing the nature of changing bodies. These concepts provide an epistemic understanding of how we perceive, engage, and experience through the lived body. When put together, their combination represents an approach to the design of enabling technology that shifts focus from what the aging body no longer can do, and instead brings attention to what the body can do; my goal is to design for the capabilities of the aging body. I seek to better my understanding of the users' bodily capabilities and use that as the premise for design by extracting some design considerations for the design framework. By doing so, I believe we can understand, address, and support the changing nature of the aging body, as well as make it more dignified by prolonging and restoring meaningful interactions between aging bodies and the world.

Merleau-Ponty did not discuss his philosophy in the context of older adults interacting with tools and digital artifacts, and I do not claim the elicited concepts to capture the entirety that unfolds when aging bodies interact with technology. However, I do believe bringing attention to eight particular concepts from his work helps me address some of the richness and complexity that follows trying to build on bodily capabilities instead of deficiencies in aging bodies. I also complement the work of Merleau-Ponty with relevant research that has previously applied similar concepts to their respective contexts and research interests in search for methodic insight and practical application. By focusing on all the fine layers and the deep history of the aged body, as well as all the ways in which the body matters in design for enabling technology, I believe my perspective to be an addition to the application of phenomenology within HCI and ID through its deepened understanding of the interacting aging bodies.

4.2.1. The relevance of Merleau-Ponty to HCI

Before I introduce the eight concepts, I need to revisit the past and present application of Merleau-Ponty's phenomenology to understand its current scope and applicability. The theory of the lived body has been mainly applied in the study of interactions of movement, such as whole-body interaction. In contrast, my goal is not to target one particular type of interaction; I direct my attention to those interactions that carry the purpose of supporting independence for older adults. As mentioned in Chapter 2, my empirical context involves various different technologies and interactions such as motion-based sensors, touch-screen interfaces, and wearable technologies. I attempt to elicit concepts that are not bound to particular types of interactions or technologies but instead cover a broad range of facilitations between bodies and technology.

The application of Merleau-Ponty's phenomenology in a design context is not new as many researchers within HCI have been influenced by him. The early works by Winograd and Flores (1986) inspired many researchers over the next two decades who gradually established Heidegger and Merleau-Ponty's phenomenology as a theoretical foundation within HCI, ID and Computer-supported cooperative work (CSCW), e.g., (Dourish, 2004; Ehn, 1988; Robertson, 1997, 2002, Svanæs, 2000, 2001). Since then, the use of Merleau-Ponty's phenomenology as a theoretical approach to embodied interaction has gradually increased. Most of the practical application found within HCI, mainly address the role of movement in interaction, see, e.g., (Antle et al., 2009; Djajadiningrat et al., 2007; Fogtmann et al., 2008; Larssen et al., 2006, 2007a; Loke et al., 2007; Loke and Robertson, 2007, 2007, 2009, 2013; Moen, 2007; Svanæs, 2000, 2001; Tholander and Johansson, 2010). Little attention has been paid to the phenomenology of the human-object relationship that arises when older adults engage with technology, whether it is advanced sensor-based interaction or just senior citizens trying to watch television. More precisely, we find little research within HCI applying the phenomenology of the lived body to (1) address how the changing nature of the aging body actuate the potential to interact with technology, and to (2) capture the entirety of the interaction between the aging body and technology. There are some notable exceptions, such as the work of Robertson (2012) and Brereton (2013). Robertson uses Merleau-Ponty's notion of sediments to

explain the embodied experiential history that lies within aging bodies. Brereton provides insight into the spatial relation in embodied interaction between human and objects from the perspective of an older woman who has made a number of convenient arrangements of things around the house to support independence and agency as she ages. In addition, in the work of those who have contributed with extensive application of phenomenology, most notably (Svanæs, 2000, 2001, 2013); (Loke et al., 2007; Loke and Robertson, 2007, 2009, 2013); and (Larssen et al., 2006, 2007a); I still find valuable insight into central concepts that are highly relevant and transferrable to my problem space. I will return to the relevance of their work later in this chapter as I introduce my eight theoretical concepts.

Phenomenology has also been applied directly to the context of older adults and people with disabilities. The work of Aho and Aho (2008) studies sickness, disease, and illness through a phenomenological perspective. Yakhlef and Essén (2012) use the *"bodily expressive-responsive skillful coping mode"* to explore innovation and improvised actions in home care service for older citizens. The work of Toombs (2001) on the phenomenology of illness and disabilities explains in detail how bodily changes come to change our abilities to engage in meaningful interactions. I also bring relevant research from domains external to my own research context to help me further my understanding of the human-object relations and how bodies acquire skills. Brey (2000) investigated the symbiotic and embodied relationship between humans and artifacts through Merleau-Ponty's perspective. I also draw on Dreyfus' extensive work (1996, 2002) on how bodies acquire *"skillful coping"* since this is relevant to the perspective of bodily knowledge and how bodies learn and use skills to interact with objects. Finally, parts of Crossley's exploration of phenomenological literature on habits inform my own understanding of habits as something embodied and natural (2001).

As we can see, the phenomenology of Merleau-Ponty has been revitalized multiple times by various studies within HCI and ID, and I am not claiming originality in the use of Merleau-Ponty's phenomenology. Nor am I insisting on any novelty in the introduction of these concepts as prior studies have previously discussed all these concepts within HCI; for instance, Svanæs' work (2000, 2001, 2013) has touched upon six of the eight presented concepts. However, the composition of these specific concepts, along with how they are

combined with practical concerns to shape my design framework, is where I believe the originality lies. These concepts have been translated into design considerations that later inform the methodological practice and the various analyses of the embodied nature of the interaction between the digital artifacts and the changing bodies.

4.2.2. Maximum grip

With newer design paradigms within HCI, such as embodied interaction and tangible interaction, spatial factors such as how the body is positioned relative to the digital artifact, the stance, the movement, and the bodily gestures, now contribute directly towards the design of the interaction. The first concepts from Merleau-Ponty relevant for the design of such interactions are the notion of ***maximum grip*** as described through the interpretation by Dreyfus (2002). The term is used to describe how our positioning towards objects lets us appreciate objects differently. As we move our position relative to an object, each stance reveals a unique perspective of the object, bringing to light different properties and attributes of the object. According to Merleau-Ponty, every object holds an optimal position from where one best can see the object, i.e., from where we get a maximum grip of the object. By taking this stance, we are able to appreciate the normative properties of objects at an optimal level. Every deviation from this optimal stance is considered a disturbance, as it does not align with the optimum, and the body will tend to realign itself. For instance, by putting my watch on the wrong hand, my body notices the deviation from the optimal positioning of the object relative to my body, which would be on the correct hand. During past ethnographic research I discovered how the participants, when talking on traditional landline phones, always ended up switching to their preferred hand. When later confronted with it, nobody was able to explain it as a conscious decision, and accordingly accepted it as a reflexive movement. Changing bodies, therefore, requires a rediscovering of optimal level towards objects. As our vision gradually impair, we might find ourselves squinting with our eyes trying to cope with the blurriness of the picture on the wall. However, as the body experiences a new positioning towards objects, it may very well find a new maximum grip. Or by introducing an incorporated object (which is later described), we may realign ourselves with our old maximum grip. Furthermore, as the human-object

relationship is relative, by repositioning objects, we can reposition our relative stance towards an object, thereby exploring new optimal levels. This chapter does not build on empirical observations to reflect on the theoretical development, but as an exception I would like to use one empirical example to illustrate this particular phenomenon: one lady described how her loss of hearing in the left ear due to surgery, forced her to move the radio from one side of the room to the other as she did not want to move her chair. Thus, the optimal level is never constant; as our bodies change, as objects change, we find ourselves in constant search for new levels of meaningful interactions. The encapsulating notion of maximum grip indirectly captures all the ensuing seven concepts I present in this section and should be considered the consequential manifestation of the ways in which aging has changed our body's ability to engage with the world.

How we perceive objects is not an isolated matter consisting only of ourselves and the object with which engage. Hence, maximum grip involves attaining an optimal position towards an object, given its existence in a world of other surrounding objects. By introducing a new object to a context, we may also affect our ability to properly perceive other objects within that context as objects reflect each other. Merleau-Ponty suggests that every object is the mirror of all others, i.e., that they inhabit the ability to *"see"* each other. And by being able to do so, when we engage with an object, we attribute to it not only its intrinsic qualities but also the qualities visible to all other surrounding objects (Merleau-Ponty, 2002). When we introduce a new object to a context, it becomes part of a symbiotic sphere in which the various co-existing objects informs the perception of other spectators of the hidden attributes and qualities of objects. As a result, by getting a maximum grip of one object, we may suddenly find ourselves no longer in harmony other objects.

4.2.3. Bodily space

As our bodily capacities weaken, our abilities to use the body to act in the world diminish, and accordingly affect our ***bodily space***, which us the second relevant concept to my design space. Svanæs (2013) describes the bodily space, in contrast to our external space, as the body's intrinsic potential to engage in the world, and points out that all external factors from clothes to

prosthesis can affect our bodily space. Weakened muscles, stiffened bones, less sensitivity in joints, and decreased body temperature are other examples of typical symptoms of aging that reduces the body's ability to perceive and act in the world. Larssen et al. (2006) explain how decreased sensitivity of the skin can affect bodily receptors of temperature and pain, thereby reducing our potential to understand certain types of stimuli such as haptic interaction. For instance, reduced mobility and balance can affect older people's ability to sense slipperiness outside during wintertime. Weakened motor skills in legs and feet gradually reduce our ability to understand the world through our legs, such as in this case the slipperiness on the road. However, in cases where one would use a crutch or hold on to a walker, one might immediately be able to better sense and understand the slipperiness. By stabilizing the balance through these tools, we can experience an increased bodily degree of freedom which in turn increases the ability to act in the world. Toombs' extensive work on phenomenology is relevant to this concept as it describes the subjective nature of bodily change. One particular example presented in (Toombs, 2001) is a description of how frequent use of a wheelchair have led her to include the wheelchair in her bodily range.

The third and fourth relevant concepts found in Merleau-Ponty's phenomenology are the notions of ***body schema*** and ***incorporated objects***. The former describes our immediate knowledge of the factual and intra-relational properties of the body such as structure, potential, and relation between different body parts; the latter explains our ability to incorporate objects into this bodily schematic understanding. Svanæs describes how objects incorporated as part of our body schema can be included in the experience of our lived body, and how external objects incorporated as a part of our body changes our structural lived body (2013). After learning to use scissors to cut a piece of paper, we no longer engage the scissors as an object out in the world; we use the scissors to understand the world (Brey, 2000). The scissors, as a tool, has become a part of us and through it, we can perceive the paper. By touching the paper through the scissors, we supplement what the eyes see, the nose smells, and the fingers feel. We sense the paper's material composition through the resistance of the paper as the scissors cut through. Our perception begins not when we grab the scissors, but rather at the point of contact between the scissors and the paper. Key examples of this

phenomenon relevant to my design context would be older adults incorporating walkers, crutches, wheelchairs, blind canes, and prostheses into their body schema.

Merleau-Ponty also explains how people perceive objects outside of one's own body schema differently from those incorporated into the body schema. He explains how the spatiality of the body should not be confused with spatiality of objects (Merleau-Ponty, 2002). We do not experience our body as a spatial entity in the world, and within the organized structure of our own body schema, we do not experience spatiality in the same we do with objects outside our body schema. Brey (2000) demonstrates this point through an analogy of how wearing glasses with red or green lenses allow us to use glasses different than we would external objects in the world. The glasses are no longer objects in the world, but instead, objects through which we engage the world. According to Merleau-Ponty, this awareness of spatial relations is, therefore, a result of our potential towards objects relative to the body and the spatial configuration plays an important role towards how we perceive objects and how their meanings unfold (Merleau-Ponty, 2002). This is relevant to my problem space as it helps me understand how older adults incorporate aiding tools to their body, and it also helps me understand how bodies engage with external objects located outside one's body. I, therefore, include ***spatial awareness***, i.e., our understanding, readiness, and potential towards objects relative to the body, as my fifth concept.

4.2.4. Movements and activity

Dreyfus (1996, 2002) builds his discourse on maximum grip on the primordial intentionality in Merleau-Ponty's phenomenology. More precisely, he uses the notion intentional arc to describe the body's acclimatization to its own environment as a result of the symbiotic relationship between agent and the world (Merleau-Ponty, 2002). Rather than an analytical assessment of the potential that lies in our actions, the body utilizes lived-through meanings to form its intentional arcs. This unfolds as pre-reflective actions towards the lived world and Merleau-Ponty emphasize this in his discussion about intentionality in movement. This is highly relevant for embodied interaction, where one of the decisive factors of success is the system's ability to correctly interpret the body language of the user. I especially focus on Merleau-Ponty's

distinction between two types of motor intentionality, namely ***concrete*** and ***abstract movement***, which together form my sixth concept. Merleau-Ponty describes concrete movements as habitual actions that come naturally as part of the situation, such as hitting a fly on the shoulder. The movement is an immediate response without self-awareness rather than a conscious decision to perform an action. On the other hand, abstract movements lack circumstantial relevance and are motivated by external tasks rather than an embodied rationality. He describes the actions as artificial in the sense that they do not evoke the same spontaneous reaction that a concrete movement would (Merleau-Ponty, 2002). This distinction helps me understand certain movements as natural in the sense that they are independent of cognitive presence, while other movements are unnatural and require training. In my context, it is especially relevant to both investigating the nature of current and new movements in interaction, as well as to what degree the body is capable of attaining new abstract movements. Apraxia and ataxia are examples of disorders associated with aging that directly affects the body's ability to incorporate new movements. The former is used to describe those unable to coordinate movements, whereas the latter is a disorder preventing movement even though the movement is cognitively desired. As a general rule, we cannot expect aging bodies to always embody the required capabilities associated with certain types of interactions, e.g., small-screen devices with touch interfaces requiring precise and coordinated finger movement. This point has been an important motivation for the research of Larssen et al. (2004), who emphasize how interactions do not necessarily require new learning.

There are also important foundations in Merleau-Ponty's work on which I can understand not only how bodies perceive objects, but also how objects perceive bodies. In this part, I find my concepts not directly in Merleau-Ponty's work, but instead through the interpretation of Svanæs' work (2001). Embodied interaction requires systems to distinguish between concrete and abstract movement in order to provide reliable assistance in a health-sensitive situation, something which is often the case for enabling technology. Svanæs uses this same distinction to separate ***foreground activity*** from ***background activity*** (2001). These two ways of describing activity make up the seventh concept that applies to my context. Whereas photo cameras need

to distinguish between a subject in the foreground and objects in the background in a Cartesian space, sensor-based systems need to separate active actions that a user wants the system to detect from background actions which may be natural movements or involuntary actions. One fitting example immediately comes to mind: older adults struggle with falls and collapse, and fall sensors are commonly found in residential complexes and nursing homes. Regardless of their technological composition, be it detection through accelerometers, infrared sensors, or ultrasound, they share one common challenge – being able to precisely distinguish between foreground and background activity. On the one hand, the sensor must distinguish between falls and people who intentionally lie down. On the other, the system must detect *"non-traditional"* falls; rather than falling or collapsing in an abrupt and hard manner, most people within my target demographic fall in an oozing way, e.g., sliding slowly out of a chair. This complicates detection for most sensors. Larssen et al. (2004) suggest that along with the affordances of technology, the forms of movement that the body allows or disallows should be a primary focus for design. Svanæs argues that on the basis of Merleau-Ponty's phenomenology it is generally impossible to reduce motor intentionality enough for sensor-based technology to distinguish between these types of movement accurately. The interactions should rely on users actively resolving undecidable issues rather than having the system attempting to make interpretations (Svanæs, 2001).

4.2.5. Bodily skill

The subjective nature of embodiment in Merleau-Ponty's work also extends into the temporal space. He distances himself from our chronometric understanding of time and instead presents time in a self-referential manner, where time not only flows but also has an awareness of itself (Merleau-Ponty, 2002). However, rather than interpreting the subjective-temporal experience of time, I find Merleau-Ponty's work on habits and skills, and how we acquire them, best fitted to explain how limited time affects our potential for interaction. The habitual nature in our bodies is the substance in Dreyfus' model on the acquisition of ***bodily skills***, which is my eight and final concept. His model explains how we through repeated interactions build an understanding of how we can engage with the object, as well as how we should

engage with the object to best achieve what we desire. Robertson (2012) uses Merleau-Ponty's notion of sediments to explain how it is the intricate mesh of previously lived moments in the present that provides us with opportunities to act in the current world. Thus, meaningful engagement requires mastery, which in turn requires time and repeated exposure. Dreyfus' model suggests that it is representations of experience, rather than mental representations, that teach the body to solicit refined responses until the body can incorporate an intuitive situated response to a given context. Dreyfus described this as actions becoming *purposive* without the agent entertaining a *purpose* (1996); once the bodily skill is incorporated, it no longer relies on the brain. Accordingly, attaining bodily skills, which are needed to understand and master certain interactions, may require time beyond what the older users may have at their disposal. The required exposure and experience do require not only time, but also a certain bodily capacity. The limitedness of time is not only a matter of chronometric values such as months and years, but it is also a matter of how the bodies endurance and readiness. Clark (2007) points out how the development of skills, especially motor skills, even among young people, require nurturing, promotion, and practice, and does not come *"as birthday presents"*.

4.2.6. Summarizing the eight concepts

I have introduced eight concepts from the phenomenology of the lived body. These are highly interrelated and should not be considered isolated concepts, but rather different ways of understanding the embodied relationships between older adults, digital artifacts, and the world. I have summarized the eight concepts, along with the main related work I have drawn on to understand them, in **Table 4.1**.

Table 4.1: *Overview of the theoretical concepts and related work*

Theoretical concept	Related work
Maximum grip	(Dreyfus, 1996, 2002; Tholander and Johansson, 2010; Yakhlef and Essén, 2012)
Bodily space	(Aho and Aho, 2008; Brey, 2000; Larssen et al., 2004, 2006; Robertson, 2012; Svanæs, 2013; Toombs, 2001)

Theoretical concept	Related work
Bodily schema	(Antle et al., 2009; Brey, 2000; Crossley, 2001; Svanæs, 2013; Toombs, 2001; Yakhlef and Essén, 2012)
Incorporated objects	(Larssen et al., 2006; Svanæs, 2013; Toombs, 2001)
Spatial awareness	(Brereton, 2013; Brey, 2000; Loke and Robertson, 2010; Svanæs, 2013)
Concrete and abstract movements	(Fogtmann et al., 2008; Larssen et al., 2007a; Loke and Robertson, 2010, 2013; Moen, 2007; Svanæs, 2013; Tholander and Johansson, 2010)
Foreground and background activity	(Svanæs, 2001)
Bodily skills	(Brey, 2000; Clark, 2007; Crossley, 2001; Djajadiningrat et al., 2007; Fogtmann et al., 2008; Larssen et al., 2007b; Robertson, 2012; Svanæs, 2001; Tholander and Johansson, 2010; Yakhlef and Essén, 2012)

4.2.7. Translating concepts to design considerations

So far in this chapter, I have introduced eight concepts from Merleau-Ponty's phenomenology that helps me understand a changing body interacting with digital artifacts: *(1) maximum grip*, *(2) bodily space*, *(3) body schema, (4) incorporated objects*, *(5) spatial awareness*, *(6) concrete and abstract movements*, *(7) foreground and background activity*, and *(8) body skills*. These concepts capture the aspects of the human-world relation that I find the most relevant. However, these concepts alone do not suggest any specific considerations I can bring along with me into my specific context. I need to translate the understanding of these concepts into something I can use to advise my design process. As such, I have reflected upon these concepts with the goal of finding some concrete elements that can translate into a design context, i.e., variables that informs which aspect of the interaction I should concentrate on when either understanding existing interactions or designing new ones. These concepts allow multiple interpretations and hold the potential to support other rationales besides mine, but I will end the section by introducing nine design considerations that summarize how I have understood

these concepts and translated them into considerations specifically relevant to my design context.

Beginning with ***(1) maximum grip***, I have found three main design considerations that help me investigate our *"grip"* on a given interaction. *Relative positioning* helps to understand the position between ourselves and the object that yields the optimal gestalt. *Interaction mode* describes the type of interaction the user is presented with and contributes to understanding maximum grip as not only how we appropriate ourselves towards the object, but also how objects speak to the body. Similarly, how the object emerges in a given context is a consequence of surrounding objects, as well as the *material and physical attributes* of the object.

(2) Bodily space describes our potential and readiness to engage in the world, and the way we experience response from objects and surroundings during interaction is directly tied to our bodily space. As such, the two main design considerations I bring along from this subsection are bodily *capacities* and *response*. The former stresses that there is a continuous developing relationship between our bodily space and our ability to interact which can be understood through our capacities. The latter is a continuation of the former by emphasizing that changes to bodily space and how we act in the world also influence how we experience stimuli from the world.

The design consideration *configuration* can be used to emphasize that to successfully incorporate external objects into our bodily schematic, the object needs to support a configuration that allows the body to alter the structural lived body gracefully; configuration will help us understand whether elements of an interaction is offering the body appropriate opportunities to fuse it into the lived experience. This variable is a combination of the two concepts ***(3) body schema*** and ***(5) incorporated objects***.

The spatial configuration and its influence on our perception of external objects are the basis for the design consideration *arrangement*. Meanings unfold from spatial relations, and while the concept ***(4) spatial awareness*** could be used to derive multiple considerations, I focus on the spatiality of our context as a way of understanding the configuration of objects and its influence on our perception of interaction.

The two types of motor intentionality, i.e., ***(6)*** **concrete and abstract movements**, describe types of movement as a reaction to

circumstantial stimuli. As such, I keep *movement* as a design consideration to help understand different types of movement as well as to situate habituated actions by studying movement. Through movement, I can also understand how well the interaction supports the existing bodily repertoire as well as use reactions to investigate the familiarity of different interaction mechanisms.

Most of my design considerations begin with the body, but it is also beneficial to have a way of understanding the body as seen from the spatial and contextual perspective. By deducing *adaptability* as a design consideration, I have a way to investigate the types of intentionality and movement that are possible within the interaction. This variable is deduced from ***(7) foreground and background activity***. It could be a matter of how the interaction adapts to various movements from one individual or how the interaction supports adaptation to multiple individuals.

The final concept, i.e., ***(8) bodily skill***, does not introduce any new design considerations, but it reinforces two previously mentioned considerations. First, understanding skills through capacities suggest that we will need to cater to multiple capacities and configurations – individuals as well as in a collective manner. Second, as we develop skill through repeated exposure over time, we will need to remodel the nature of the interaction and the environmental stimuli it offers after what the user needs for the actions themselves to remain purposive through their bodily change.

Table 4.2 below expands **Table 4.1** with these design considerations to illustrate the translated move from phenomenological concepts to design considerations. To summarize, I will bring the following design considerations with me to the next section when I look for design opportunities: *(1) adaptability, (2) arrangement, (3) movement, (4) relative positioning, (5) interaction mode, (6) physical/material attributes, (7) configuration, (8) capacity, and (9) response*.

Table 4.2: *The theoretical concepts paired with design considerations*

Phenomenological dimension	**Theoretical concept**	**Design consideration**
Everyday living space *(Space)*	Spatial awareness Foreground/background Concrete/abstract movements	Adaptability Arrangement Movement
Digital artifacts *(Objects)*	Maximum grip Incorporated objects	Relative positioning Interaction mode Physical/material attributes
Changing bodies *(Body)*	Bodily schema Bodily space Bodily skill	Configuration Capacity Response

Besides being expanded, the table has introduced a column on phenomenological dimension and reordered the structure of the theoretical concepts – these two moves require an explanation to clarify my intent. As I described in the previous chapter, the phenomenology of the lived body is an intertwined and inseparable entanglement of our body and its relationship with the environment and surrounding objects. For the purpose of retaining this relationship while still being able to relate them with a similar separation as one often makes within design, i.e., the division of user, interaction, and context, I have separated them into three linear layers in the model; I relate these layers to the particularities of my design space, i.e., the design of digital artifacts for aging bodies in their everyday living space. This separation of the phenomenological dimensions might seem artificial given the ontological reasoning where the lived-body is inseparable from the world, but I consider it a necessary operational reduction to help clarify the different layers of analysis and design opportunities that will follow. The same can be repeated about the eight theoretical concepts in the next column: these are highly interrelated and should be considered as such also within this framework. I have used my own interpretation in combination with related work to find ways of operationalizing these concepts, and the clustering helps me explain how I have chosen to apply them in my design space. Hence, the concepts are grouped into two triples and one pair to help them serve as a bridge between

the phenomenology and the concrete aspects of interaction I study; they are connected with the most relevant phenomenological dimension on the left and three design considerations on the right.

4.3. Designing for the changing body

In the previous section, I elicited eight theoretical concepts and translated them into design considerations that would help me understand and analyze the interaction between changing bodies and enabling technologies. Since I also want my framework to serve a purpose when we co-design with the users, it needs another column that describes what moves I can make as a designer to extend the idea of designing for capabilities. As such, I continue the operationalization of my theoretical concepts in this section by introducing design opportunities that can inform how I go on about design and evaluation activities.

I am designing for interaction in the physical world, and I turn to the field of TI to direct my attention towards the aspects of interaction mainly affected by the common characteristics of a changing body. After a short introduction of TI and its relevance to my study, I analyze the well-known framework of Hornecker and Buur (2006) with regards to changing bodies and narrow down those aspects of physical and embodied interaction that are most relevant to me.

4.3.1. TI in my design space of enabling interaction

Most of the technologies currently available at the various facilities in my empirical context rely on screen-based interfaces – some with touchscreens, other not. Only in a few exceptions did the technology allow other modes of input and output, e.g., the movement-based light control. My design focus, i.e., the aspects of interaction I am mainly concerned with, begins in the physical world and can be classified underneath the umbrella term TI. Besides helping me more precisely communicate to other researchers the nature of the design cases I will later explore, there were three main reasons for positioning my design scope within TI. I return to these three rationales after defining my understanding of TI as it encompasses a broad range of perspectives (Hornecker and Buur, 2006).

The original work defining TI attempted to overcome the limitations of screen-based interfaces by exploring computational systems that could reside in the physical world. The introductory term of Tangible User Interfaces (TUI) described the consolidation of bits and atoms, i.e., computational interfaces that ubiquitously and invisibly coupled digital information with physical objects in the real world (Ishii and Ullmer, 1997). This vision was at the time of its creation an encouragement for HCI to expand its horizon. As such, the epistemologies and theories applied to understand the nature of TI in later work (e.g., Dourish, 2004; Hornecker and Buur, 2006) were not part of the original vision. However, their motivation for expanding the scope of HCI contained one vital argument highly relevant to my epistemic perspective: the currently dominating interfaces in HCI research, i.e., GUIs, could not embrace the *"richness of human senses and skills people have developed through a lifetime of interaction with the physical world"* (Ishii and Ullmer, 1997).

Over the past two decades, TUI – and the later popularized term TI – has received increasingly more attention within the HCI community. As Dourish argued in 2004, TI had been mainly opportunistically and practically driven and found little theoretical support in the theories governing traditional interaction (2004, p. 52). This new umbrella term opened up a way of discussing the theoretical underpinning of interactions where the body, the physical space, and the social aspect, all served a vital role. By augmenting physical objects in the real world, the manifestation of the computing system can fade into the background, and I can focus on the aspects of interaction that take place in the physical world. With gradually more emphasis on the wholeness of interaction, the focus on interaction replaced traditional pure interface-oriented foci – a shift that introduced an increased attention towards rapid prototyping, physical and social aspects, as well as real-world objects as thinking tools that all helped infuse both the body and the physical world into the design space (Hornecker, 2014). Some of the contributions to the development of the field in the past decades that are relevant to my work include (Fernaeus et al., 2008; Fitzmaurice et al., 1995; Hornecker and Buur, 2006; Ishii and Ullmer, 1997; Klemmer et al., 2006; Wensveen et al., 2004).

TI remains an umbrella term building on approaches from various disciplines – mainly HCI, computer science, product design, and interactive arts – while encompassing a broad range of aspects related to interaction,

most notably (1) tangibility and materiality, (2) physical embodiment of data, (3) bodily interaction, and (4) embeddedness in real spaces and contexts (Hornecker and Buur, 2006). If I return to my own research, I find this broadness helpful as my design space is not restricted to specific types of interaction or technology. Furthermore, TI provides a different way of understanding and analyzing both existing technologies as well and new design alternatives with my theoretical lens due to its intrinsic embodied nature.

As mentioned, there were three reasons for using TI literature with my particular design space. First, TI was never a forced alternative to screen-based interaction for my participants, but rather a shift in representation. My motivation was to find a scope for the design space that did not restrict the design alternatives to the existing range of interaction modes; the goal was to facilitate a design process where the design space could encourage exploration of alternative enabling technologies beyond interaction mechanisms available in current technologies. For instance, several research explorations, e.g*., Collaborative Change Experiment (RE #2)*, *Motus (RE #8)*, and *Elbø (RE #14)* all included large screens. However, the use of screens emerged out of the co-design activities rather than being a predefined requirement. TI provides an openness to explore a wider range of alternative ways of carrying out daily and supportive tasks by starting in the real world. As Dourish explains, *"[...] tangible interaction does not simply argue in favor of physical representations; it argues for a transition from symbolic representations to physical ones"* (2004, p. 206). Second, I chose TI because I wanted the study of interaction to align with my theoretical lens by putting the body first; TI builds on phenomenological traditions and acknowledges a broader design space that includes other important dimensions of the interaction experience such as social dimensions (Hornecker and Buur, 2006). Third, I found methodological benefits with using TI. As I will later argue in Chapter 5, it was important for the design process that the participants found opportunities to build on their own competence and expertise in their role as co-designers. I needed to support my design space with literature that did not presume that the design would end up with a specific interface or use a predetermined type of technology. TI shifts the realm in which the participants make choices and suggest alternatives by encouraged a body-first perspective that allowed

participants to detach from technological restraints when imagining future designs (**Paper 3**).

Lastly, it should also be mentioned that combining TI – or its historically preceding relatives such as embodied actions – with a Merleau-Pontian philosophy was done no less than two decades before me. Robertson's work on embodied actions (1997) and the work of Dourish on the introduction of embodiment (2004) serve as two early examples of applying the phenomenology of the lived body to theorize the understanding of interactions and actions. Moreover, these two particular seminal bodies of work illustrate how important aspects of currently governing understanding of TI, for instance, the social dimension, strongly builds on the early work on interaction in the real world made by these pioneers (Hornecker and Buur, 2006).

4.3.2. Related work within TI

The last decade has seen many studies attempting to connect older people with technology through new tangible and embodied interactions. The studies most relevant to the development of my design framework are those who suggest implications or principles that can be transferred to my context when considering both the user group and the type of technology. The backdrop of the birth of TI was the desire to *"tease out the underlying human skills on which we could build our interaction techniques"* (Fitzmaurice et al., 1995), and I have focused on prior work that strengthens the practical understanding of human skill and development and the role they play in interaction. As such, the papers I now briefly introduce will all be drawn on to support the design opportunities I introduce as the final component of the design framework.

Brereton (2013) discuss the role of various *"habituated objects"* in one older person's agency and the general implications for design involving novel technology. Naumann et al. (2010) investigate differences between various modalities in older versus younger users to discuss the suitability of multimodal interaction as a strategy for inclusion of older users. Brox et al. (2011) study the role persuasive technologies relying on motion sensors can have on encouraging seniors to engage in physical activity and prevent loneliness. Van den Hoveen (2004) explores how personal histories and identities are captured, mirrored, and recollected in digital devices, including graspable user interfaces. Representing and sharing the history and the life

experiences through augmented physical objects is also a focus of (Ciolfi and McLoughlin, 2011) who discuss several related topics, e.g., the relationship between objects and the opportunities of the environment. The work of Boussemart and Giroux (2007) revolves around a study of tangible user interfaces for neurodegenerative users where novel interfaces were discussed to compensate for impaired functions of the brain, and they present several principles for design. Waller et al. (2008) employ tangible computing to provide older people at nursing homes with new and adapted alternatives for the television media. Al Mahmud et al. (2008) report from a tangible tabletop game intended for senior citizens where they discuss the need to connect with past experiences in novel design. Marques et al. (2011) also discuss tabletop games for older adults and reflect on the viability of tangible objects.

4.3.3 Design opportunities

One of the generic frameworks within TI is the conceptual framework presented by Hornecker and Buur (2006). This framework consists of four interrelated themes that help unpack TI and provides different concepts within each theme to help concretize relevant opportunities. However, as the authors suggest, this framework is intended as a conceptual aid that calls for further development, i.e., application in analysis and design, as well as refinement or expansion (Hornecker and Buur, 2006, p. 9). The relevance of this framework for my research is tied to the broad range of systems and interfaces it covers and the wholeness it offers with regards to systematized thinking around embodiment in interaction; I am looking for design opportunities when designing for changing bodies with my phenomenological perspective, and this framework helps us cover most of the aspects of interaction with objects in the real world, i.e., material/physical and social aspects of interactions. Another benefit of eliciting design opportunities with the help of this framework is that the authors are also influenced by the work of Merleau-Ponty (Hornecker and Buur, 2006, p. 9) and that they draw on a similar epistemological reasoning as I introduced in the previous chapter. Their complete framework with the four themes and 14 concepts is illustrated in **Figure 4.1**. The four themes cover abstract levels through the themes and more conceptual and analytic levels through the associated concepts. As this framework is widely applied and cited in research, I do not expand on the

details of each concept in this dissertation and refer to (Hornecker and Buur, 2006) for further details – the framework is accompanied by detailed explanations of the scope and rationale of each concept.

1. Tangible Manipulation	**2. Spatial Interaction**	**3. Embodied Facilitation**	**4. Expressive Representation**
A. Haptic Direct Manipulation	**A.** Inhabited Space	**A.** Embodied Constraints	**A.** Representational Significance
	B. Configurable Materials		
B. Lightweight Interaction	**C.** Non-fragmented Visibility	**B.** Multiple Access Points	**B.** Externalization
	D. Full Body Interaction		
C. Isomorph Effects	**E.** Performative Action	**C.** Tailored Representations	**C.** Perceived Coupling

Figure 4.1: *A conceptual framework for Tangible Interaction from (Hornecker and Buur, 2006)*

My goal is to analyze this framework from the perspective of changing bodies. While I have described some of the general traits and effects associated with aging earlier in this chapter, I want to apply a structured procedure in my analysis of this framework. To reflect on this framework with my research interest in mind, I will structure the analysis after the three areas of sensory-motor challenges of aging described by K.M. Newell et al. (2006): physical fitness, information processing activities, and neurophysiological control.

As mentioned, the themes and concepts in the framework are interrelated. The motivation behind the analysis is to elicit some design opportunities, and I have chosen to focus on the most severe – at least as I see them from my theoretical standpoint – disruptions between aging bodies and technology. It is important to stress that by excluding non-motor related aspects of aging, such as most cognitive aspects, I am not attempting to perform an exhaustive analysis, but rather find opportunities to elicit opportunities for design that are most relevant to my research scope. As I go

through the three areas, I will point back to Hornecker and Buur's framework by referring to specific concepts.

Physical fitness

Reduced physical fitness limits the ability to manipulate material objects directly, and thereby constrains the possibilities for ***haptic direct manipulation (1A)***. Because of loss of strength, flexibility, and endurance, the body is no longer able to grip, hold, lift, pull, or push in the same manner it once knew. With age, we also struggle with physical disabilities that make us dependent of mobility aids such as walkers, rollers, wheelchairs or electrical scooters. Such aids greatly reduce the potential for a ***full-body interaction (2D)***; for instance, in situations where the user is intended or expected to stand, the design needs to be operable mainly with one hand. Similarly, reduced mobility may prevent the use of ***configurable materials (2B)*** that require particular object manipulations or moving objects as part of the interaction. Reduced fitness, in general, would imply that certain objects can no longer serve the same purpose as they once did due to challenges with configuration. When the bodies change, objects are experienced differently because our potential to act in the world has been altered. The change might have a medical diagnosis or explanation, but its bodily manifestation may be subjectively experienced in multiple ways that may vary greatly from one person to another; it can be matters of weight, balance, coordination, and strength that complicated previous ways of interaction. Nevertheless, physical fitness, as it is directly related to the body's ability to navigate in Cartesian space, is mostly concerned with the two first themes of ***tangible manipulation (1)*** and ***spatial interaction (2)***.

The area of physical fitness also covers bodily disorders. Tangible manipulation involves interaction between users and objects, and the reduced ability to grip and hold objects also increases the chances of accidentally dropping, misplacing, or damaging objects. A common solution would be to replace existing material with more durable and solid material. However, certain materials, e.g., cold and hard steel, might be more durable while not inducing the desired inviting appeal. Changing the shape or material may also eliminate the shared reference of an object, thereby actuating an adverse effect on the ***representational significance (4A)***. In addition, various degrees of

hypokinetic disorders (decreased bodily movement) may imply different requirements. Certain symptoms, like bradykinesia (slowness of movements), may not impose any major difficulties for the user, and milder cases of rheumatism or Parkinson's disease may still allow for direct manipulation. However, when the trembling, shaking, or rigidity becomes too severe, ***haptic direct manipulation (1A)*** may no longer be suited, especially if the symptoms of the disease are expected to continue aggravating. When stronger symptoms, such as tremor, tics, muscle twitching (e.g., myoclonus), and abnormal postures (e.g., dyskinesia and dystonia) become too prominent, direct manipulation should no longer be considered a viable option. In addition, sudden and involuntary movements may also complicate the way other people and sensory system perceive us. Undesired body language may prevent successful ***performative actions (2E)*** and limit the options for ***full-body interaction (2D)***; it is a challenge to design automatic recognition where we are able to distinguish between imprecise or poorly-performed movements on the one hand, and involuntary bodily movements stemming from a disease on the other.

Information processing

Changes in information processing activities, mainly the reaction time and movement time, require more patient interaction mechanisms. Ensuring ***lightweight interaction (1B)*** is not a particular challenge itself, although it does require an interaction that grants the user enough time to react to instructions and move accordingly. The weakened ability to carry out multiple actions simultaneously may also create a transition from actions currently understood as intertwined tasks to sequential actions that together complete the task. Frequent actions that require rapid reaction can easily become too difficult for both the body and mind to handle and might even require several attempts. By dividing tasks into smaller concrete actions, i.e., concrete movements, we may ease the ***isomorph effects (1C)*** and help users connect actions and their effects, as well as clarify the ***perceived coupling (4C)***.

Neurophysiological control

Neurophysiological control is described across two dimensions, namely posture and fine motor skills. How we position the limbs of our body, i.e., our

intentionally assumed position, is called posture. Posture is the interplay between our central and peripheral system and is therefore fundamental to human action (K. M. Newell et al., 2006). Poor sitting posture is a longtime struggle for caretakers of older citizens (Herzberg, 1993), and it is common to experience discomfort with anterior sitting postures (i.e., forward leaning) during interaction with both close and long-distance objects. Changing bodies can automatically develop strong preferences towards a posterior type of sitting posture (i.e., backward leaning) as the body affords us to assume the optimal bodily configuration, for instance, a position that enables resting. More importantly, a posterior sitting posture does not create a distraction like maintaining balance, posture straining, or discomfort while carrying out a task, thereby allowing maximum focus on the task at hand. In general, spatial interaction demands a certain level of spatial skills in order to give meaning to an object; ***Full-body interaction (2D)*** asks for smooth and expressive movements that are observable and intelligible (Hornecker and Buur, 2006). Regardless of whether the interaction involves a standing or sitting posture, issues with fatigue, discomfort, or inability may prevent certain movements, and the probability for the user to perform movements with the gracefulness needed to communicate ***performative actions (2E)*** is greatly reduced. Similarly, the arrangement, placement, and relative positioning of the interaction mechanisms can enforce undesired ***embodied constraints (3A)***. For instance, in a scenario where a user interacts by sitting in a chair using hand gestures, elements such as the height, material, and rotating abilities of the chair, as well as how the chair is relatively placed to the other interaction mechanisms, affect the ability, quality, and duration of the interaction. Adverse straining on the neck or shoulders due to the relative positioning of the chair can also have adverse effects on the posture. The long-term effects of uncomfortable or badly designed arrangement may, therefore, result in postural strain and increase the chances for pressure sores.

The ability to perform finer finger and hand movements and gestures, i.e., the dexterity, may also diminish as the body ages. Fine motor skills involve coordinated and precise movements of hands and fingers, as well as gestures such as palming, pinching, squeezing, and clamping. One common reason for limited dexterity is arthritis or other similar inflammatory responses from the body. While the ability to interact with small-screen devices and

touch-based interfaces might be greatly reduced, using large and durable enough material might only yield negligible effects at best on the ***haptic direct manipulation (1A)***. There are several ways through which reduced tactile perception can be compensated, e.g., with size, shape, or material. However, our somatosensory system also registers skin sensations, including touch and pressure. As the skin becomes thinner, dryer, and more fragile, the use of haptic feedback directly on the body, e.g., through vibration or pulsing, may have less effective results (Culén and Bratteteig, 2013).

4.3.3. Eliciting opportunities

Returning to the framework of Hornecker and Buur (2006), I can now summarize the analysis by inserting the expected challenges described within the four themes to understand how the interaction space is affected by changing bodies. Each sensory-motor area applies to 1-3 themes and has been listed in **Table 4.3**. While the tone of this section has been heavily oriented towards sickness and disease in aging bodies, the table should not be considered a pessimistic summary of my analysis. One might be immediately intimidated by the high number of red squares, but I am not mainly concerned with those; I am looking for a potential to use the capabilities of aging bodies, i.e., the green squares in **Table 4.3**. There are more green squares than there are red – suggesting that there is indeed a big potential for interaction. These characteristics are not mutually exclusive, and experiencing multiple symptoms simultaneously would naturally reduce the number of empty squares. It is also important to remember that not everyone experiences these challenges as equally severe, and people cope differently with changes.

Table 4.3: *Overview of sensory-motor challenges and their effect on the interaction space*

Sensory-motor challenge	1. Tangible Manipulation	2. Spatial Interaction	3. Embodied Facilitation	4. Expressive Representation
Physical fitness				
Spatial and reasoning abilities		X		
Reduced physical fitness	X	X		
Involuntary body movements	X	X	X	
Information processing				
Slower information processing	X			X
Neurophysiological control				
Postural limitations		X	X	
Diminishing motor skills	X			

Nevertheless, I choose to keep a positive attitude towards the results from this analysis. Humans are not biologically immortal, and disabilities will inevitably appear at some point in our lives. But by acknowledging the most likely challenges we will encounter in interaction and introducing some design considerations to counteract or delay their influence, I can focus on the remaining capabilities and let those shine through. The changing nature of older bodies will necessarily close some design spaces as we have fewer opportunities to act in the world, but it does not automatically equal a reduction in abilities to interact. Building on the phenomenology of the lived body, I focus on still-inhabited capabilities – as well as see capabilities as a combination of bodies and artifacts – to demonstrate how a reduction of capabilities does not automatically have to be a problem.

As such, the final step before I introduce the design framework is to use my design considerations from **Table 4.2** from Chapter 4.2.7 to look for design opportunities. To repeat, the design considerations were: *(1) adaptability, (2) arrangement, (3) movement, (4) relative positioning, (5) interaction mode, (6) physical/material attributes, (7) configuration, (8) capacity, and (9) response*. The opportunities I now seek will help address likely interaction challenges from the very beginning rather than having adjustments and adaptations added on top of a finished design to support challenges that may arise over time. However, they should not be considered rules implying certain methods or guidelines suggesting specific practices

(Dourish, p. 161); these opportunities are intended to direct the designers' attention towards that which should be considered important when investigating, evaluating, and designing in accordance with my theoretical perspective. They help address the nature of the interaction between technology and aging bodies, and they describe one specific aspect of interaction that can provide a starting point for the investigation of a larger phenomenological dimension. As I use the design consideration one by one to find opportunities for design, I will use the notation ***design consideration → design opportunity*** to emphasize the relationship between the design opportunity we choose and the design consideration it addresses. Some of the design considerations are almost intrinsic opportunities by themselves, and the distance between consideration and opportunities might seem short in some cases. Nevertheless, it is important to articulate all moves I make to follow my reasoning because other misleading interpretations might come to the reader's mind if I leave any room for confusion.

Adaptability → Blending in with existing context

The context of the home is important as it holds various physical objects that carry meanings and memories important to us (Nilsson et al., 2003; van den Hoven, 2004). The physical manifestation of devices and technologies puts additional pressure on adapting the aesthetic nature of the design. As the spatial and reasoning abilities slowly degrade, the importance of designing with the context in mind increases. This is especially important when aiming for long time use; the strength of attachment is tied to the quality aspects of design (Odom et al., 2009), and to expect continued use we should build on spatial and embodied relations found within the context rather than attempting to rely on mainly newly introduced relations. For instance, Krasner (2006) argues that the habits of older people tend to be anchored in the materials in the home and that the tangibility of the home and immediate surroundings offer comfort and support their habits. Boussemart and Giroux (2007) suggest embedding sensors and parts of the system into everyday objects. Nevertheless, by offering designs ***blending in with existing context,*** we increase our chances of adapting to existing spatial relations found within the use context. Taking contextual aspects into consideration

may even allow new objects to integrate into other existing purposes as described by Ciolfi and McLoughlin (2011).

Arrangement → Situating interaction and configuration

The way we arrange and present the technologies within a given space is crucial as we develop certain spatial relations that are hard to unlearn. Situating the design space to where people live and act is also one of the principles mentioned in (Boussemart and Giroux, 2007) and can even be a difference-maker according to Waller et al. (2008). We associate certain tasks with specific locations, e.g., within the home, and we attribute intentions and opportunities with technology to the arrangement we meet. Re-arranging the objects in strategic locations in the home is part of how we develop and identify with a place (Brereton, 2013) and we should aim at shifting the interaction rather than shifting the setting as *"it is a wise rule to change as little as possible"* (Waller et al., 2008, p. 38). By ***situating interaction and configuration,*** I argue that placing the origin of interaction, i.e., in a Cartesian space, being where the user is, along with adhering spatial relations, the arrangement of technologies can align with situated intentions, preferences, and knowledge. The technology can meet the user where the user finds the intended tasks most natural, and it can help avoiding adverse physical long-term effects, e.g., straining, due to unnatural or uncomfortable arrangements. From a foreground-background perspective (Svanæs, 2001), situating the foreground activities may help us better understand this relation as we are now seeing (or detecting) bodily actions through space rather than as separated movements which are more prone to false detection due to, e.g., involuntary movements.

Movement → Incorporating familiar movements and gestures

Users often find other configurations than the designers had intended, and in the same way that technologies fail to become habituated if we do not understand how objects get adopted and habituated in their lives (Brereton, 2013), the same may be said about incorporating said object into our personal sphere. As our physical fitness and neurophysiological attributes change, our ability to perform certain movements and gestures with past level of refinement change accordingly with altered embodied behavior, due to, e.g., gait, reaction time, or involuntary movements. Such symptoms of aging may

also reduce our ability to attain new abstract movements. Certain types of interactive systems, such as those relying on embodied facilitation, may experience challenges in perceiving our intentions correctly. Hence, ***incorporating familiar movements and gestures*** suggest that we should allow the user to continue relying on those input mechanisms they are familiar with and masters (Larssen et al., 2006) rather have the system adapt its detection procedure or algorithm. Decreased flexibility, reaction, and movement speed may change how we move and act in the world, but may still hold a strong optional to convey our intentions if the system adapts to the bodily and spatial changes.

Relative positioning → Allowing spatial reconfiguration

When we experience changes to our neurophysiological control, we may simultaneously experience a shift in preferred or feasible bodily configurations, e.g., through changes in postural preferences. It is likely that such changes may alter our maximum grip on a given interaction and the realignment where the user gradually discovers a new maximum grip may require new spatial configuration of the interaction. By ***allowing spatial reconfiguration*** of the interaction, we can increase the likeliness of the interaction remaining optimal even when the optimal gestalt changes as we support a re-arranging of objects in the home along with our capabilities' change (Brereton, 2013). This becomes even more important when introducing new interactions where the user is expected to mature skills which may also alter preferences over time through repeated exposure (Dreyfus, 2002); one spatial configuration may be needed for a novice user but may become disfavored for advanced users who find their maximum grip through a different relative positioning.

Interaction mode → Building on lifelong habits and routines

Building on familiar lifelong habits and routines remains an important motivation in my dissertation. However, it can also be considered a specific design opportunity that helps to minimize the cognitive effort required for users experiencing a decline in information processing abilities. It can also be considered an approach that minimizes the chances of confronting users with something they cannot do (Ciolfi and McLoughlin, 2011). The perceived

familiarity of a design, including the interface, can by itself draw on experiences to provide the user with *"an opportunity to act"* (Bakke, 2015; Raskin, 1994) Our lifelong experience of acting in the world has generated an array of refined movements that constitute our reflections, reactions, and responses to environmental stimuli. These responses could be considered sediments (Robertson, 2005) having been refined through repeated exposure. Not disturbing existing habits (Marques et al., 2011) and building habits on top of existing routines and familiar interfaces (Nilsson et al., 2003; Waller et al., 2008) have also been emphasized in past findings. Al Mahmud et al. (2008) even discuss building on elements of game experience, e.g., game rules, when designing new experiences. ***Building on lifelong habits and routines*** helps us target those actions and responses that are natural – i.e., purposive (Dreyfus, 1996) – reactions to environmental stimuli; these situated responses are more likely to remain less dependent – or even independent – of mental representations.

Physical/material attributes → Addressing physical/material dimensions

Objects themselves hold qualities (Brereton, 2013), and how we perceive and use an object in an interaction is closely linked to how we feel the object in a haptic or kinesthetic sense (Larssen et al., 2006). Physicality and materiality are dimensions that influence this aspect of our experience of objects, in particular, those objects aiming to become or remain incorporated. When using incorporated objects to perceive the world, such objects should be designed to remain incorporated in our structural lived body (Svanæs, 2001). For instance, if reduced hand strength prevents us from using a white cane optimally due to poor grip, redesigning the handle with different materials or physical attributes may help the white cane remain purposeful. Ciolfi and McLoughlin (2011) and Nilsson et al. (2003) stress the importance of material consideration as it is linked with our ability to connect with the environment. Enabling technology that is designed to act similarly, i.e., to either become or remain incorporated, should aim at ***addressing physical/material dimensions*** in the search for the ideal attributes. Greenhalgh et al. (2013) argue that material features impact whether technologies will be used or not. For instance, the experience of wearing a safety alarm with a cold and hard

metal strap on the hand may yield very different experiences with regards to how external the body perceives the object compared to a leathery and warm strap.

Configuration → Supporting multiple configurations

People rely on prior knowledge when manipulating digital objects, and as past experience differs, providing users with multimodal interaction can be a strategy to provide users with choices (Naumann et al., 2010). Physical changes can introduce the need for new configurations. For instance, the introduction of mobility aids would alter the configuration between the user and technology. This point is also made by Toombs (2001) who describes the change to the bodily range when using a wheelchair. The way we can – or prefer – to approach an interaction is a mere reflection of our embodied capabilities. If we need to stand further away from an object because now there is a walker between us and the object, then surely the circumstances have changed. But when we sit down, we are interacting with the object like everyone else. A system ***supporting multiple configurations*** would acknowledge that different users, or even the same user, may want to interact with the system through different configuration.

Capacity → Adapting the design to changing capabilities

Our physical fitness should not be considered a static and constant value, but rather a continuous development that alters our bodily skills. The change can manifest itself quickly due to for instance an accident, or it may be a matter of gradually decline; they are sometimes only temporary, e.g., due to side effects from medication or minor accidents, and they may also be positive change over time. Offering various configurations is an important part of why multimodality is interesting for inclusive design (Naumann et al., 2010), but also a way for us to support different bodies interacting with the same piece of technology. Forcing one way of interaction may suggest or even enforce (as with the case of Marques et al. (2011)) rules of behavior that are undesired, uncomfortable, or unfeasible to the user. Variations in capabilities will be inevitable and ***adapting the design to changing capabilities***, i.e., acknowledging that the users' capabilities will not remain constant, can greatly improve the chances of prolonging the opportunities for interaction.

Response → Providing embodied feedback

It is reasonable to expect changes in abilities to process visual and audial information with age. Such changes can affect our bodily space and readiness towards the world. As we gradually experience a decline in these capabilities, the system should not lose its ability to communicate its feedback to the user. Augmented feedback is mainly directed towards our cognitive skills, and an alternative to such feedback would be a system ***providing embodied feedback*** where the movement itself constitutes the action that provides the feedback. Djajadiningrat et al. (2002) and Wensveen et al. (2004) apply the term inherent feedback to in the discussion of this type of feedback where the action itself provides the feedback rather than additional sources, and the use of immediate feedback as soon as goals are reached is also encouraged by Brox et al. (2011).

4.4. The design framework

I have arrived at the final version of my theoretically informed design framework, illustrated in **Table 4.4**. The extent of this chapter, as well as the previous one, has been necessary to explain the backdrop of this framework as it has been constructed, not found. As such, it is intended to hold the tentative theory of the phenomenon under my investigation – it supports and guides the rest of my design (Maxwell, 2012, p. 39). This design framework blends together the related concepts, considerations, and opportunities drawn from the fields of phenomenology and TI with emphasis on sensory-motor changes in aging bodies. It is not derived from my empirical findings, but rather from theory and related work that can now guide my own research; it will help direct the way I facilitate design processes, decide what factors and variables that mainly concern me, as well as provide a platform for me to support my justification later. As already mentioned, the novelty and contribution of this framework come not from the concepts themselves or their relevance to newer design paradigms, but rather the way I relate theoretical concepts with concrete considerations and opportunities for design practice and understanding within my specific space.

Table 4.4: *The theoretically informed design framework*

Pheno-menological dimension	**Theoretical concept**	**Design consideration**	**Design opportunities**
Everyday living space *(Space)*	Spatial awareness Foreground/background Concrete/abstract movements	Adaptability Arrangement Movement	Blending in with existing context; Situating interaction and configuration; Incorporating familiar movements and gestures
Digital artifacts *(Objects)*	Maximum grip Incorporated objects	Relative positioning Interaction mode Physical/material attributes	Allowing spatial reconfiguration; Building on lifelong habits and routines; Addressing physical/material dimensions
Changing bodies *(Body)*	Bodily schema Bodily space Bodily skill	Configuration Capacity Response	Supporting multiple configurations; Adapting to changing capabilities; Providing embodied feedback;

While the framework does not suggest any specific methods or approaches, the design considerations can help determine the appropriateness of different methods. The design considerations are not exhaustive and could be further tailored or expanded for a more specified user group or type of technology, but this framework is intended to serve a purpose across various design cases and needs to remain at a level where I have some provisional points I can use to structure my understanding. Each design consideration mainly relates to one design opportunity. Each design opportunity represents an opening we can use to address an important consideration – which in turn relates back to a theoretical concept on how to understand changing bodies. By following these opportunities, I can make sure the interaction that manifests itself within and around an object in a given context draws on my theoretical understanding of how older people – with and through their bodies – experience interaction.

The subjective and contextual nature of my epistemology would not align well with a rigid framework – the way I understand interaction is not linear or unidirectional. As such, this framework is to be considered one intertwined unity, but it holds few restrictions with regards to starting point and movement within the framework. One can move between design

considerations and design opportunities, and the framework can be approached from any direction, either from the right, left, top, or bottom. The vertical axis covers all three interrelated phenomenological dimensions, but what extreme point one might begin with is not predefined. Depending on the concrete design problem being explored, one may prefer to begin in the space and choose a top-down approach, or one can start with the body and work bottom-up. Either way, the framework will always suggest moving from space towards the body or from the body towards space to emphasize their intertwined relation. If one attempted to theorize and understand people, technology, and their relation, it would be preferable to move from left to right along the horizontal axis, but in cases starting with design practice or research artifacts, one can just as easily move from right to left. While there is room to study isolated aspects, only the combination of multiple instances would cover enough aspects of the interaction to support theoretical reflections – regardless of which direction or starting point one chooses. As such, even if only considering the spatial-contextual dimension, one cannot escape the underlying epistemology where we experience space through the lived body as every piece of the framework is anchored in a phenomenological reasoning.

This design framework will follow me in the rest of the dissertation. I will use its design considerations to help me infuse the PD methodology with indicators on relevant research concerns, and I will also use this framework to analyze various exploratory design outcomes developed across different research explorations. I will eventually use the analyses of selected design outcomes to generate knowledge that can mature this framework into my final theoretical contribution in Chapter 7.

Chapter 5

A methodology for enabling interaction

The philosophy of phenomenology includes both an ontological and an epistemological understanding that must shine through in my methodological approach. Dourish refers to this specific underlying relationship as the *"Phenomenological Backdrop"* (2004, p. 103). This chapter will use the design framework introduced in the previous chapter to connect activities and choices in the design process with the underlying theoretical lens – thereby bridging the gap between theoretical understanding and practical application in my design space. It will also address the practical limitations of engaging older adults in design activities and use the reflection of these practical concerns to explore further how the design process can be further facilitated to support participation on own terms.

My theoretical lens demands a methodological approach that aligns with a heavy emphasis on the subjective perspectives of phenomena. Moreover, I needed a critical yet respectful methodology that allowed enough freedom to incorporate perspectives on embodiment into the design process. To support both my underlying values as well as my epistemological reasoning, I chose PD as my methodology. As I have discussed related work within the PD community in **Paper 3**, this chapter mainly concentrates on adapting the phenomenological PD process to the practical concerns of working with older adults.

5.1. The values of PD

The beginnings of PD can be traced back to political, social, and civil demands in the 1970s. In particular, the workplace democracy movement that emerged with among others Kristen Nygård (see, e.g., Nygård and Bergo (1975)) in the late 70s and early 80s emphasized a new approach with

underlying democratic motivations. Critical to their vision was to allow people who would be affected by the technology to influence its design. The fundamental principles and motivations were socio-political values such as democracy, power relations, emancipation, mutual learning and co-realization that served as the underlying and unyielding values that transcended the particularities of the execution (Simonsen and Robertson, 2012, p. 2). Considering the broad range of methodologies applied within the field of HCI and ID, the uniqueness of PD lies within this set of core principles. For instance, improving the knowledge upon which systems are built, as well as enabling people to develop realistic expectations, are not novel or unique characteristics when compared to existing development approaches (Gregory, 2003); it is the underlying idea of a design democracy with participation right in decision making that sets this approach apart and simultaneously anchors its political and cultural values in the Scandinavian post-war tradition. In the rest of this dissertation, I will refer to mutual learning, co-realization, and having a say as the three core principles of PD (Bratteteig et al., 2012; Kensing and Greenbaum, 2013).

Another prominent trait of PD which is highly relevant to my design space of enabling interaction is its emphasis on the imagined future. The idea of allowing people to participate in the development of technology that they would later encounter in their daily lives gives PD an intrinsic future-oriented perspective. This is one of the characteristics of PD that has remained persistent throughout the development of the field; the earliest roots of PD were contextualized to the workplace environment, yet researchers have spent the last decades on expanding the application of PD beyond that specific context and employed PD in other more relevant contexts such as home-bound or care home contexts. As such, applying PD to co-explore unfamiliar technologies is not a novel approach (see, e.g., DiSalvo et al. (2012)). However, the idea of methodological development in PD as a response to shortcomings in properly engaging older adults in PD activities has been discussed and advocated previously (Müller et al., 2015, p. 2295; A. F. Newell et al., 2006, p. 998; Vines et al., 2012b, p. 1176). One line of response to this call – without necessarily adapting a PD perspective – has been the development of design-oriented approaches that can expand the ways in which we engage older adults (Blythe, 2014; Blythe et al., 2015; Vines et al., 2015a).

This use of design-oriented research have opened up new possibilities for engaging participants. Examples include design fiction and critical design as anti-solutionist strategies (Blythe et al., 2016, p. 4968), a thespian approach involving actors and role-play (A. F. Newell et al., 2006, p. 1000), invisible and speculative design (Vines et al., 2015b, p. 88), and experience-based PD workshops (Müller et al., 2015, p. 2299).

Similar to these studies, most of my participants have very limited experience with modern technologies and their interfaces and interaction mechanisms. To combine this oldest-old generation with state-of-the-art technology unfamiliar even to majorities of younger generations – such as the induction chargers in **Paper 5** – I have to tailor a phenomenological PD process where participants can explore their own lived experiences in the present. As I want to focus on providing participants with actual exploration of embodied relations rather than having to imagine them, I will not adapt any approach directly from the mentioned design-oriented studies, but instead try to relate their work to the methodological choices I make throughout this chapter. That being said, I do recognize relevant work within the PD community that can provide insight applicable to my research. Particularly relevant to my design space is the application of PD in the homely sphere with older participants or specific co-development of enabling technologies. For an extended outline of related work on PD and old people, see **Paper 3** and (Joshi and Bratteteig, 2015).

While many methodologies suggest and even encourage user participation, one characteristic trait of PD is its consideration of correctly and respectfully involving users. A correct involvement does not mean to follow predefined procedures, but rather that the way in which participants are included support the fundamental principles of PD, e.g., democracy, emancipation, and trust. Participants are invited not only to have a voice but also to have a say (Bratteteig et al., 2012, p. 129). Accordingly, rather than emphasizing a formula-based way of organizing a fixed set of design activities, PD is more concerned with remaining true to its underlying values. As each use practice will be unique, every PD process will be different. Hence, PD provides enough freedom for me to facilitate a unique design process tailored to the distinctiveness of the design space while constantly compelling me to find opportunities that allow participants to contribute on their own terms

rather than just detaching them from the decision-making in the design process. However, this flexibility does not equal methodological impreciseness. I would argue that it suggests the contrary, i.e., that I need to be even more specific on exactly how I shaped my design process to best support the participants' role as co-designers without compromising the core values of PD.

This natural emphasis of continuous inclusion of users throughout the whole design process helps me remain true to the goal of the dissertation, i.e., allowing older participants to be who they are with those capabilities they inhabit and still find a role in shaping their own futures by co-designing enabling technologies. Excluding participants from design activities, even only a few activities, automatically challenges their autonomy, which in some cases can lead to highly undesired outcomes, e.g., invasive, demeaning, or oversimplified technologies. These three specific symptoms have been observed within my own empirical context (see **Paper 1** and **Paper 2**) and served as the ultimate motivation for selecting a more inclusive design process. While other methodologies often applied within design research, e.g., User-Centered Design (UCD), could potentially save both time and resources through a more strategic inclusion of participants, I did not find that they resonated with my values – nor with the epistemological reasoning I make – in the same way that PD, with its flexibility, could.

Lastly, but equally important, PD supports design processes that I believe respect the older adults as able-bodied participants with enough capabilities, competence, and experience to contribute to the design process as equal co-designers. The whole rationale behind employing the phenomenology of the lived body as the theoretical lens was to discover new ways of appreciating the long-lived competence of the older population. It would mean nothing if I did not transfer this theoretical perspective over to my practical application by recognizing their potential to contribute to a design process; this would be particularly ungracious in a design space like mine lying so close to their personal sphere.

5.2. Infusing phenomenology into PD

While the previous section described the underlying values of PD, the phenomenological nature of my particular PD methodology will be explained through three main characteristics. The three characteristics are structured as

three separate themes for clarity, but I stress that they are all interrelated and only meant to be considered as complementary parts of a whole.

5.2.1. Capturing embodied experiences

In a phenomenological study, we focus our attention on the lived experiences of phenomena rather than individual stories; our goal is to gradually expose common perspectives on how participants experience a phenomenon rather than sharing narratives of single individual stories (Creswell, 2012, pp. 57–58). When I bring attention to a specific example by reciting a single participant's experience, the objective is to demonstrate a single instance of a larger issue that spans across participants. To organically integrate Merleau-Ponty's phenomenology of the lived body into a PD process, the methodology needs to revolve around embodied experiences, as Merleau-Ponty defines the body as the epistemic center, i.e., the *"vehicle of being in the world"* (Merleau-Ponty, 2002, p. 94).

Merleau-Ponty's work suggests that we reconsider the understanding of object experiences, which in my design space related mainly to the digital artifacts that enable interaction. If we for a moment return to *"Phenomenology of Perception"*, we register that Merleau-Ponty claimed our perception to end in objects (Merleau-Ponty, 2002, p. 77). He applies an object-horizon structure to explain how we are unable to grasp an object from all possible perspectives simultaneously, and that how we simply see things are not how they are ultimately experienced by most people. While this spatial and temporal perspective allows us to separate objects from each other, objects can still *"see"* each other, and they are always mirroring all the other angles from which co-existing entities are also seeing the object (Merleau-Ponty, 2002, p. 79); it is the three-dimensional sum of all these alternatives perspectives that truly reveals our transcended experiences of objects. Kelly explains this object transcendence, i.e., the phenomenological distinction between two-dimensional facades and three-dimensional entities, as a rarely made distinction due to us inadvertently having experiences of *"objects rather than as of mere façades"* (Kelly, 2005). Nevertheless, in my approach, I need to acknowledge our visual perception's immediate inability to appreciate the entirety of a phenomenon – especially among participants who are unable to comprehend the phenomenological idea of object transcendence – when

disentangling the phenomena I study. I accomplish this by incorporating exploration and reflection on embodied experiences to better help participants recognize the totality of the interaction.

As described in most of the included papers, I have made significant efforts to facilitate the activities of in adapted PD process to support exploration and reflection on embodied experiences. For instance, having participants try out a broad range of existing technologies before committing to any decision-making helped them concretize and communicate their own expectations; experiencing alternative designs helped participants re-discover old embodied experiences as well as discover new maximum grips that better aligned with their current bodily capabilities. Furthermore, it yielded a different design process than if participants had relied on imagination alone. This way of using off-the-shelf technology in PD workshops including older adults has also been applied by Müller et al. (2015, p. 2299). The precise nature of my methodic procedure of this approach has been described in **Paper 3** and **Paper 5**.

To facilitate for the design considerations in my design framework mainly concerning the body, i.e., ***configuration***, ***capacity***, and ***response***, the example from **Paper 5** on accessing embodied experiences through exploration of existing alternatives demonstrates my approach. Providing users with a wide range of digital artifacts with different interaction mechanisms helped users learn more about their own capabilities and preferences. **Figure 5.1** below illustrates how participants from the research exploration *Inductive Charge (RE #10)* freely explored various configurations to inform their decision-making in later design activities.

Figure 5.1: *Participants exploring a range of existing alternatives to inform decisions*

I also strived to coordinate these experiences in ways where participants could collaborate and observe each other while exploring digital artifacts, both existing and new alternatives. Our everyday experiences cannot escape space

as it permeates our thinking (Dourish, 2004, p. 88), and the presence of other people during explorations contributed to evoke the curiosity I attempted to foster among the participants. The relationship between the subject-body and other bodies is complex, and according to Merleau-Ponty, there is always a contrast between what we recognize as true internally and what we based on our relationships with others conclude as our particular set of opinions (Merleau-Ponty, 2004, p. 87). With this understanding in mind, one could argue that mutual learning is strengthened by the very presence of other people alone.

> *"There is no way of living with others which takes away the burden of being myself, which allows me to not have an opinion; there is no 'inner' life that is not a first attempt to relate to another person. In this ambiguous position, which has been forced on us because we have a body and a history (both personally and collectively), we can never know complete rest. We are continually obliged to work on our differences, to explain things we have said that have not been properly understood, to reveal what is hidden within us and to perceive other people." (Merleau-Ponty, 2004, pp. 87–88)*

In the research exploration *SmartWalker (RE #9)*, we focused on movement when exploring indoor navigation utilizing the mobility aid's movement as the means of input. Since almost 90 % of the residents in this specific research exploration relied on mobility aids (Källström et al., 2015), the presence and awareness of other people being the same space with their own patterns of movement were important to explore the three spatial design considerations: ***adaptability***, ***arrangement***, and ***movement***. We did not want to have non-users of mobility aids attempt mimicking these other users, and as such, the presence of others became a necessity to recreate a realistic context in which spatial aspects could be truly experienced. One challenge was narrow halls, and users of mobility aids would usually have to adapt movement if encountering another similar user, and without other people present, the participants would not be able to recreate realistic movement patterns in space. **Figure 5.2** shows some of the older adults that participated in these activities.

Figure 5.2: *Participants recreating movement patterns*

Another essential element of my initial data gathering was to explore new ways of collecting data that better reflected participants' embodied experiences. I wanted to bring attention to the movement of the body, like the suggestions of Larssen et al. (2004). Their work suggests that along with the affordances of technology, the forms of movement that the body allows or disallows should be a primary focus for design. One prominent example was the research exploration *Leap (RE #1)* where I attempted to learn about ***movement***, ***relative positioning***, and ***configuration*** during interaction with everyday technologies. In this study, I had two requirements: first, I wanted the method of inquiry to be non-intrusive and with particular emphasis on minimizing physical straining; second, I wanted to get closer to the first-hand experience of the participants than I would be able to capture with only interviews and observations. The solution was to follow the phenomenological concept of incorporated objects (see, e.g., Brey (2000)) and use everyday objects that had already blended into their bodily schema as the basis. More precisely, I used three types of cameras: (1) glasses with a hidden built-in camera, (2) Google Glasses, and (3) a tie-clip camera. These cameras are depicted in **Figure 5.3**. These were light-weight, non-intrusive, and did not conflict with their daily routines. It also generated video data suited for insightful analysis, for instance, movement analysis as seen in (Larssen et al., 2007a; Loke and Robertson, 2010). While I never aimed at analyzing this video data in a similar manner, it still served as an important input in later design activities. The first-perspective angle in the videos allowed participants to *"see"* (Merleau-Ponty, 2002, p. 79) each other's experiences rather than only hearing about it. The use of such props was also one way of allowing

meaningful engagement and new modes of agency for the participants similar to the use of the glove in (Light, 2011, p. 2239) as it helped them understand how technologies would manifest themselves in their lives.

Figure 5.3: *Glasses with hidden built-in camera, Google Glasses, and a tie-clip camera*

5.2.2. Communicating through an embodied language

Building on the previous theme, I also attempted to use these embodied experience as the platform for facilitating dialogue. My assumption was that enriching communication and discussion with an embodied perspective could reinforce the mutual learning as well as provide a broader opportunity to express expectations and preferences. As I am designing enabling interaction with participants who might be unfamiliar with the opportunities current and future technology offers, I hold that exploration through a dialogue-driven discussion alone limits both the mutual learning as well as the decision making; participant simply cannot comprehend the wholeness of the interaction with unfamiliar technologies, and in most cases, nor can we as experts on technology. A technology-focused dialogue-driven process cannot fully capture the participants' embodied competences, i.e., the inhabited and historic set of tacit skills manifested as their lived body. I believe utilizing embodied competence can greatly contribute to participants' own and shared perception of how the various technologies harmonize with their own capabilities. By facilitating embodied exploration, participants can get a first-hand experience of how something feels rather than hearing about it through the experiences of others, thereby making a better-informed decision throughout all phases of the PD process.

Another important benefit of PD is its ability not only to reveal and communicate perspectives but also important use practices (Bratteteig et al., 2012, p. 135). This has been a central aspect of PD throughout its development. Three decades ago, Ehn drew on the language-game philosophy of Ludwig Wittgenstein to suggest a shift from *language as description* towards *language as action* where use practice was highlighted (Ehn, 1988, 1993, p. 62). Despite building on a Wittgensteinian and constructivist reasoning, Ehn's discussion of language – and in particular the role of the language we use to understand practice – brings up an important perspective on facilitation that applies to my PD process as well. As I attempted to build a design process that supported lifelong use practice, the language became an integral part of how all participants, including myself, understood and shared use practice through embodied experiences.

Again, it is important to remember that the application of PD has developed from its original context and traditional participants. While PD began in a workplace environment with its main participants being mainly employers and employees, its application grew out of the professional scene a long time ago; PD's shift into everyday contexts has expanded the range of participants included as well as the design spaces we explore – from professional employees in a professional setting with an established shared language to informal contexts with more personal perspectives and fewer common terminologies to build upon. The past decades have also seen increasingly more technologies enter our personal sphere and range of devices we encounter builds on a much richer range of interaction and interface metaphors. Thus, when I attempt to explore and understand use practice in my empirical context, I recognize that the premises have changed and that my process needs appropriate adaptions to successfully *legitimizing those marginalized* (Björgvinsson et al., 2010, p. 50).

Technologies shape our language; new technologies introduce new terms, new meanings, and new associations that gradually blend into our daily language. In my empirical work, the way the participants spoke about the technology revealed several interesting aspects, e.g., their prior experiences with technologies as well as strong pointers of their generational belonging (see **Paper 1**). This organic property of our evolving language grants a precise and highly-communicative vocabulary in a professional context.

However, it is this property of our language that simultaneously challenges the mutual learning in my PD process and demands adaptations. When I consider the long-lived lives and varying age spans of my participants, it becomes difficult to find common ground where all participants can understand and describe enabling technologies through the same technical terms or devices.

Furthermore, the language applied should compensate for any communicative barriers among participants and designers. My pool of participants consists mostly of people above the age of 80 with little prior experience in non-Norwegian communication. In most cases, new linguistic additions to our everyday language emanating from a technological domain are either derived from English terms or kept in their original forms. This further complicates the premise as most of my participants are unable to fully participate in a design process that is partially bilingual and simultaneously expects them to be equal designers. Shifting to a body-centric language with emphasis on how we can experience the technology rather than through an objective and descriptive language allows participants to continue the dialogue in their native tongue rather than relying on technical and foreign terms that they might not fully comprehend.

Using an embodied language also contributed to less risk of designer-dominance. Grönvall and Kyng (2011) point to this being particularly dangerous when involving ill or weak participants. To fully participate in a PD process, a participant should not be limited to only answering questions; they should also be able to ask them. Early on, I saw that not giving the participants an opportunity to ask the questions made the design converge towards solutions that not all participants preferred or understood. As we designers were the only ones asking questions we forced the design problem and its answer to address the world we know, i.e., the technological world. In one of my first research explorations *Leap (RE #1),* I explored alternatives to the implementation of the lighting systems in the apartments. As I only explored options based on novel technologies, e.g., sensor-based lighting, self-adaptive lighting, and remote-controlled lighting, I forgot to include the most preferred option, namely the traditional wall-mounted light switch. I mistakenly believed the alternative to the existing technology to necessarily be of a technological kind. It was only during the open discussion that one participant said that she missed the old light switch; it was something she

knew, something she mastered, and something she wanted. This allowed the rest of the participants to think of non-digital technology as a valid option, and thereby expressed their new opinions on the matter in a more familiar and comprehensible language, i.e., talking through their embodied experiences. I learned an important lesson this day; if the participants are not given the time to benefit from mutual learning, how will they then be able to ask the right questions? If designers are the only ones asking the questions, we might end up forcing the answer to lie within the world that we know.

Finding a language that is closer than systems descriptions to the users' everyday practice is important in PD projects (Ehn, 2008). To support Ehn's emphasis on language as action, as well as to facilitate a body-first vocabulary, my approach relies on embodied experiences to counter apparent language barriers among the participants. The PD process puts an embodied perspective first, and the design considerations from the design framework serve as the main anchors of the dialogues. Thus, an important characteristic of my methodology is the shift of the language from a descriptive technical language to a normative and embodied language where the lived experience of the interaction is more important than the technical nature of the implementation. This facilitations relates to all design consideration of the framework, but it proved especially helpful with the design considerations that designers would usually describe with technical terms, namely ***interaction mode***, ***physical/material attributes***, and ***response (feedback)***.

5.2.3. Thinking through physical objects

Use practices are vital to the joint understanding and sharing of embodied experiences. As such, my design activities had to be facilitated in ways where participants could access these embodied use practices. Dialogue working out of devices and using that dialogue to foster both criticism and new opportunities have been seen in past studies, e.g., in (Vines et al., 2012b, p. 1175). With the example of the camera-glasses and tie-clip camera, I demonstrated one attempt at getting closer to embodied perspectives in the early stages of data gathering. To facilitate a similar experience during the succeeding activities, I heavily emphasized the application of physical prototypes. Co-construction activities where designers and users collaborate on making concrete prototypes is a central part of PD, and can historically be

considered one of the basic stages of any kind of PD (Brandt et al., 2012; Spinuzzi, 2005, p. 167). Rather than discussing design ideas through low-fidelity paper-based prototypes such as sketches, storyboards, and wireframes, i.e., prototyping techniques that do not provide direct access to embodied experiences, I structured my design process around physical prototypes. While this demanded several time-consuming adaptations to the process, I believed it was a necessity to support the embodied dialogue desired. One example of this facilitation mentioned in **Paper 3** is how we had to bring prototyping equipment such as 3D-printers to their care homes for them to be part of the prototyping activities. The heavy emphasis on research prototypes and research products also aligns with the suggestions of Blythe et al. (2015, p. 3854).

I also wanted the participants to share and demonstrate lifelong embodied experiences through objects. To achieve this, the process encouraged participants to bring in personal objects, both technical and non-technical, that they used in their daily lives. These objects became vital to the shared understanding of current use practice, but they also served as design inputs that could be incorporated directly into the prototyping. Drawing on the lifelong experience of the users to sustain a familiarity in design by using familiar metaphors, technologies, or interaction mechanisms has been advocated by former studies such as Piper et al. (2013), Vines (2012), and Vines et al. (2015a, 2015b). The various prototypes of induction chargers in **Paper 5** demonstrate how non-technical objects can serve as the basis for alternative designs that incorporates new technology while still supporting old habits. Another benefit of thinking through objects is that it could enhance the traditional means of data gathering such as interviews and observations with artifacts, either prototypes of ideas or existing technologies. Having participants explain challenges and opportunities through familiar digital and non-digital artifacts allowed easier articulation by building on concrete experiences. **Figure 5.4** shows three examples of participants communicating past and current experiences through their everyday objects. This way of enabling participation helped participants bring attention to details that would otherwise have been hard to communicate. This was, in particular, the case with understanding the role of the design considerations *interaction mode* and *physical/material attributes* in existing embodied habits.

Figure 5.4: *Everyday objects were used as thinking tools*

The exploratory design outcomes from the various PD activities also held an important communicative purpose. As results, they encompassed all the various perspectives that arose during the design process. Ehn's discussion of language suggests using the design results as a shared platform to bridge the gap between participants and designers, something that supports empowerment and participation (Spinuzzi, 2005, p. 168). As we discussed in **Paper 3**, few participants had the desire or capacity to join all design activities. An important part of the arrangement became to extend the mutual learning beyond the design activities themselves by facilitating discussion and sharing among participants between design activities; as most participants resided within the same care facilities, they would regularly meet outside of our scheduled design activities, for instance during social settings. To help their ad-hoc dialogue revolve around embodied experiences, I frequently left behind design results that would allow absent participants to come directly in contact with design results rather than through other people's reiterations. We used Polaroid cameras to leave photocopies of all design results, but more importantly, we also left behind physical artifacts, such as 3D-printed prototypes. This also allowed participants to single-handedly explore the design results and make up their own minds without having to rely on other participants' explanations. **Figure 5.5** shows some of the 3D-printed input devices left behind at some point; the devices on the left are from the research exploration *Elbø (RE #14),* while the devices on the right are from various explorations and included in **Paper 4**.

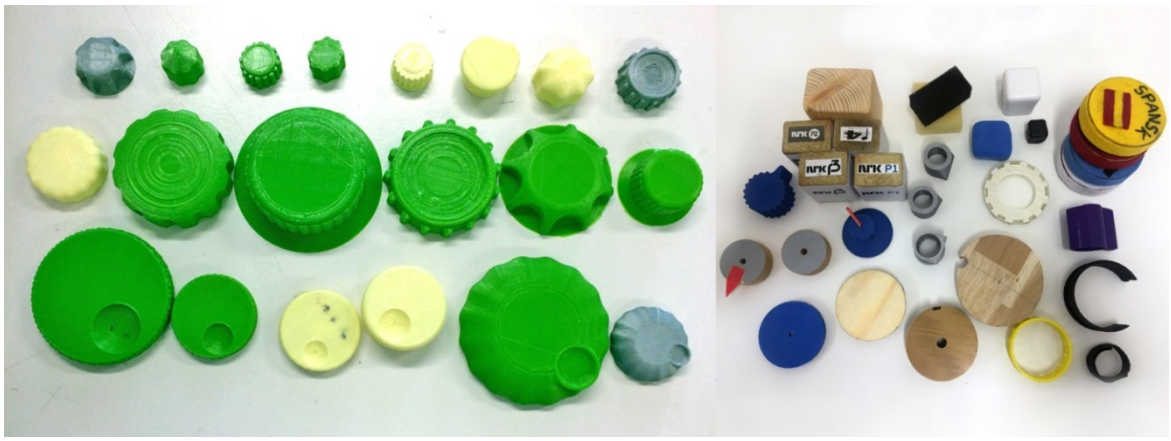

Figure 5.5: *3D-printed components used to explore various types of input*

A final reason for preferring physical prototypes is their role in supporting participants in concretizing choices. As demonstrated in **Paper 3**, through Schön's notion of design as sequences of reflective actions, we can describe a PD process as a manner of *"seeing-moving-seeing"* (Schön, 1983). This means that participants need to properly *"see"* design alternatives to make the best-qualified decision, i.e., *"moving"*. To help participants make a decision based on actual embodied experiences rather than imagined scenarios, some activities required the development of research products rather than only research prototypes (Odom et al., 2016). Only then could the design outcomes invoke the experiences I wanted to build upon. The claim behind this choice is that the more realistic use practice experience the design results can induce, the better chance we have at not ending up with stretched activities where *"move"* after *"move"* is undone due to a mismatch between expectations and experience. Furthermore, the final *"seeing"*, i.e., the evaluation, depends on whether the design results demonstrates to the users that the situation is understood differently as well as on whether the design results matched the expectations or not. As my participants had limited time for participation (see **Paper 3**), I aimed at providing the best foundation before making the next *"move"*.

5.3. Research methods

I have described the way the phenomenological lens influenced the methodology through three main characteristics. I have summarized these characteristics in **Table 5.1** below and outlined the facilitations they formed

and the related design consideration from my design framework. As we see, the different design considerations have influenced different parts of the facilitation.

***Table 5.1**: Methodology characteristics summarized with facilitation and design considerations*

Characteristic	Facilitation	Main design considerations addressed
Capturing embodied experiences	Participants using a range of existing artifacts prior to decision-making to help concretize and communicate embodied experiences and expectations	Configuration Capacity Response
	Participants exploring embodied relationship with other people in realistic contexts to recreate realistic actions and reactions	Movement Arrangement Adaptability
	Participants using incorporated everyday objects to capture their experiences from a first-person perspective that they can use to share experiences with others	Movement Relative positioning Configuration
Communicating through an embodied language	Participants applying a subjective and embodied language rather than a technical one to help articulate experiences	Interaction mode Physical/material attributes Response
Thinking through physical objects	Participants communicating challenges and opportunities with the help of familiar digital and non-digital artifacts	Interaction mode Physical/material attributes

I have abstained from describing concrete research methods so far in this chapter because I consider the methodological reasoning more important to my approach rather than the specific methods I have employed. The design considerations from my design framework can help inform and adapt most methods applied in design research to align my phenomenological lens. As most of the research explorations I have carried out throughout this

dissertation also have resulted in their own papers, a description of most methods have already been provided in the respective papers. However, I would like to address two points related to research methods in this section that have not been directly addressed in any published papers. First, I would like to use my design framework to demonstrate how it relates to literature within HCI and ID on research methods and what we can learn from past research. Second, I would like to describe two specific research methods that we applied in the research exploration *Materiality (RE #13)* to demonstrate how the phenomenological lens opens up new opportunities to facilitate exploration – in this case, accessing embodied experiences without the *"disturbance"* from visual stimuli and cues.

5.3.1. Using the design framework to build on related work

The eight theoretical concepts found in my design framework have all been operationalized in past research, and as such, there are many opportunities to relate my own methodic procedure to relevant examples found in related work. **Table 5.2** presents an overview of past studies involving these concepts to either investigate the current role of bodies in interaction or to inform the design of new interactions. The rightmost column in the table is not divided into rows as the methods and techniques applied may be applicable in my design space beyond what the authors intended them to have, including addressing additional concepts. However, not all contain concrete methods and techniques transferable to my design space, so I only present a short description of the most relevant work among these related studies before giving a summary of all the research methods applied across all the research exploration of this dissertation.

Table 5.2: *Overview of relevant methods and techniques from related work*

Concept	Related work	Relevant methods and techniques
Maximum grip	(Dreyfus, 1996, 2002; Tholander and Johansson, 2010; Yakhlef and Essén, 2012)	**Demonstrative interviews** (Larssen et al., 2007a; Moen, 2007; Tholander and Johansson, 2010; Yakhlef and Essén, 2012) **Movement observations** (Antle et al., 2009; Brereton, 2013; Loke and Robertson, 2007, 2010; Yakhlef and Essén, 2012) **Video analysis** (Antle et al., 2009; Larssen et al., 2007a; Loke and Robertson, 2010; Tholander and Johansson, 2010) **Field study** (Larssen et al., 2007a) **Exploring through concept prototyping/project** (Antle et al., 2009; Djajadiningrat et al., 2007; Loke and Robertson, 2013; Moen, 2007; Tholander and Johansson, 2010) **Experience analysis, reenactment** (Larssen et al., 2007a; Loke and Robertson, 2009, 2013) **Scoring and movement analysis** (Djajadiningrat et al., 2002; Loke and Robertson, 2007, 2009, 2010, 2013; Moen, 2007) **Comparative testing** (Antle et al., 2009)
Bodily space	(Aho and Aho, 2008; Brey, 2000; Larssen et al., 2004, 2006; Robertson, 2012; Svanæs, 2013; Toombs, 2001)	
Bodily schema	(Antle et al., 2009; Brey, 2000; Crossley, 2001; Svanæs, 2013; Toombs, 2001; Yakhlef and Essén, 2012)	
Incorporated objects	(Larssen et al., 2006; Svanæs, 2013; Toombs, 2001)	
Spatial awareness	(Brereton, 2013; Brey, 2000; Loke and Robertson, 2010; Svanæs, 2013)	
Concrete and abstract movements	(Fogtmann et al., 2008; Larssen et al., 2007a; Loke and Robertson, 2010, 2013; Moen, 2007; Svanæs, 2013; Tholander and Johansson, 2010)	
Foreground and background activity	(Svanæs, 2001)	
Bodily skills	(Brey, 2000; Clark, 2007; Crossley, 2001; Djajadiningrat et al., 2007; Fogtmann et al., 2008; Larssen et al., 2007b; Robertson, 2012; Svanæs, 2001; Tholander and Johansson, 2010; Yakhlef and Essén, 2012)	

The work of Loke and Robertson (2007, 2009, 2010, 2013) is extensive and relevant to my research. They explore first-person qualities of experiences through exercises and practices in dancing (2010), and help visualizing movement through techniques such as video analysis, Labanotation movement analysis, scoring, and shape analysis. In addition, demonstrative interviews with participants acting out movements and practice were conducted in search for *"in-the-moment"* sensations (2007). Their design methodology of *"Moving and Making Strange"* also provide a range of relevant methods and techniques found within HCI literature that can help understanding and describing movements, such as reenactment, personas, scenarios, physical role play, body storming, and experience prototyping (2009, 2013). Larssen et al. (2006, 2007b, 2007a) provide important understanding of the bodily aspect of the interaction between bodies and technology through their feel dimension, i.e., the haptic and kinesthetic sense. They apply moving and re-enactment to exemplify empirically-based descriptions as ways of informing designers of the experiential nature of movement (2007b). The notion of within-reach versus out-of-reach in (Larssen et al., 2006) provides interesting perspectives on body-thing coupling, which makes it relevant for my design space. In (Larssen et al., 2007a), interviews, participant observations, and case studies were used to explore kinesthetic experience and external feedback. Kinesthetic interaction is central to the work by Fogtmann et al. (2008) and addresses bodily potential towards interactive systems. Their work uses sensor-based interaction to explore four different interactive systems focusing on developing bodily skills, generating abstract movements, providing meaningful mappings, and guiding bodily stance. Kinesthetic movement is also the emphasis of Moen (2007), who similar to Loke and Robertson (2010), turns to modern and contemporary dance in search for terms and notions that can vocalize movement. The prototype presented in the paper explores two relevant perspectives through the use of accelerometers. First, it demonstrates how designs can be personalized and how external objects are incorporated to the body schema. Second, it demonstrates a design that recognizes bodily movements and gestures, as well as provides an opportunity for the users to explore new or undefined movements. Tholander and Johansson (2010) present interaction qualities for whole-body movement-based interaction based on exploration of how skilled use of artifacts affects how we experience the

world. Semi-structured interviews and video analysis were used to capture performance, and the aforementioned prototype from (Moen, 2007) was also part of this research. Antle et al. (2009) explore various movements as mappings for parameters of a full-body movement-based augmented environment and contribute to my design space by discussing systems building on embodied metaphors. In their study, participants were instructed through four tasks, and the quantitative measurements were complemented with observation notes and video analysis.

Returning to my own research explorations, I have applied many different research methods across the different research explorations that constitute this dissertation. Some are drawn from the related work mentioned above, some are adaptations of traditional methods found in the literature, and some are introduced by me or the people I have collaborated with in the different research explorations. Since most of these research methods have been described in past papers, I have limited myself to only summarize them in **Table 5.3**.

Table 5.3: *Overview of the main methods used in each of the 14 research explorations*

#	Research exploration	Main methods
0	**Initial studies**	Home visit, interview, task-based group evaluation
1	**Leap**	Material testing, incorporated exploring, spatial prototyping, core body measuring
2	**Collaborative Change Experiment**	Usability testing, shadowing, diagnostic evaluation, case study
3	**PiRadio**	Usability testing, material testing, feedback testing, interview
4	**HomeCare Expected**	Interview, home visits
5	**Simplicity**	Task-based group evaluation, simplicity evaluation, demonstrative interview

#	Research exploration	Main methods
6	**Tangible Alternatives**	Contextual interview, focus group, embodied exploration, usability testing
7	**Motor Radio**	Psychomotor evaluation, usability testing, mixed-design ANOVA
8	**Motus**	Demonstrative interview, home visit, group observation, usability testing
9	**SmartWalker**	Home visit, spatial prototyping, interview, usability testing
10	**Induction Charge**	Material testing, familiarity inquiry, spatial prototyping, performance analysis
11	**GLiMT**	Material testing, tactile exploration, usability testing, focus group, demonstrative interview
12	**Magnetic Radio**	Spatial prototyping, blindfold testing, material testing
13	**Materiality**	Blindfold testing, material testing, demonstrative interviews
14	**Elbø**	Survey, interviews, usability testing, material testing

5.3.2. Using the design framework to open up new opportunities

Earlier in this chapter, I mentioned that I need to *"acknowledge our visual perception's immediate inability to appreciate the entirety of a phenomenon"* (Chapter 5.2.1). One way I achieved this was through blindfolded material testing and tactile exploration. I have, together with master student Heidi Bråthen, reported on these methods in the papers (Joshi and Bråthen, 2016b, 2016c), but I bring these two cases up here to exemplify methodic opportunities supported by my phenomenological lens. The blindfold testing served as a method for investigation while the tactile exploration was used to evaluate finished designs and generate new design ideas. These particular methods are tied to the design considerations ***physical/material attributes*** and ***adaptability***. The goal of the research exploration was to study whether

physical/material attributes could serve as the bridge between past experiences and new enabling interactions within my design space. More precisely, we studied whether using certain materials in digital artifacts could invoke embodied experiences that made the interaction both more familiar and context-appropriate to the participants.

In the material testing, we investigated the combinations of digital and non-digital materials to explore embodied experiences embedded in the materials. Examples of digital materials we explored include sensors, microelectronic components, conductive fabric, and paint, while examples of traditional materials explored include wood, play dough, polymer clay, acrylic, paper, and silicone. To not let the visual perception influence the natural first contact with the material, i.e., the surface (Vallgårda and Redström, 2007), all participants were blindfolded, and the objects were also covered with a cloth. Moreover, blindfolding also prevented other material characteristics such as texture and color to affect the immediate experience of the material. In the tactile exploration, we studied how the material aspects of the design outcomes from the research exploration *GLiMT (RE #11)* and *Materiality (RE #13)* related to the intuitiveness and familiarity of the interaction. We focused on whether the material aspects invoked any natural actions, movements, or gestures as a result of the contact with the material, and recorded the performance to investigate whether there was a correlation between material aspects and ability to carry out tasks. These two methods demonstrate the way the design framework and the underlying phenomenological perspective can suggest new ways of understanding the human-technology relation within my design space. **Figure 5.6** depicts some of the participants in the tactile exploration.

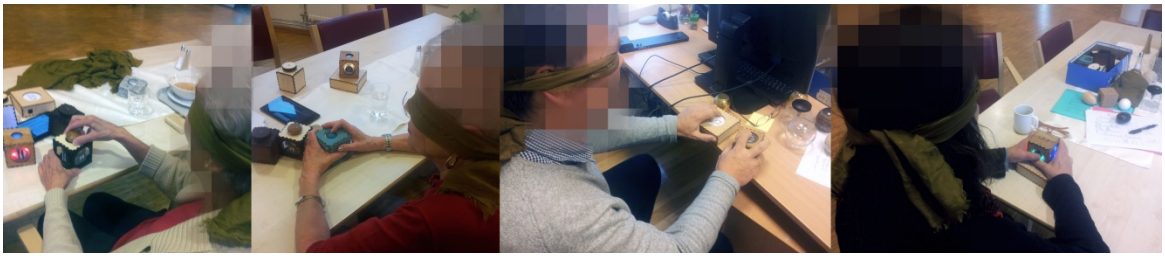

Figure 5.6: *Participants engaged in tactile exploration (Joshi and Bråthen, 2016c)*

5.4. Supporting older adults in participation

An important part of this dissertation has been to develop a design process that is informed by phenomenology and then adapted to the practical concerns of engaging older adults in co-design activities. This section extends the analysis of the PD process introduced in **Paper 3** by specifying the practical challenges encountered and describing the concrete adaptations I made to support participation. I present an analysis that together with **Paper 3** finalizes the methodological contribution of this dissertation.

Paper 3 contained an empirical analysis that resulted in five principles summarizing how I adjusted the PD process to support the older adults in participating on their own terms and still being able to partake in decision-making. We argued for a facilitation consisting of smaller fragments that fit the older adults' capacities for participation but still allows participants *"to influence the bigger picture emerging from the puzzle of smaller pieces"* (**Paper 3**, p. 29). The paper introduced the five principles to bridge the gap between the smaller pieces and the large picture: recruiting, timing, continuity, representativity, and immediacy. In the discussion in the paper, these principles are connected to larger ideals of PD such as empowerment, but also to the three core perspectives of PD, namely having a say, mutual learning, and co-realization (Bratteteig et al., 2012, p. 129). The list below repeats the five principles from **Paper 3** and **Table 5.4** summarizes how they contributed to different perspectives of PD.

- **Recruiting:** Participants did not want to commit to long-term engagements or activities planned a long time ahead, so postponing their final commitment until the very same day as the activity took place was vital to the recruitment. Spending time with the participants in their context was important to find appropriate opportunities to recruit them.
- **Timing:** It was important to immerse into the context to understand how to facilitate activities without disturbing other ongoing routines or activities. The PD activities were organized as several short sessions rather than few long ones to accommodate the users' physical capacities for participation. Short and repeated sessions provided flexibility in

participation and served as constant reminders and reinforcements for participants who could not or did not want to attend certain activities.

- **Continuity:** Situating activities to common spaces such as the library or cafeteria helped bridge the gap for participating users unable to attend specific activities. It also allowed the mutual learning, discussion, and sharing of experiences with both other participants and non-participants to extend beyond the duration of the activity. Use of spaces they already used for artistic tasks, such as the painting area, helped nurture a creative atmosphere.

- **Representativity:** The administrative staff, care workers, relatives, and friends of the participants with insight or experience that could contribute to the activity were invited to selected sessions. These people had pre-established relationships with the participants and helped foster a safe and open environment, but equally important helped paint a richer picture of the phenomenon we were exploring that the users might not have experienced themselves personally.

- **Immediacy:** To concretize and realize design outcomes in shorter time frames was necessary to demonstrate to the participants their influence on the process. It also allowed participants to show rather than tell through outcomes of the process which further helped to mature the co-construction and to develop the mutual learning faster.

Table 5.4: *The five principles from* ***Paper 3*** *and their contribution to core perspectives of PD*

Principle from analysis	Core perspective of PD
Recruiting	Having a say
Timing	Having a say, co-construction, mutual learning
Continuity	Having a say, co-construction, mutual learning
Representativity	Mutual learning
Immediacy	Co-construction, mutual learning

However, something I did not include in the paper is an explanation of exactly how the specific smaller pieces, i.e., the structure of concrete activities and practical facilitation, contributed to the core perspectives of PD. The five principles I have presented in the table above represents abstracted characteristics sustained by many smaller and related fragments. For instance, many different types of facilitation were necessary to support the more general idea of timing, and the exact activities that together ensured continuity may also have contributed to additional PD principles besides those emphasized in the paper. As such, the table above abstracts out some of the details about exactly how the specific activities and facilitation contributed to the larger picture. To expand on the analysis presented in **Paper 3**, which mainly focuses the analysis on the five principles above, I will introduce a new analysis in this section. I believe this is necessary as the details of how my PD process enabled participation and decision-making constitute an important part of the methodological contribution of this dissertation. In this analysis, I will use the same people and the same stories as presented in **Paper 3** but framed in another structure to complete the connection. I will introduce and analyze the specific activities and facilitations that characterized the process outlined in **Paper 3**, and then summarize their impact on the core perspectives of PD.

5.4.1. The activities and facilitations

I will use these five stories from **Paper 3** to highlight the various fragments of adaptations I made to facilitate the PD process. **Figure 5.7** gives an overview of these five illustrative cases. Each color corresponds to an individual participant and illustrates their participation throughout the various explorations.

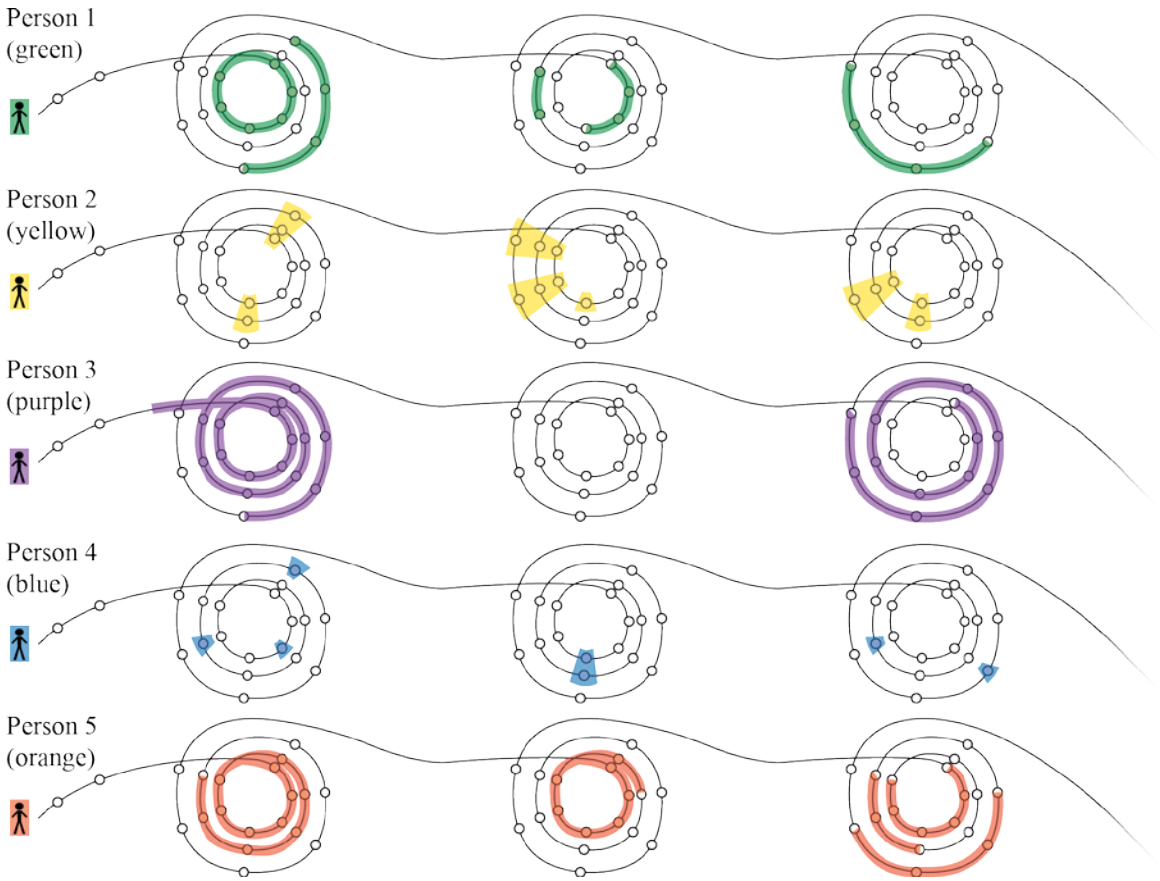

Figure 5.7: *The five user stories from* ***Paper 3*** *used to describe participation patterns*

The main characteristic of my approach was flexibility in participation, i.e., participants not being present during all design activities. In my case, this flexibility became a necessity to achieve the level of influence, decision making, and power that I wanted in the various activities. Most of the participants had difficulties making long-term commitments, for instance participating in a whole PD process. It was important to divide up activities so that participants could experience all components of see-move-see (Schön, 1983) both in a short-term perspective and in a long-term perspective spanning over several months. However, I also needed to balance this desire of efficacy in shorter time frames with their varying and unpredictable opportunities and capacities to participate. My solution was to keep all activities brief and then repeat them in multiple iterations that together composed each design cycles; one whole research exploration would typically consist of 2-3 such cycles. This way, the participants could see, feel, and experience the development of the design outcomes in smaller fragments. This type of facilitation was time-consuming and required a lot of resources, yet

participants could repeatedly and frequently see and reflect on their influence after each iteration, after each design cycle, and ultimately in the final exploratory design outcome. In the rest of this chapter, I will introduce seven activities and facilitations that will be related back to the core perspectives of PD, before I summarize the different pieces that constitute my methodological contribution.

5.4.2. Same-day finalization

Some participants were unable to make advance commitments to participation until the very same day due to unpredictability around their own physical and mental capacities; scheduling design activities across several days and including different participants would make it impossible for them to guarantee their presence. This was the case for Person 1 (green). As a result, it seemed neither reasonable nor desirable to anticipate their presence during all activities, and my focus remained on maximizing their presence. For instance, I would visit the care homes in the morning to ask about their outlook on the day and only then finalize the details of the PD activity. When participants felt like they had a *"good day"*, i.e., being able and motivated to participate, they usually stayed as long as they managed rather than preemptively selecting or discarding specific activities. In addition, participants with unpredictability in participation due to other commitments, as was the case with Person 4 (blue), also benefited from this same-day finalization. It should be no doubt: this organizational format was profoundly time-consuming – yet it was justifiable as I felt it was vital to achieving the level of influence amongst the participants that I desired.

5.4.3. Non-mandatory participation and repeated iterations

Person 2 (yellow) illustrates how certain participants desired freedom to control their own participation – with regards to both frequency and duration. Respecting these terms for participation was important to us. The solution became to organize non-mandatory tightly-scheduled activities as a mean to provide both freedom and power balance. We use the term non-mandatory as opposed to voluntary because we emphasize that we would encourage participation, but always with a caveat: we only encouraged participation as long as it did not conflict with either capacities or desires to participate.

While it might seem self-evident that no PD project should ever force participants into undesired participation, there is also the matter of how we choose to communicate this message. We chose to amplify the encouragement of non-participation when it was unsuitable by offering the opportunity to experience the same activity at a later stage within a short time-frame; hence, the repeated nature with multiple iterations. As the idea of autonomy was built into the format of the project they did not experience the abundance of activities that came with multiple iterations as overwhelming, but rather as windows of opportunities to participate on their own terms. Besides Person 2 (yellow), the participation pattern of Person 4 (blue) confirms how forcing a certain participation scheme would make their terms incompatible with my expectations. To ensure a justifiable power balance, we did not want to restrict or enforce a minimum level of participation. Therefore, this unrestricted and self-determined level of participation became a necessary remedy for my participants to be co-designers in the PD projects without compromising with who they were in the bodies they had.

To further support my choice of non-mandatory participation, we also registered that the frequency or duration of the participation did not necessarily determine the sensation of power and influence in the PD process. As we registered with Person 1 (green), who during the second design cycle ended up participating in only 6 of the 18 activities, limited participation does not exclude a satisfaction with one's own contribution. The measurement of success for some participants lies in the end-result, not in the process. If they can see themselves and their opinions in the design outcome, it can bring forth a sensation of both power and influence – as was the case with this person. Similarly, selective participation such as seen with Person 2 (yellow) did not interfere with her own feeling of contribution. Throughout the project, she even managed to concretize what kind of contribution she wanted to make. Along with such a discovery, certain activities became superfluous – almost to the point of being excessive. To fully support her participation desires, quality in participation became of more importance than the quantity of participation.

5.4.4. Scheduled reorganization

While scheduled absence allowed enough flexibility for most people to participate on their own terms, it was not easily accomplished. It was not

feasible to me or the participants to pre-determine which activities that would become the most rewarding to them. I attempted to extend the idea of flexibility to provisional schedules where participants were encouraged to reorganize their participation schedule after experiencing the various types of activities. For instance, Person 5 (orange) valued participation in one full iteration per cycle as more important to her sense of power and influence than an evenly-distributed participation. Person 2 (yellow) also used own capacities as the basis to discard less interesting design activities and continuously reconsidered her participation schema – even going so far as to step outside her *"boundary of interest"* as the design process progressed. Even participants with almost no recorded participation, such as Person 4 (blue), helped me realize how the experience of participation constantly altered needs and preferences; when only participating in a handful of activities spread across multiple iterations and cycles – while still expecting to see some traces of participation in the design outcomes – this encouragement of constant merit assessment helped participants concentrate their energy on the most rewarding activities rather than feeling bound to a predefined participation pattern. Again, I saw how the idea of flexibility helped balance out the power relationship between the facilitators and participants; people came before the process, and the value of the activities was reflected by the attention the participants decided to give them rather than whatever importance I prescribed.

5.4.5. Long perspective

As mentioned, I wanted the participants to see results in both a short and long perspective. The reason I chose to keep each project running over several months was to support mutual learning among the participants who managed to participate throughout the whole lifecycle. Person 3 (purple) demonstrates how participants without any noteworthy technical experience utilized the time to their benefit; her perspectives, competence, and most importantly, sense of mastery, improved significantly through the collaborative activities. In addition, a long-term project offers more opportunities for stable engagement in shorter periods. Despite being absent for three months due to hospitalization, she still managed to build on the prior engagement to find enough confidence and positive reinforcement to jump right back into the

penultimate cycle and stay until the end. Furthermore, as we saw in the case of Person 2 (yellow) and Person 5 (orange), learning about own preferences and capacities often shifted the priorities throughout the PD project. The knowledge and experience that laid the foundation for their later scheduled reorganizations required enough time for them to first learn from each other. As explained through the idea of see-move-see (Schön, 1983), what you see will necessarily affect how you move as well as whether to move forward or backward. The long perspective became my way of giving the *"seeing"* enough time and space to properly guide the *"moving"*.

5.4.6. On-site facilitation

All activities were facilitated within the premises of the care facilities in which the participants resided. The main reason behind this choice was that the elimination of travel time in combination with the close proximity to their own apartments made it easier for participants to engage to their fullest extent. It was also important to the preparations that I had the test apartment mentioned in Chapter 2 available at one care facility. This allowed preparations without disturbing the participants before the actual design activities began, and it allowed my preparation not to take time away from other frequently ongoing activities in the common spaces where the design activities would usually take place. Moreover, the spaces we used, e.g., libraries or offices, were familiar, safe, and neutral spaces. Finding a venue within their safe zone helped lower the threshold for participation, especially for those with limited experience with technology who already found the process overwhelming in the beginning, e.g., Person 2 (yellow). For participants with limited engagement such as Person 4 (blue), seeing these activities continuously reminded him of the ongoing activities and helped him follow the activities from a distance, even when not participating himself. His particular case also reveals another important consideration as the close proximity was also an ultimatum for his participation; his limited endurance would usually restrict his participation to one activity before having to return home to rest quickly. As most participants did not know exactly what to expect from the design process, the close vicinity helped participants combine their participation with easy access to recuperation to come up with interesting strategies for participation. One such example was Person 5

(orange) who would swap between short rounds of participation and rest respectively to maximize her participation.

Designing within the same facilities as the technologies were intended to be used provided an important sense of ownership for the participants. When imagining future enabling interaction blending into their daily lives, having this direct access to the space in which the technologies would reside helped participants situate their ideas. Designing from within the design space made participants see themselves in the same scenarios for which the technologies were being developed, and thereby enforcing the design *"for"* and *"with"* users through this stronger attachment to the developed design ideas. The sense of ownership was further strengthened by the facility's constant reminder of them all being a part of the same *"resident team"*. Person 4 (blue) in particular demonstrated this by stating that he valued the sense of ownership that came with being part of the team more than equalizing the level of participation.

5.4.7. Leaving behind artifacts

Another benefit of situating the design process to their shared realm was that I could leave behind design outcomes. Leaving traces of the design process served three main purposes by being a channel for communication. First, it gave participants concrete artifacts that encompassed the choices made and helped reinforce their own learning, share their experience with other participating and non-participating residents, and reminding themselves of their participation. For instance, Person 2 (yellow) needed time to explore and understand technologies and would use the time between activities to continue her mutual learning. Second, it helped participants who were absent from an activity to bridge the gap between their last participation and the current status of the design process. Person 1 (green) had a strong technical understanding and could use the design artifacts to evaluate on his own. Similarly, Person 3 (purple) who was hospitalized and absent from a whole design cycle, used the design artifacts to catch up once recovered. Third, the design artifacts were mainly left behind in spaces that were otherwise frequently used by the residents, for instance, the library. Their very presence instigated many discussions – both among participants and non-participants.

Through this phenomenon, the design artifacts became an important means for recruitment of future participants.

5.4.8. Home visits

While most activities were carried in open and shared spaces within their own facilities, I made adaptations to bring participants closer to their embodied use practice and habits. This mainly consisted of moving certain activities into the homes of participants to help them easier show rather than tell. In the same way being within their own facilities helped contextualize the design ideas, the move into their homes, i.e., their private sphere, also provided close access to their embodied experiences. Participants like Person 2 (yellow) who did not have the necessary vocabulary or experience to precisely communicate her experience and perspective through words could use opportunities like this to vocalize her opinions through demonstration. Being in their homes also brought attention to their own devices and objects that could evoke certain desired or undesired experiences and later be integrated into the design process as thinking tools to help access and share embodied experiences.

5.4.9. Assembling fragments into a whole

All of these activities and facilitations were necessary smaller components that together allowed participants engage in mutual learning and co-construction. The phenomenological PD process outlined in **Paper 3** demonstrates a flexible and adapted perspective on how to engage older adults with limited capacity for design participation in the design of enabling interaction. The organizational structure of the process, i.e., dividing the PD-work into smaller pieces, reflects the phenomenological and salutogenic backdrop: how to facilitate a process where people who can participate in smaller engagement over time can still contribute to a larger whole? The structure is illustrated in **Figure 5.8**.

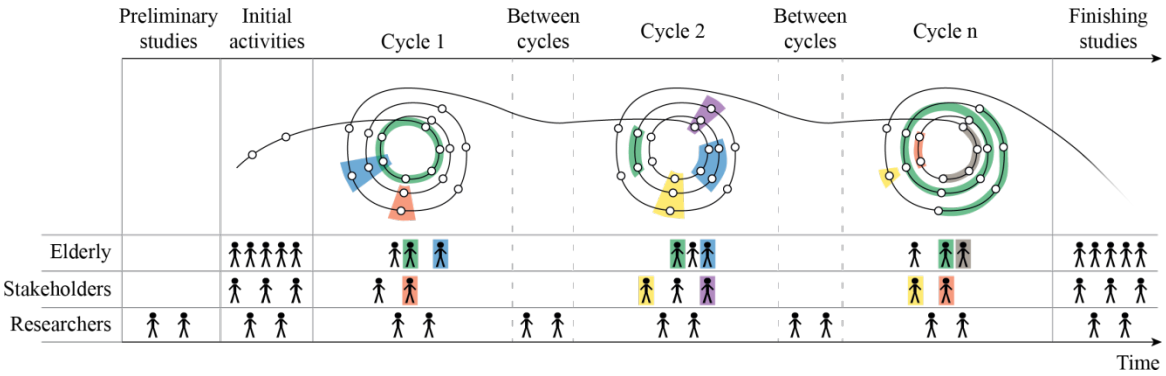

Figure 5.8: *The assembled fragments of how participants were engaged over time*

One of the recurrent themes across all these activities and facilitations is time. Time emerged as an important term for the participants and is the focus of this analysis. On the one hand, time is a necessity needed to ensure patience (as advocated in **Paper 1**) and allow the imagination to expand by developed mutual learning. But on the other hand, time was dear to most of the participants. As mentioned in **Paper 3**, all the five principles refer to how the older adults experienced time differently – and as having less time. While timing is listed as a separate principle, both continuity and immediacy are direct variations of timing issues. Similarly, both recruiting and representativity are concerns related to time.

> *"When collaborating with old people time is crucial: the scope of the project, the planning horizon, the stamina of the participants, the maintenance of dialogue over time, and the everyday rhythms that structure the days at home" (Paper 3, p. 26).*

This analysis intends to demonstrate how I found opportunities to support PD by collaborating with the users about the importance of time. For instance, when participants were unable to make long-term commitments or participate in long activities due to physical capacities, organizing on-site facilitation became a way for me to support continuity over time – both for participants and non-participants. Or if participants needed more time than the activities offered, their window for mutual learning could be extended by leaving behind artifacts. As such, the five principles presented earlier are generalized principles maintained by these underlying and intertwined concrete, but smaller, fragments. I have summarized in **Table 5.5** how these activities and

facilitations relate to the core perspectives of PD: having a say, mutual learning, and co-realization. This table supports the more general principles presented in **Paper 3** with specific activities and facilitations. These specific examples demonstrate how to implement the principles from **Paper 3** in a PD process, but do not restrict others from finding their own ways of realizing the same principals.

Table 5.5: *Overview of how the activities and facilitations contributed to core principles of PD*

Mutual learning	Co-realization	Having a say
On-site facilitation		
Leave behind artifacts		
Non-mandatory participation		
Long perspective		
Home visits		
		Scheduled reorganization
		Same day finalization

5.4.10. The methodological contribution to PD

This chapter has demonstrated how I combined the theory of phenomenology and perspectives of PD to design a process that allows older users to engage in the design of enabling technology. The process supports the underlying ideas of designing for capabilities rather than disabilities and demonstrates specific practical adjustments made to the activities and facilitation based on empirically observed limitations of involving older adults as equal co-designers. This process is an example of how we can tailor a design process that allows older adults – with their capacities and preconditions for participation – to still engage in meaningful PD. The process has been theoretically informed but has been continuously reshaped throughout the 14 research explorations to meet the practical concerns. **Paper 3** draws on five user stories to present a rich description of the different activities and facilitations that constituted the phenomenological PD process over time, and the analysis introduces five

abstract principals that express the characteristics of the tailoring. The analysis in this section has further detailed the specifics of my PD process by exemplifying concrete activities and facilitations and how they resulted in a process that allows older adults to participate on their own terms while still honoring the core perspectives of PD. As such, the methodological contribution of this dissertation consists of four main components: (1) a description of how PD can be organized and facilitated to meet the older adults on their own terms; (2) an analysis of how the PD process relates back to core perspectives of PD; (3) an analysis of older adults' preconditions for active PD; and (4) an analysis of actual participation and decision-making.

Chapter 6

Design outcomes as PD results

In this chapter, I present and analyze selected design outcomes from various design explorations as PD results. Being clear on what exactly *"That which is represented"* (Kyng, 1995, p. 48) is in the eyes of the designer, the participants, and the research community, is an important part of conducting design-driven research. My main concern, as reflected in my third research question, deals first and foremost with what the design outcomes are and can be in terms of generating new knowledge within my design space of enabling interaction. I will return to this in the next chapter. However, the outcomes are also central to my interpretation and reflection of the methodology I have followed, and they are bearers of meanings and values that reveal important analytic perspectives on the participants' role and influence in generating said knowledge. In any case, I see my design outcomes not as *"things"*, but rather as Things, i.e., modifiers of *"the space of interactions and performance and that may be explored as socio-material frames for controversies, opening up new ways of thinking and behaving, being ready for unexpected use"* (Björgvinsson et al., 2012, p. 102).

I will draw on two different traditions and perspectives when I use selected outcomes as reflective tools in Chapter 6 and Chapter 7. When I look at the design outcomes as a manifestation of a co-design process for and with users in this chapter, I will refer to literature within the PD community to reflect on the results and the values embedded in them. When I analyze the design outcomes as research products that can generate new learning and knowledge in the next chapter, I will use literature on reflective design practice, mainly from the research through design community. I am not advocating for either as the superior approach; I am merely finding myself

unable to address the wholeness of my research with the literature of either research community alone.

As Ehn (2008, p. 93) discusses, the design outcomes are both devices and things. The former refers to the *"embodiment of the object of design"*, something that from an engineering perspective could be said to fulfill the requirements put forward by the users. The latter is then the spatial and social implications of introducing the device as a thing into the environment of the users. As such, design outcomes from design projects can follow different paths of analysis depending on whether we want to analyze the outcome as a design result or as a modifier of the lifeworld of the participants. Related to this idea of how to interpret outcomes was also raised by Krippendorff (2005) who in his critique of modern schools of design questioned the philosophical and practical foundations of our design traditions. He called for a semantic turn where the attention shifts from only considering the artifacts' aesthetic qualities to also address the artifacts' social implication on the lifeworld of the users. The way the design outcome can enter and reshape the world of the user is what we are usually designing for in any project, and addressing this should be on top of the list of how we understand and interpret the outcomes. The other important way to interpret his *semantic turn* is that introducing the design outcome into the design space alters the conditions and context of that same design space and it opens up possibilities for the reflective practice of our own understanding – as designers – of the design space we study. Björgvinsson et al. put forward a similar argument when describing the fundamental challenge of moving from designing *"'"things" (objects) to designing Things (socio-material assemblies)"* (2012, p. 102). The various analyses involving design outcomes presented in the rest of this dissertation, which stretches from this chapter and into the first part of the discussion, attempts to collectively address what Krippendorff argues constitutes a scientific move for design, i.e., that I reflect on the design outcomes as *"both a science of making and a philosophy of realizing artifacts with and for others"* (2005, p. 197).

Therefore, to reflect upon whether my methodological approach aligns with my motivation of engaging participants in a respectful manner, I will use the design outcomes as PD results in this chapter and look at what type of results they are and how I can use them to trace the voices of the participants.

6.1. Reflecting on methodological concerns

The long traditions of PD bear resemblance to modern design rhetoric such as design thinking (Björgvinsson et al., 2012). PD has been an important influence on the development of the design practices of research through design, specifically the part on how to follow design through society framed as field research (Koskinen et al., 2011, pp. 69–88; Zimmerman and Forlizzi, 2014, p. 170).

> *"What made this research and not design practice was the focus on developing a new design methodology that borrowed research practices from anthropology and sociology and combined them with design. Over time, researchers began to also see the artifacts they produced as a research contribution." (Zimmerman and Forlizzi, 2014, p. 173)*

One of the pieces missing in novel design rhetoric designing for change that is relevant to my own research agenda is the ability to reflect on the users' role in arriving at these exact and unique pieces of digital artifacts – and demonstrating *through* the design artifacts, rather than only through a reflection of the design process, the significance of their participation. I think the last sentence in the paper of Björgvinsson et al. sums up the point I want to make when describing a design approach aiming to make a change, which is the importance of reflecting on the challenges and values of engaging participants in the problem-solving*: "Design thinking that wants to make a difference cannot ignore the challenge of passionate engagement in controversial design Things"* (2012, p. 116).

Research through design generates knowledge from the reflective insight gained through design practice. This insight is one of the foundations of the inquiry designers use to ultimately address the *"wicked problem"* in question. I will return to this in the next chapter. But equally relevant to my research concern is the ability to also reflect on the design activities as a way of engaging participants in meaningful design activities that also contributes to an increased agency. As such, this chapter will use the design outcomes to reflect on methodological concerns rather than on the generated knowledge contributing towards solving the problem.

6.2. Reconfiguration of human-technology relations

Co-creating outcomes with a certain level of maturity was important to me. To properly evaluate them, I need to situate them within the design space and allow it to integrate with the real use context. The design outcomes in my dissertation demonstrate ideas and intentions meant to co-exist in an everyday setting, and it can be argued that the design outcomes need to mature to the degree that allows an assessment of a real use situation (Bratteteig and Wagner, 2016, p. 142). The phenomenological lens of my study does not only encourage exploration and introduction of new design alternatives; it equally encourages exploration of the manifestation of the current human-technology interplay as the basis for new ways of enabling participants. As such, it is a matter of seeing how the ideas we introduce blends into the design space and reconfigures the circumstances and with it the opportunities for interaction. To illustrate this point of how new perspectives on the existing human-technology configuration can be a design result of a PD process, I will use a specific outcome shown in **Figure 6.1**.

Figure 6.1: *A reconfiguration of spatial relations to open up new opportunities for interaction*

During my studies of challenges with existing technology in *Leap (RE #1)*, we used the tablet (described in Chapter 2.4.1) as the basis to look for new design opportunities. The demonstrative interviews revealed that many participants were unable to operate the tablet due to the weight and size; most people were struggling with holding it up with one hand and had to have it in their lap or on a table to use it. During reenactments, most users ended up sitting too far away from the screen and ended up in a hunched position to get as close to the screen as possible which led to a strain on their back. Furthermore, several

residents were bedridden most of the day and struggled with using the tablet from a lying position. The current configuration the tablet supported assumed a set of sensory-motor skills such as strength, endurance, and coordination, and it also resulted in pain for those who sat with the tablet too long. Returning to the design framework from Chapter 4, the participants and I agreed that it was a matter of relative positioning and arrangement. The framework was used to look for opportunities for spatial reconfiguration and situated interaction. It was obvious that different participants desired different positions and configurations with regards to both how the interaction was presented and where it happened. The design we came up with was an incorporation of the tablet onto the fixture of a typical dentist lamp – a metaphor all participants understood. It allowed the tablet to be suspended-in-air in any angle as seen in **Figure 6.1**. It required no holding and allowed all types of spatial configuration towards the body. Furthermore, it did not restrict the arrangement as it could be situated in any space - in the living room next to their favorite chair as well as over the bed in the bedroom. By providing reconfigurability in use, and thereby providing an opportunity for the user to find their maximum grip, it led to less straining in use. It also allowed the tablet to remain purposeful to users over time as its configuration could follow their changing bodies evolving needs. Residents lying in bed most of the day also found use of the tablet through this design suggestion; by freeing up the one hand that previously held the tablet, the bodily space expanded as they experienced an increase in degrees of freedom.

6.3. Tracing the voices of the participants

I have mentioned multiple times that the inclusion of participants as co-designers was necessary to arrive at the various design outcomes. To reflect on their importance to the design process, I will try to demonstrate how the end-results embodies their voices (Bratteteig and Wagner, 2016; Robertson and Wagner, 2012). My design space addresses the larger issue of society's future caretaking need. For the participants to reflect on their own future needs and the designed technology's influence on their independence, each participant has to dive into their individual perspective on needs and caretaking; independence can be directly related to ensuring one's own state of health and other aspects of the personal lived environment (Leong and Robertson, 2016,

p. 36), and this is a concern that starts with their own lifeworld and the lives and stories it contains. Naturally, there are many concerns, both personal and social, that relates to independence, but for my design space, one highly relevant criterion for assessing individual needs is how the design reflects the participants' tacit knowledge (Björgvinsson et al., 2012, p. 103).

The most prominent design outcome to illustrate the individual voices embedded in the end-result would be the design outcomes from *Induction Charge (RE #10)* presented in **Paper 5**. By allowing participants to bring in their own digital and non-digital equipment, the design outcome was not one specific design, but rather a set of ten designs; each design reflected a small, but traceable, unique change to the representation based on the embodied experiences of the participants. While the collaboration with 31 participants only yielded 10 concrete results, it was the coinciding of participants' perspective that led to multiple people considering one design as their preferred option rather than limitations enforced by me. Nevertheless, this array of a similar idea executed with only slight adjustments still demonstrates the opportunity participants had to bring in their individual perspectives on the desired configuration of technology within their own context. One example from **Paper 5** that highlights this opportunity is the example of the 83-year old woman who brought her own *"table setting"* into the design activity and allowed others to explore their own experiences from that same vantage point, i.e., their own home, their own table, and their own arrangement of objects. Another example would be the radio from *PiRadio (RE #3)* which was briefly described in **Paper 3** and **Paper 4**. The design attempted to recreate an interface that resembled traditional radio interfaces by building on familiarity and lifelong habits. The interaction mode could change according to past preferences and adapt to future needs and allowed easy switching of knobs and wheels supporting a tailored design based on individual needs over time. Moreover, the design attempted to invoke an embodied feedback that matched the expectations of the participants, something that was important to acknowledge the need for individual tailoring. As I will describe later in this chapter, the flexible and adaptable nature of this particular radio was not enough tailoring to offer the optimal design for everyone; the continuous development of additional examples of radios intended for the same design space only reaffirms the emphasis on

allowing individual perspectives to emerge. The design outcomes were both a way to trace the voice of the participants, but simultaneously an opportunity for the participants to continuously close in on what they ultimately considered their individual needs to be. For those participants that were part of multiple radio exploration, a desire for a continuous engagement would be less likely if they could not see the results of their own choices in each design outcome they encountered. These two sets of design outcomes, i.e., from the *Induction Charge (RE #10)* and the five exploration involving *radios (RE #3, RE #6, RE #7, RE #11, and RE #14)*, are the basis for the statistical analysis I present in Chapter 8 where I demonstrate how these outcomes actually allowed participants to perform better individually.

A final example was the telecare exploration from the *Collaborative Change Experiment (RE #2)* where we designed a system compatible with individual concerns. To build a system that did not interfere with the individual setups in the home required design suggestions that allowed participants to scaffold their exploration with the experience of their own home, their own living room setup, as well as their own embodied routines, habits, and preferences within that environment. **Figure 6.2** illustrates the television set up in four different homes, and the camera on top is the component we introduced into this ecosystem. It was built to support multiple configurations based on personal and contextual preferences, and it was designed with the considerations adaptability and arrangement in mind. It blended in with the existing technical context without causing any intrusiveness, and it was designed to fit on top the current setup participants had in their living room, thereby taking spatial concerns such as distance, height, sitting position, lighting, and acoustics into consideration. More of the challenges and adaptations made have been described in (Joshi and Woll, 2014, 2015a, 2015b).

Figure 6.2: *The television set up in four different homes*

6.4. Communicating through the design outcomes

Another way of interpreting the design outcomes is to reflect on its influence, and more precisely whether it can demonstrate increased agency of users in a democratic sense (Balka, 2010). The design outcomes have served as embodied manifestations of an important voice in the political and administrative arena, i.e., the way in which the outcomes contributed back to the context and problem space. The close collaboration with the municipality allowed me to share the design outcomes in important political and social arenas. Bratteteig and Wagner (2016, p. 142) state that an important difference-maker is the design outcomes' ability to bring about change within the relevant organization or community. The results from my various research explorations have been presented to the prime minister, two ministers of health, the mayor and the city council, as well as various governmental departments and institutions that hold the overarching responsibility of overseeing the delivery of enabling technologies. The design results have been a part of my presentation during most of my 59 invited presentations between 2012 and 2016.

I will address the benefit of building a portfolio of possible solution residing within my design space in the next chapter, but there was a clear benefit of having a set of design outcomes to present with regards to increasing the agency of the users. One of the challenges for those in charge of acquiring enabling technology on behalf of the municipality is – like for most people – envisioning end-results that can actually help solve the challenges they foresee. The design outcomes have demonstrated important concerns, for instance, the need to include participants from the very beginning, and recent changes in the official requirement specifications for the acquisition of enabling

technology bare traces of the suggestions the participants and I made based on the design explorations. The design process itself, involving participants from potential end-users to politicians, has opened up a positive dialogue between decision-makers and end-users. Rather than presenting the design outcomes myself – as the situation usually becomes when the design results are not sufficiently matured to survive independently of a researcher bridging the gaps – having access to functional design outcomes allowed the participants to demonstrate, from within a real use context, the fruits of their participation to external parties. This was important for the participants themselves to see the results of their own efforts, but also an important message to politicians and decision-makers who could see the participants as constructive and highly knowledgeable contributors to future processes. **Figure 6.3** illustrates how two participants from the *Collaborative Change Experiment (RE #2)*, namely one older adult and one home care nurse (on the screen), demonstrate the design results in action to politicians. The two people standing in the back in the rightmost image were at the time the Vice Mayor for Primary Health and Social Services and the Norwegian Minister of Health, respectively. The lady in blue is my research colleague, Anita Woll, with whom I cooperated in this study and the man in the chair is one of the participating residents.

Figure 6.3: *Presentation of design outcomes to politicians*

We experienced openness and willingness from the municipality, and I wanted to return the favor by demonstrating how the older adults that we all ultimately want to have the best experience when interacting with enabling technology, can indeed be part of creating spaces in which people *can "reflect, make mistakes, learn, and debate"* (Light and Akama, 2014, p. 159). I also believe that the design results have demonstrated to politicians how such design processes can indeed be productive for everyone involved, including

political stakeholders. Besides the cooperation from the municipality, it was also important to demonstrate to the participants and other adults that their participation mattered. The older adults' desire to contribute to the process and understanding the problem space was a necessity to generate these various examples of solutions – there was a communal desire to invest time and effort into the activities (Leong and Robertson, 2016, p. 33) that I believe can be a starting point for continued collaboration. In future research, it would be interesting to study whether this design approach can contribute to a more long-lasting challenge which is to *"create and sustain an ongoing dialogue, especially for non-wage earners"* (Kyng, 2010, p. 63).

6.5. Opening up new arenas for cooperation

My work has mainly revolved around older adults and the use of enabling technology, but as outlined in **Paper 3**, the design process also involved stakeholders such as home care nurses who were a part of delivering services involving the use of technology. I will continue to use the example of the Collaborative Change Experiment to demonstrate how the presence of functional design results opened up new arenas for collaboration. One of the challenges with PD has been that users are designing before the actual use takes place, something that involves participants anticipating and envisioning the use situation (Ehn, 2008, p. 92).This became an apparent challenge for the home care service that had to consider not only the design itself, but how it would fit in with their work-oriented context, as well as how it altered their routines such as their work schedules, delivery of services, and fallback procedures. The design outcome being a functional system that could actually be implemented was convincing enough for them to set aside enough time and money to continue exploring and evaluating the outcomes in a realistic context. The observation of different requirements of pace in different stakeholder groups in such a long-term and large-scale PD project was very similar to the experiences described by Müller et al. (2015, p. 2302). The leader of the local home care unit and the representatives of the municipality agreed to relieve home care nurses of their daily tasks to participate in the study during work hours. One of the challenges with PD is to generate design results that *"appeal both to users and to those who pay"* (Kyng, 2010, p. 50), and this particular story demonstrated to us how the presence of a convincing

design outcome became the triggering factor for new arenas of exploration. The realistic context in this research exploration involved a simultaneous two-sided interaction where we needed to coordinate with both residents in their own homes and the home care nurses in their offices. For this exploration to continue without our presence, we had to install and configure all the equipment, including televisions and cameras, within the respective use environments, and we also had to install a separate Internet connection to not interfere with the private network of the home care unit. Nevertheless, this story demonstrates how none of this would be possible without having a design outcome that could convince collaborators to continue the exploration as they were needed – both the nurses and the money to pay for their time – to move the system into a realistic use context. **Figure 6.4** below demonstrates two home care nurses communicating with a resident in her own living room through our system.

Figure 6.4: *The nurses using the proposed system as part of their routine*

6.6. Reflecting on assumptions

One of the main roles of the prototypes with regards to my design space has been to learn more about the assumptions about the users, the enabling technology, and the interactions between them. I believe the way I have employed an embodied language as the basis co-creation realizes one of the claimed benefits mentioned by Muller and Druin (2010, p. 39), which is a *"critical examinations of assumptions"*. My motivation for writing this dissertation was indeed my own assumption of other designers making wrongful and generalized assumption about the users of enabling technology. As I exemplified in Chapter 5.2.2 with the case of the wall-mounted light

switch, my design process has been a continuous confrontation with my own assumption – both intentional and unintentional – and I have attempted to adapt the design process as my own, and the participants' learning moved along. The use of personal stories, existing equipment, and measurements of bodily capabilities, as illustrated in **Figure 6.5**, have all served important ways of reflecting on my own assumptions. However, in retrospect, the design outcomes have been the best and most important way for the rest of the participants and me to reflect on the assumptions about the design space.

Figure 6.5: *Various ways of accessing bodily capabilities*

It is also important to recognize the benefit of possessing fully-functional design outcomes, i.e., research products, as they open up new possibilities for participatory inquiries. One such benefit is that they can survive independently in realistic use environment without any interference, and this gave me an opportunity to reflect upon assumptions about the use situation we had all designed for in my design activities. Instead of already assuming someone as end-users, the design results allowed me to follow the participants in either *becoming* or not becoming users by studying their experience with use after design (Redström, 2008, p. 410). It has also been important for me to use the outcomes as a way of verifying that I am not defining use through design, but rather defining use through use (Redström, 2008, p. 413). Allowing participants to define use from their actual embodied experiences and habits rather than imagined experiences when exploring alternative use, unintentional use, or re-defined use was a concrete choice I made to support mutual learning throughout the activities. As explained in **Paper 3**, both long-term and short-term term evaluation activities were key components in the design process, and giving participants space and time to understand use

through use was vital for them to make informed choices. These types of activities and facilitations require design results as they become important thinking tools for the participants' reflection – regardless of whether they see themselves as users or non-users. The design result becomes the facilitator of the embodied impressions experienced through use over time that ultimately determines whether the participants can identify with the enabling effects the technology offers; using design results as descriptive artifacts (Muller and Druin, 2010) serving as means of facilitating reflections on embodied experiences helped maturing the design significantly. In terms of what the design results have meant to the development of new concepts and future exploration, I will address this concern in the next chapter.

However, there is also the case of using design results as a way for the participants besides myself as the facilitator to reflect on their own assumptions about capabilities and opportunities. Building on my last point, the design results were equally important for the users as reflective tools. The vast use of design results became necessary pieces in realizing my body-oriented methodological approach, and this helped to facilitate physical reflection throughout the design process. Reflecting on assumptions required maturation and development of perspectives throughout the design process. To further support this maturation among the participant as well as for me, using non-standard mediums for capturing the subjective nature of the participants' embodied experiences was a methodic necessity. Accessing these embodied concerns has required a shift similar to the one described by Björgvinsson et al., where we move from system description to *"engaging hands-on design devices, like mock-ups and prototypes and design games that helped maintain a family resemblance with the users' everyday practice and that supported creative, skillful participation and performance in the design process."* (2012, p. 105). The design results allowed physical reflection among the participants where they could continue to employ the same co-created embodied language of analysis and design that went into the process of discovering, articulating, and sharing needs and opportunities. My technical background contributed the main source of knowledge on how to construct various representations, as well as knowing of opportunities and limitations for changing them (Kyng, 1995, p. 48), but it was the experiences of the participants that shaped and re-shaped the design results and their

representations as they explored use in real contexts. This point of how the shared nature of a co-created language and its physical manifestation may result in benefits has also been raised by Muller and Druin (2010, p. 37).

One illustrative example of how the design results supported reflection was the conceptual prototype called LightUp from *Tangible Alternatives (RE #6)*. The research prototype explored multiple purposes but mainly revolved around how the body itself could be the input for digitalized systems in the home. The objective of the exploration was to see whether the capacities found within the body could be the sole input to rethink existing technologies. In this case, it was the heating system described in Chapter 2.2 that was targeted as the current interface was both confusing and restricting. By using a wireless body temperature sensor that could integrate with the wrist-watch safety alarms they were all currently wearing, and thereby taking their current bodily space into consideration, the body temperature could be used as the source of input for the heating system. It was then suggested by the participants that the color of the light in the room could use the body temperature as input – the bodily temperature of the resident could be reflected in the color of the light. The light offered a range of white level intensities, ranging from cold and hard blue-white to warm and comfy red-white. It was only through the mutual learning, the purpose of this suggestion became evident to me. The idea came from participants who had heard that recipients of home care service could end up having as many as five visits per day from multiple nurses and that one part of their routine was touching their body to feel their bodily temperature. As the nurses worked in rotation, it often became an uncomfortable and tense situation when different people – often barely familiar – would come into the home and repeat this routine. The idea of shifting the whole routine from involving touching to the nurse using the light in the room to verify the bodily temperature of the resident was a conceptual idea put forward by participants as a way of using technology to get more control of the circumstances. **Figure 6.6** shows the prototype as implemented and evaluated as well as the outcome needed for the participants to continue their exploration of the design space. A more explanatory description of this conceptual prototype has been presented in (Iversen and Joshi, 2015, p. 161).

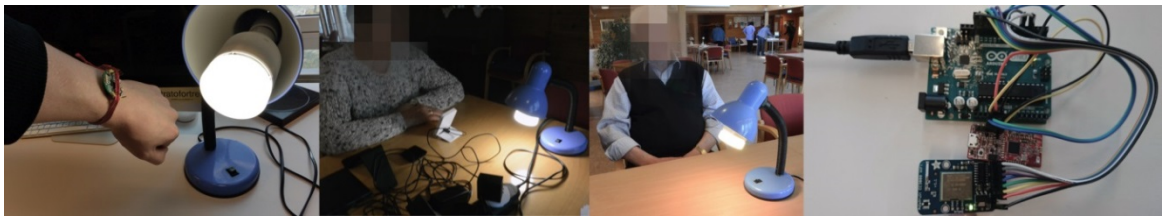

Figure 6.6: *LightUp – a conceptual prototype from (Iversen and Joshi, 2015)*

This conceptual prototype – in all of its simplicity – was an eye-opener to all participants, including myself. Considering the passive body as a mode of input to a system was a novel concept for most participants and hard to imagine without any concrete design outcomes to demonstrate the implications and opportunities. While I and my master student, Thomas Iversen, who implemented the technical solution, knew of the technical possibilities, it was only through this exploration with participants we were able to contextualize it, as well as understanding the role it could have in enabling new forms of interaction and configurations.

Chapter 7

Design outcomes as generators of knowledge

7.1. Generating knowledge through design

In the last chapter, I used the design artifacts to reflect on my methodology I have followed to trace the participatory engagement and agency. However, the main intention of producing design artifacts in this dissertation has been to help inform the overarching research question. This is reflected in my third research question. Besides being studied through traditional HCI methods such as performance evaluation, the design outcomes have served a purpose as reflective tools for generation of knowledge. There have been discussions of whether researching through the design artifacts intends to produce theory (Zimmerman et al., 2010, p. 316) or what types of theories to expect (Gaver, 2012). In my case, however, the intention has not been to create any new theory but to continue the development of theory by learning more about the phenomena. I wanted to complement my theoretically informed design framework with learning from the analysis of the design artifacts and use the strengths of both theory and design to restructure a solid design framework. As such, the generated knowledge has a predefined main purpose of critically reflecting on the underlying theory (Goodman et al., 2011, p. 1068). I am saying main purpose rather than sole purpose as one of the strengths of this type of analysis is that speculations and salient questions that can fuel further research are likely to emerge (Massimi et al., 2011).

I would argue that this reflection is particularly relevant to the phenomenological nature of my design framework. Phenomenology concerns

practice and our sedimented actions are so tied to habits or situations that we often remain unaware of how and why we act as we do. Accessing this practical nature of embodied experiences becomes an important step in untangling how and how well my theoretical concepts can be materialized. I believe Max van Manen's (2007) work on lived experience and the phenomenology of practice contains a quote that describes the type of knowledge I am trying to access with this reflective practice on the design artifacts:

> *The pathic dimensions of practice are pathic precisely because they reside or resonate in the body, in our relations with others, in the things of our world, and in our very actions. These are the corporeal, relational, temporal, situational, and actional kinds of knowledge that cannot necessarily be translated back or captured in conceptualizations and theoretical representations. In other words, there are modes of knowing that inhere so immediately in our lived practices—in our body, in our relations, and in the things around us—that they seem invisible. (van Manen, 2007, p. 22)*

To that end, this chapter will present two different lines of analysis of selected design artifacts to support my reflection. The specific selection of design artifacts is only a part of all the design outcomes constructed across the 14 research explorations; selecting another combination of outcomes would also have been possible. Nevertheless, this chapter aids me in reshaping the design framework by suggesting adjustments informed by design and use practice rather than theory. I will end this chapter by presenting the final version of my theoretical contribution, i.e., a design framework for enabling interaction that encompasses both theoretical and practical concerns.

7.1.1. Purpose of the analysis

My design space, when considered a matter of addressing and planning the future caretaking needs, deals with a societal problem in need of continuous *"re-solving"* to reflect the evolving needs of society. These types of problems have been labeled as *"wicked problems"* (Rittel and Webber, 1973, p. 160), i.e., problems ungraspable by mechanical and reductionist approaches (Zimmerman et al., 2007, p. 494). As such, I am not attempting to solve specific problems with the design outcomes, and these should not be

considered final manifestations on how to address the evolving nature of wicked problems; as everyday artifacts, they themselves, as well as their representation, need to evolve over time as our use develops (Kyng, 1995, p. 46). The role of these design artifacts is not to constitute an irrefutable evidence of a prescriptive design approach that will always hold true; it is about demonstrating how my design approach builds on a theory that can be *"sometimes right"* (Gaver, 2012, pp. 940–941) as well as to generate enough knowledge to support a reflection of my overall approach and help me further mature the design framework. I want to showcase how my process has resulted in multiple examples of how the design artifacts can indeed be the enablers of the transformation from the world that is to the world that should be (Zimmerman et al., 2007, p. 497).

7.1.2. Positioning of the analysis

The main purpose of this design-oriented part of my dissertation is to contribute with knowledge on practical and situational issues concerning the *"problem setting"* that the theory could not reveal (Fällman, 2003, p. 231). My overall approach holds the same motivations as Zimmerman et al. (2007), i.e., attempting to shift the circumstances through the design artifacts' ability to solve real problems. The role of the artifacts is not to contribute with an un-contextualized advancement of theory at a general level, but refinement of existing – as well as elicitation of new – theoretical concepts that are directly related to the users, the specific problem, and the particular use context (Stolterman and Wiberg, 2010, p. 102).

Using a theoretical point of departure to both inform design practice and to help tackle the complexity of the human-technology relation in use situations results in an approach that bears a resemblance to several forms of intermediate knowledge suggested by the trajectory of design-oriented HCI research. My goal is not to advance the theory of phenomenology, but rather to move forward the use of phenomenology of the lived body as a theoretical body to understand a specific use context, and within that, the users and their problems. The research presented in this dissertation is not able to reflect on phenomenology as a theory at a general and context-detached level but remains focused on designing for capabilities anchored in a phenomenological understanding. This scoping is also the reason my work does not look for

"external exemplars" that are lifted out of their context as seen in, for instance, the actualization of bridging concepts (Dalsgaard and Dindler, 2014, p. 1637). Rather than drawing on interpretations of similar artifacts from other design practice, the knowledge production is supported by a set of examples all derived from the same overarching problem space. Thus, it lies closer to the theoretically-anchored knowledge production advocated in concept-driven design (Stolterman and Wiberg, 2010). While the design artifacts are intended to respond to the particularities of the use situation, they also represent manifestations of concretized theoretical concepts. The idea of designing for capabilities holds theoretical and practical opportunities to construct knowledge at an abstract level elevated above the particularities of my research context that may eventually mature into strong concepts (Höök and Löwgren, 2012, p. 2). This type of knowledge production would require both horizontal and vertical grounding, which is not explored within this dissertation.

There are also resemblances to other bodies of relevant design-oriented research. The notion of bridging concepts, a particular form of intermediate knowledge proposed by Dalsgaard and Dindler (2014), is relevant as this part of my dissertation has both informed specific research explorations while also contributed to the refining of theoretically-informed concepts. However, the specific move from theory to design practice and back to theory limits the ability to explore the full strength of a mutual and continuous exchange between theory and practice. The process of *"grounding, re-grounding, articulation, and re-articulation"* (Dalsgaard and Dindler, 2014, p. 1643) that fosters reflection on concepts as bridges between theory and practice has not been explored thoroughly in this dissertation. As mentioned, parts of my process also resemble concept-driven design research, which is both design-centered and theory-oriented (Stolterman and Wiberg, 2010, p. 113). Each design artifact, while not considered end-goals of my research, is a necessary component in assuring that the collection of design examples can contribute to understanding the real issues at hand. My goal is not to produce final products serving as a definitive solution, but rather to understand and explore the overarching issue of designing enabling technologies for older adults. I have visited several of the methodological activities outlined, and I follow their idea of artifact crafting as a process of theorizing and use the design

manifestations to validate conceptual and theoretical assumptions (Stolterman and Wiberg, 2010, p. 111). I will return to the role of the design artifacts as verification tools in Chapter 8.1. However, my approach also differs from concept-driven design research. The emphasis on advancing the theoretical development by shifting focus from supporting a use situation and rather dedicate its focus to the maturation of theory does not fit with my approach. Both *the client* and *the problem* (Stolterman and Wiberg, 2010, p. 102) are key components in the overarching concerns of this dissertation. My research consequently revolves around those three specific components outlined as less important concerns of concept-driven design research: the users, i.e., the older adults; the specific problem of designing for capabilities; and the particular use context of the home.

I have argued earlier in this dissertation for utilizing the strength of both theory and practice to help understand and react to the complexity of the overarching research concern. In my research, the use of PD intrinsically involves intangible aspects such as values and politics that cannot be separated from the design (Höök et al., 2015, p. 34). Thus, it could be argued that the overall knowledge generated throughout this dissertation lies both *"in"* and *"with"* the designed artifacts (Stolterman and Wiberg, 2010, p. 103) as it is also communicated through the revised edition of the theoretical framework. Having the context of the overarching design space, which includes epistemological and methodological components, helps me anchor this knowledge in situated use and the phenomenologically role that the artifacts assume in these surroundings. I believe this makes it easier for a more scientific audience – as opposed to design practitioners – to relate the knowledge back to their language (Höök et al., 2015, p. 35).

7.1.3. Procedure of the analysis

Each design outcome is the result of a different research exploration and therefore deals with a different inquiry; they can serve different roles and help to answer different questions, but they all reside within the same design space. Within the artifacts resides knowledge that led to the exact design as the response to the research objective (Pierce, 2014; Zimmerman et al., 2010). I will use these two analyses to highlight the most important characteristics of selected research products from various research explorations. I believe my

approach has directed more attention towards methodological concerns than might be the norm within common design practice, and while methodologies and theories can come at the expense of design (Gaver and Bowers, 2012, p. 42), I firmly believe that the design outcomes of my research hold the potential to generate new knowledge – as artifacts subject to reflection and as thought-provokers raising new questions that by themselves manifest a contribution to knowledge.

I used annotated portfolios (Gaver and Bowers, 2012) to structure the first analysis of my design artifacts as a systematic collection of individual artifacts making up an area within my design space. The first analysis introduces five radios that are first annotated individually to explain their characteristics and then reflected upon as a collection of design artifacts. The second analysis follows a similar procedure with annotated artifacts but reflects on the design outcomes as various manifestations of the collaborative design effort between the participants and me.

One challenge when attempting to generate insight through the artifact is that *"there is no agreed upon method to document the knowledge — methods, theories, and insights — that emerge from this type of research"* (Zimmerman et al., 2010, p. 310). I believe my two analyses have provided knowledge that allows me to revisit the design framework and make adjustment anchored in research generated through design. To scaffold my own reflection of how these artifacts responded to the problem, I have also included qualitative data from the aforementioned research exploration in which these artifacts were produced. The data is drawn from the same evaluation activities that have been outlined in **Paper 4** and **Paper 5**. This data includes key quotes and observations that can reinforce or contradict my own reflection as it allows me to take the users' experiences from testing these artifacts in real environments into consideration.

Analysis 1

This first analysis uses the five radios made in the following research explorations: *PiRadio (RE #3)*, *Tangible Alternatives (RE #6)*, *Motor Radio (RE #7)*, *Magnetic Radio (RE #12)*, and *Elbø (RE #14)*. These designs serve two purposes: first, as different responses to the problem space; second, as design artifacts that can be clustered together into a portfolio. As such, both

purposes are important means of conveying the scientific value these design artifacts hold. For that reason, they will first be presented as individual design artifacts with annotations that describe their individual nature, and I will then structure the next part by clustering the annotations from these five design artifacts into two main themes.

The annotations allow the artifacts to speak for themselves, and I have not explained the details behind each annotation for each artifact. The features of the radios are not individuals considerations put together into one device, but the embodiment of multiple intertwined considerations. I am therefore not pinpointing the annotation to specific points of the design – dissecting the artifacts in such a way would contradict the considerations I hold of them as a layered and entangled design.

Analysis 2

The second analysis concerns the design outcomes from *Induction Charge (RE #10)*. In this research exploration – as described in **Paper 5** – the participants were part of a co-design process aiming to find new ways of delivering a common task by building on embodied experiences. More precisely, it studied the design of alternative ways to solve the everyday task of charging devices such as tablets and mobile phones by beginning with the body.

This second analysis also relies on annotated portfolios, but with a different investigative focus and a different structure. This is still an inquiry into the designed objects, but it is an analysis of design outcomes generated in a collaborative design effort and therefore expands on my own theoretical understanding by including layers of participants' perspective on how the design should manifest itself. While the first analysis began by introducing each design as individual artifacts, these designs are all from the same research exploration and have overlapping characteristics that demand a different analytic approach. Rather than presenting them as individual artifacts, I am using their overlapping features to demonstrate manifestations of different considerations and strategies used to respond to the problem space. To structure this second analysis, I use the three phenomenological dimensions of my design framework: the people and their bodies; the actions and interactions; and the interaction as part of the spatial context. The

annotations are not tied to each individual artifact but to the group of artifacts as a set of artifacts adhering to one of the three dimensions of my framework. These two analyses are first analyzed separately and then pulled together to state the final result of this analysis. **Figure 7.1** presents an overview of the steps followed in the two lines of analysis to generate knowledge through reflection.

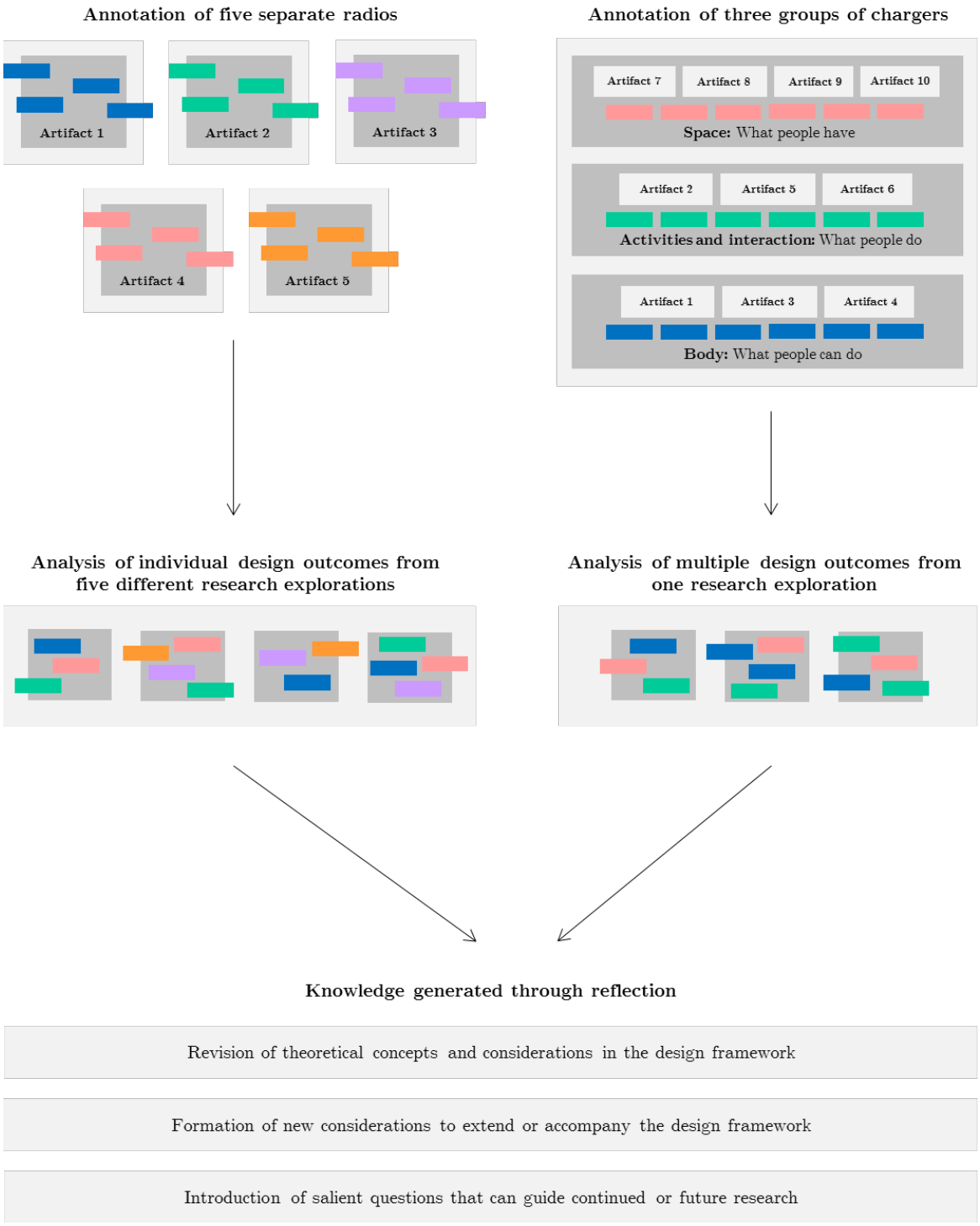

***Figure 7.1**: Overview of the different steps of analyses*

7.2. Analysis 1: The five radios

This analysis will draw on the qualitative data gathered when observing these radios in real use to bring out the most important features of the design that the users were mostly concerned with in their everyday use situation. By looking at the annotations, there are many design features that could be analyzed further. However, I want to emphasize those that were most important to the users' experience of the design.

7.2.1. PiRadio *(RE #3)*

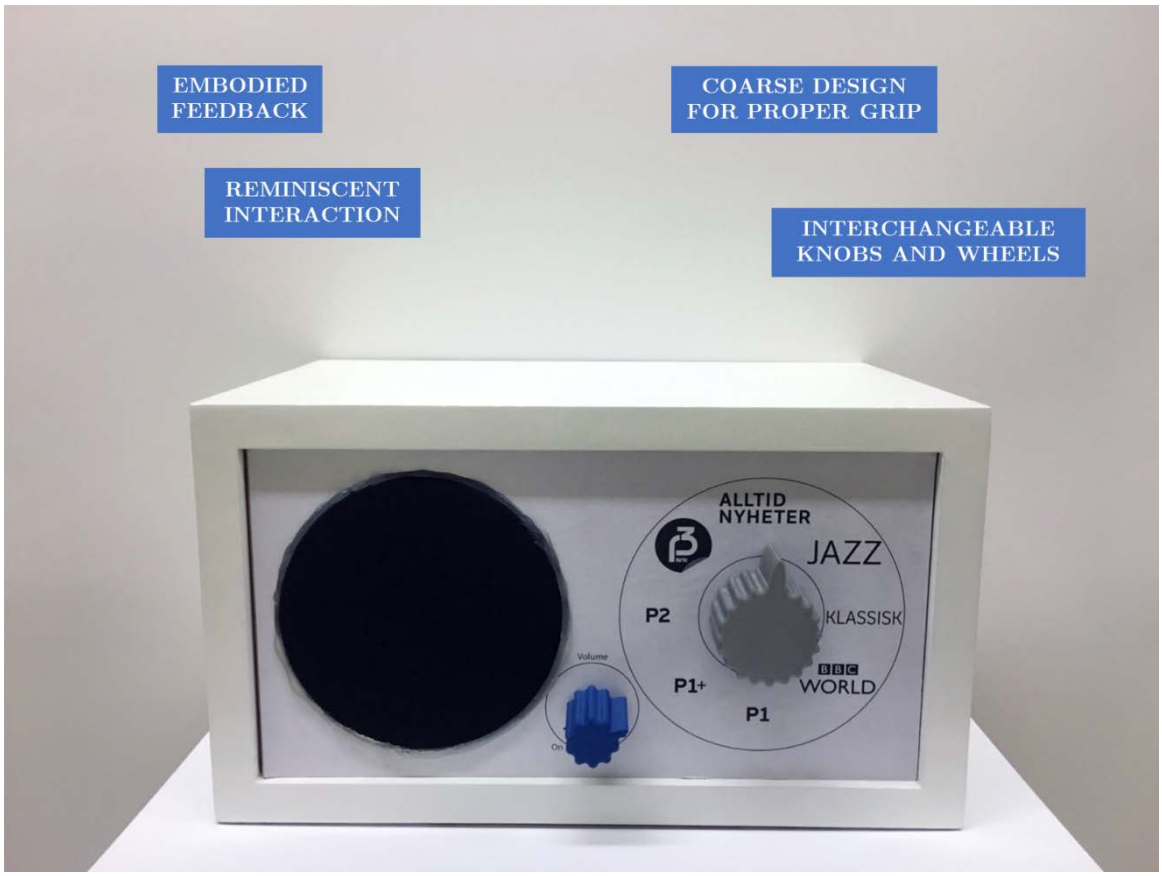

Figure 7.2: *PiRadio*

PiRadio: The radio is designed to provide reminiscent feedback similar to older radios. Specific rotary encoders have been used to reinforce experiences of old use habits by replicating feedback from the radio during operation. The knobs and wheels are interchangeable and are constructed to counteract slipping during input through the use of material properties. The coarse surface of the hard knobs and wheels offer a sturdy grip that counteracts involuntary slipping. The radio has a solid wooden frame coated with white paint for a non-intrusive aesthetic finish. The design is intended to offer durability and sturdiness through the solid construction.

Collaborators: Espen Johnsson, Magnus Ofstad, and Sarujanthan Subaschandran

7.2.2. TRadio *(RE #6)*

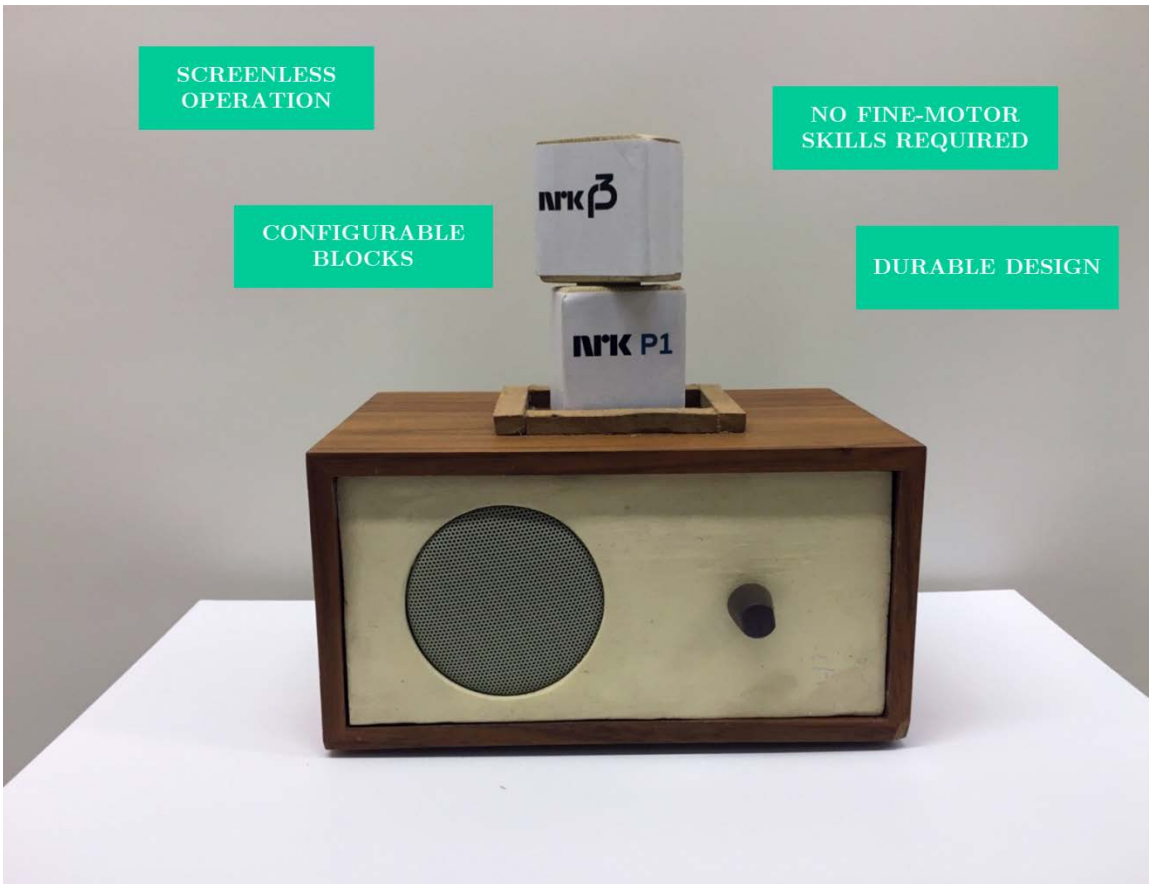

Figure 7.3: *TRadio*

TRadio: The radio is designed to offer people struggling with tasks requiring fine motor skills an interface that involves the use of other capabilities. The radio uses hand-sized building blocks as the input mechanism. Each block represents a channel, and when placed within the designated zone on the top, the radio plays; when removed, it stops. The radio is designed to offer durability through the use of oak and has a stained finish to offer a pleasing aesthetic look. The blocks are intended to balance light-weight interaction with firmness while remaining sturdy enough to be gripped firmly. The blocks are also made out of wood matching the radio's look, but the blocks can be freely configured in terms of size, weight, and material.

Collaborators: Thomas Iversen

7.2.3. Podio *(RE #12)*

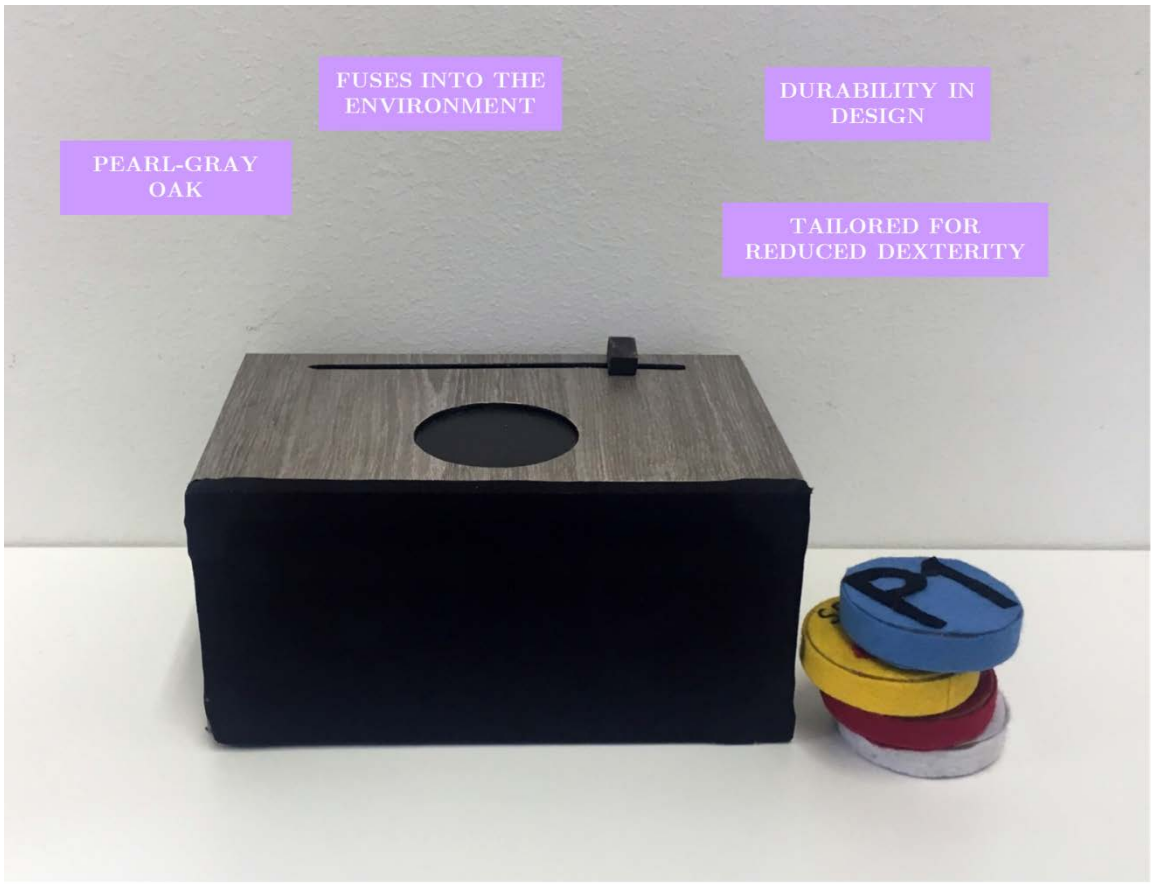

Figure 7.4: *Podio*

Podio: The radio is designed in pearl-gray oak and attempts to blend into the environment by aligning with the home aesthetics of older adults. The radio is intentionally designed without small buttons and smaller input mechanisms. Circular pods are placed in a hollowed and lowered circle to initiate the radio and removing the pods ends the operation. The pods use strong colors to help distinguish the options and have been designed to be easily gripped. To counteract negative experiences with cold, hard, and slippery surfaces, the pods have been coated with soft fabric.

Collaborators: Anna Sofie Schei, Ellen Katrine Sveen, Jostein Hellerud, Espen Wøien Olsen

7.2.4. Magnetic Radio *(RE #7)*

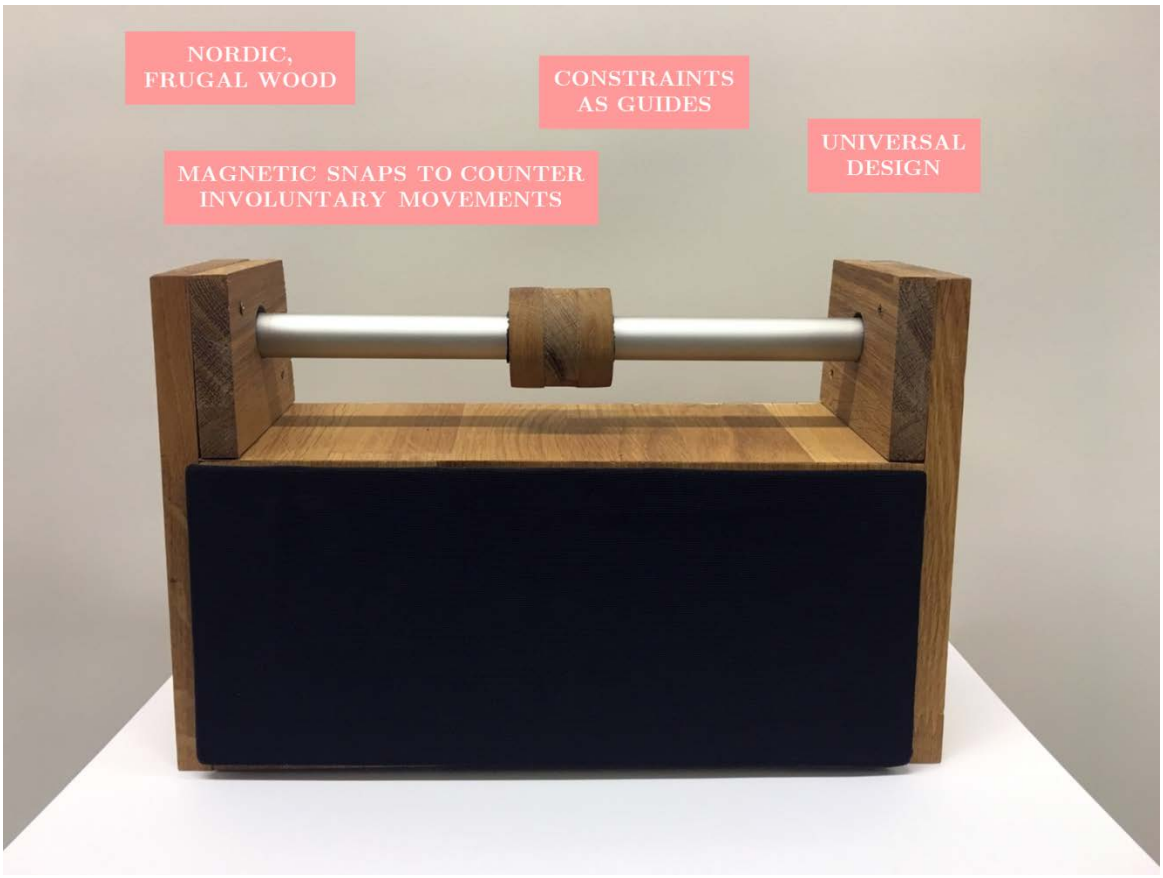

Figure 7.5: *Magnetic Radio*

Magnetic Radio: The radio is designed with magnetic snaps that counteract interaction difficulties due to tremors, involuntary twitching, or reduced fine motor skills. The pole has three pre-defined positions that each represents a channel. Users interact by sliding the wooden piece between these positions. The sliding operation is guided by a magnetic force that reduces the need for accuracy by completing the unfinished movements in a specific direction. The radio is built in Nordic, frugal wood similar to the Scandinavian traditions of home aesthetics.

Collaborators: Jorun Børsting, Espen Johnsson, Lena Drevsjø, and Vegard Søyseth

7.2.5. Elbø *(RE #14)*

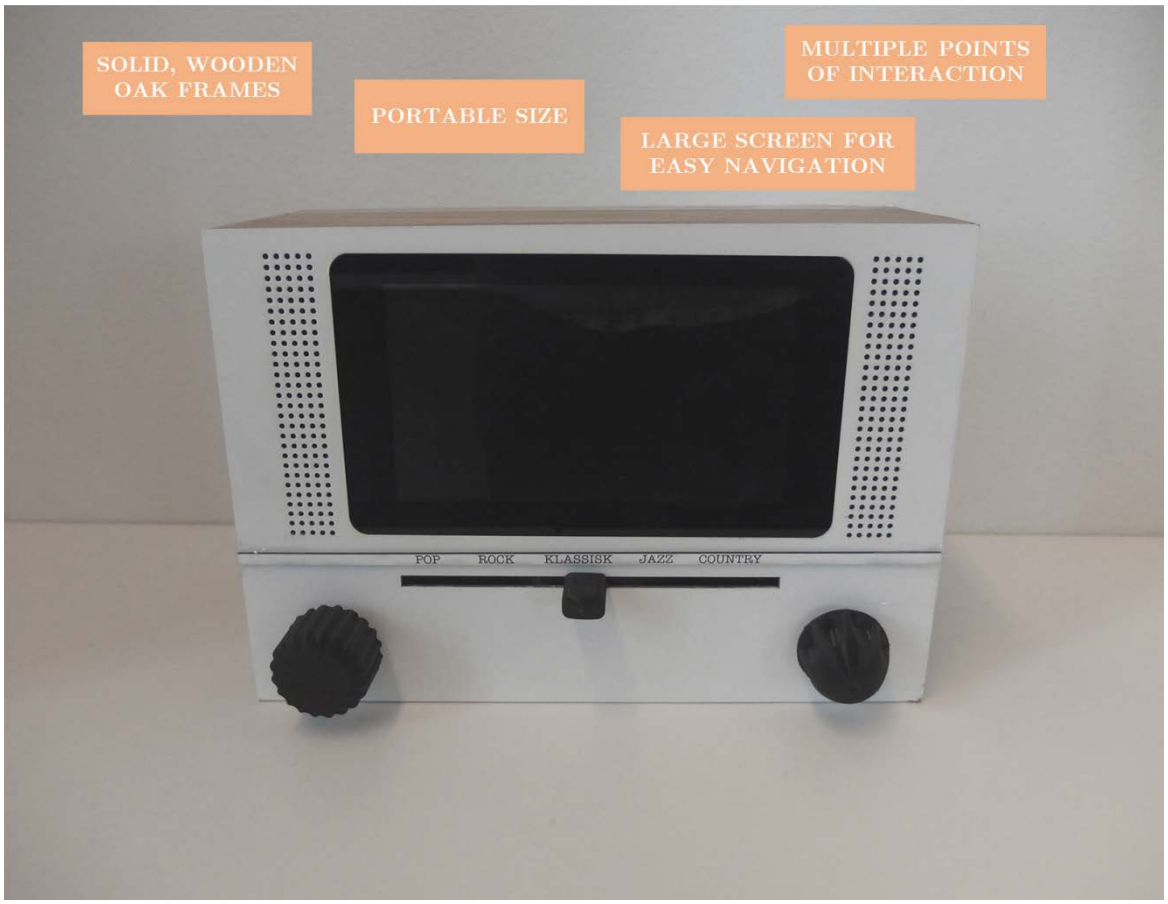

Figure 7.6: *Elbø*

Elbø: The radio is designed with wooden oak frames and a front design with strong color contrasts. The design intends to offer a retro look inspired by an analysis of 45 older radios from the 1950's and onwards. The input mechanisms attempt to combine specific tailored details such as strong color contrast with older input mechanisms such as sliders and knobs. The slider allows snapping into position to remove needs for accuracy and the snap motion is driven by a mechanical snap that completes movements. All wheels and knobs are interchangeable and can be customized in terms of material, colors, and resistance. The screen offers users access to more advanced navigational operations.

Collaborators: Sigrid Bakås, Martin Bjerkeengen, Kai Chen, and Anna Finstad

7.2.6. The radios as a portfolio for reflection

The furnishing and arrangement in the different apartments of the Care+ facility were unique despite having the same architectural layout and infrastructural facilities. My assumptions based on numerous co-design activities suggested that wood could be an appropriate material holding aesthetic features that would not disrupt their current home aesthetics. However, part of the assumption was uncertainty on how wooden textures would be welcomed into the homes and blend together with their everyday context and routines. As such, the use of wood as a part of all radios was a way to study how specific design choices unfolded in use situations while still allowing enough freedom for it to not predetermine the main design focus.

The radios' ability to blend into the environment was generally favored due to their frugal and wooden design that aligned well with the furnishing and arrangement of most of the users' living rooms. One of the users said that the wooden objects invoked a sense of calmness – it was a natural and relatable material that made the appearance more approachable and less intimidating by design (man, 78). He preferred Podio as the pearl-gray oak tones of the wood brought back old memories of *"pale, monochromatic, and organic"* designs. While the wooden texture was well-received, it was not a matter of unanimous acclaim. For instance, one lady had more textile than wood furniture in her apartment, and she had a coherent interior with strong colors that made modern technology, e.g., her television, cell phone, and tablet, stand out through their polished and black design. This was to her aesthetically suboptimal, but she had *"learned to live with it"* (woman, 83). However, her main concern was that the radios introduced a third theme that did not comply with either one of her current aesthetically contrasting themes, and that she would rather have a black and polished design as she did not find wooden texture suitable for her home environment. As such, there were clear opportunities to dive deeper into understanding the role of materials when constructing digital artifacts as part of a context in which other materials already reside. Moreover, there were also a few users who did not feel as strongly about wood as a material; one user even questioned the combination of a traditional non-digital material as wood with digital components and said that it was a confusing union in her opinion (woman, 76). Both of these emerging issues inspired and motivated later lines of inquiry; for instance, in

the research exploration *Materiality (RE #14)* we investigated the role of materials in the design space independent of these particular radios, see, e.g., (Joshi and Bråthen, 2016c, 2016b).

One important feature across all radios is that they are meant to be durable by design. The design avoids fragile materials such as glass, as well as features that would make the construction itself fragile such as sharp or pointy edges, while at the same time being small and compact in size and avoiding heavy materials. The TRadio was dropped twice by participants during the evaluation mentioned in **Paper 4**, but it did not break. For several users, their past experiences with wood as a material communicated ideas about the robustness and weight of the digital artifact, and this resulted in a more inviting design. One user said that the square shape and the wooden frame made him *"less afraid of breaking something because he was expecting durability in the material based on past experience"* (man, 78).

Another appreciated feature across all radios was that the construction did not suggest that the radios had been tailored for specific demographics. There were differences in how materials were perceived and favored, but all five designs were praised for tailoring not coming at the expense of embodying a nature of vulnerability in the design; technology does not have to radiate *"helplessness"* which is demeaning to the user and may carry a negative connotation in the context. One user explained that the radio pleasant to have in her everyday space as opposed to other technologies such as her safety alarm that she would hide when not using because it constantly reminded her own vulnerability – something the radio did not (woman, 79). As such, all five radios are examples of how this design space is not in conflict with making designs that can appeal to an audience outside the immediate demographic. The particular universal design annotation on the Magnetic Radio was added to reflect the praise from the staff and family members for a design appealing beyond the target demographic. For instance, the design of the input mechanisms, whether it is rotary wheels or wooden blocks, demonstrates a shift away from design features that can be considered stigmatizing due to the visual presentation itself; none of these radios contain specific design features that signal a tailoring towards a specific demographic, e.g., large numbers and buttons. This reinforces the idea of design not having to look like it is catered to a *"weakened"* demographic by remaining interesting to everyone.

Across the five designs, there are few and concentrated interaction mechanisms targeting very specific task solving. My research scope focused on sensory-motor challenges and the interaction mechanisms towards which I have directed my attention, reflect this research interest. The different radios represent different ways of tailoring input mechanisms towards specific sensory-motor challenges. For instance, the PiRadio uses a coarse and corrugated surface to ensure a proper grip, and the Magnetic Radio uses magnetism to guide and correct input. A user that experienced trembling treasured the magnetic force both counteracting and autocorrecting unintentional moves due to abrupt movements when using the Magnetic Radio (man, 73). Another user who tested all radios said that he only liked PiRadio because of the reminiscent interaction and feedback from the wheels and knobs; none of the other radios connected with his past use habits and experiences in the same way (man, 71), and this was particularly important to him because demanding that technology supported his daily routines was his way of taking control over how technology shaped his life. This was a principal statement, but there were also clear indicators of how individual perspectives emerged during use. The statistical analysis from **Paper 5** demonstrated how no single design solved everything for everyone, but that across these designs, everyone could find at least one alternative that allowed them to take up the use of radios again. As such, these five radios are only examples of tailored design emphasizing input mechanisms in particular.

The physical constraints are not enforced restrictions made to reduce the degrees of freedom simply because the users are unable to use them otherwise; the physical constraints demonstrate various ways of starting with a capability and then ensuring necessary support needed to continue using that capability in the design. The users who were fully capable of performing movements but struggled with fine precision tasks discovered that the little support in both TRadio and Podio could provide the preciseness they needed through the use of physical constraints. The physical barriers of both these radios are minimal. I was concerned that some users would think these designs were too oversimplified and stigmatizing (as discussed in **Paper 2**), but most people said everything had to lie somewhere between no support and support overtaking control of the whole situation, and that these two radios found a pleasant balance.

Another important reflection related to both stigmatizing design and physical constraints came up during studies of Elbø. The sliding function of Elbø prevented unintended moves from disturbing or resetting their main movement. Rather than calling such design features constraints – which to me carries a negative connotation of users being in need of error correction mechanisms – I believe these design examples demonstrate a way to talk about it as supportive features, i.e., where the design reflects a supporting nature of the moves we want to make rather than preventing all unintended moves from happening. One lady used strong words such as *"detest"* when describing interfaces where every unintentional move would either restart her progress or require additional steps (woman, 76); Elbø, in particular, allowed her to make a move and see progress which served as important motivation for her to complete the move. She did not express the same enthusiasm about TRadio or Podio as she once dropped a cube under the table and because of how that affected her immediate experience when only wanting to listen to the radio, she never bothered to use the radio again.

The reconfigurability of the blocks of TRadio, the pods of Podio, as well as the knobs and wheels on both Elbø and PiRadio, demonstrates a design intention of allowing users to put the final touch on how the interaction eventually unfolds. The use of granulated details such as the resistance from the wheel demands an understanding of a user's capability and preference that makes these design signal an important positional statement: some design details are nearly impossible to predict for designers when designing for changing needs over time. In my case, predicted needs were never relevant, but it took countless rounds of testing material details such as size, weight, and shape, of each single input component – and at one point, one user even saying that *"it sometimes felt like we were remodeling his old radio"* (man, 71) – only to realize that it had to be a design where users could put the final touch on the design themselves. Only then did the interaction make sense to the users in the present, and only by seeing the responsive nature of the radio work in the present did they trust the design to adapt similarly over time. While this is a matter of design that *can be*, it still demonstrates how design that *was* brought up concerns not covered in these design but highly relevant to the design space, e.g., matter of trust which was mentioned in **Paper 1** as one of the emerging issues.

Finally, all five radios offer embodied feedback. The PiRadio use special rotary encoders to recreate past experience of embodied feedback. The radio is built around habits and experiences by offering similar feedback to similar actions; the force required to perform the movement, as well as the resulting sound and snap, is designed to offer a similar experience in use. Similarly, both the Magnetic Radio and Elbø snap automatically to a position which indicates clearly to the user that their action is completed. Podio and TRadio were made to compensate for dexterity issues such as precision, and uses physical locking of the pods or blocks to provide feedback on a completed action. As such, the radios demonstrate interfaces that have been tailored to provide feedback on movement with embodied cues rather than visual cues.

7.3. Analysis 2: Induction chargers

The second analysis studies design outcomes of the collaborative design effort of induction chargers from *RE #10* outlined in **Paper 5**. This analysis is inspired by the general procedure of annotated portfolios but is structured differently to direct the focus towards the design framework. **Figure 7.7** and **Figure 7.8** show all the ten designs from this research exploration. Each column depicts the front and back of the design. These ten designs are annotated in groups of three or four designs where the grouping reflects the three phenomenological dimensions from the design framework: the people and their bodies; the actions and interactions; and the interaction as part of the spatial context. The annotations and reflections are not structured in separate subsections similar to the first analysis but presented together to concentrate the reflection to each of the three sets of design outcomes.

Figure 7.7: *Design outcomes #1-5 from* ***Paper 5***

Figure 7.8: *Design outcomes #6-10 from* ***Paper 5***

7.3.1. Designing for what people can

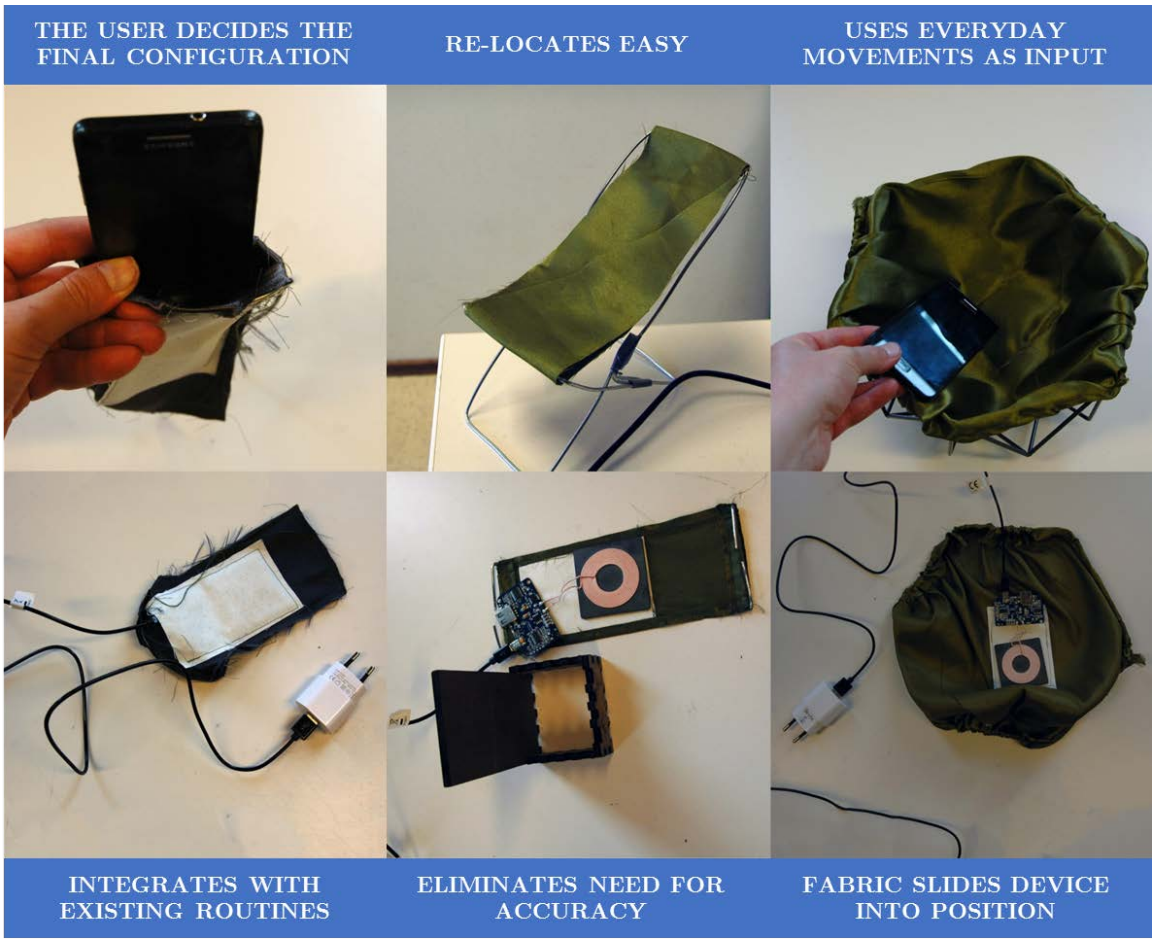

Figure 7.9: *Design outcome #1, #3, and #4*

The first theme addresses how the design reflects the capabilities of the users. The three artifacts demonstrate manifestations that do not assume a certain level of dexterity or preciseness during the interaction. For users who were struggling with the small components such as charger cables that required precise insertion or the wall-mounted docks in the apartment of Care+ where a tablet would have to be positioned on an exact spot (see Chapter 2.2), these designs opened up new opportunities. As all the chargers were designed for induction charging, technological requirements still demanded that the device was placed precisely, but it simultaneously gave more flexibility in terms of what type of actions that were necessary from the users. The varying capabilities of the users resulted in different everyday routines that all required very different types of tailoring, and multiple points of interaction and better flexibility in terms of relocating were the two main features that

allowed the design to get closer to their everyday life by starting with their current familiar, everyday movements. For instance, if someone wanted to drop the tablet or cell phone into a bowl like he or she did with other objects, the material and physical attributes would help slide the device into the right position, thereby removing accuracy as a requirement for interaction. This was especially important to users who were struggling with tasks dependent on fine motor skills but were otherwise fully functional. One user who struggled with gripping objects, especially with his *"polished and slippery devices like phones"* (man, 74), used the fabric of the pocket design to push the device out and the fabric acted as a layer between him and the device that gave him a better grip.

The most important lesson that emerged by watching users interact with these designs was that acknowledging changing capabilities is not only about supporting a permanent shift in capabilities but equally about supporting an everyday life where capabilities fluctuate. On days when the body was aching, being able to move the charger closer to the bed was important, but during other days, the regular habits aligned best with a different configuration out in the living room. Thus, giving users the agency to take control over the final manifestation and continuously let the technology mirror their current capabilities is vital for the design to survive over time.

7.3.2. Designing for what people do

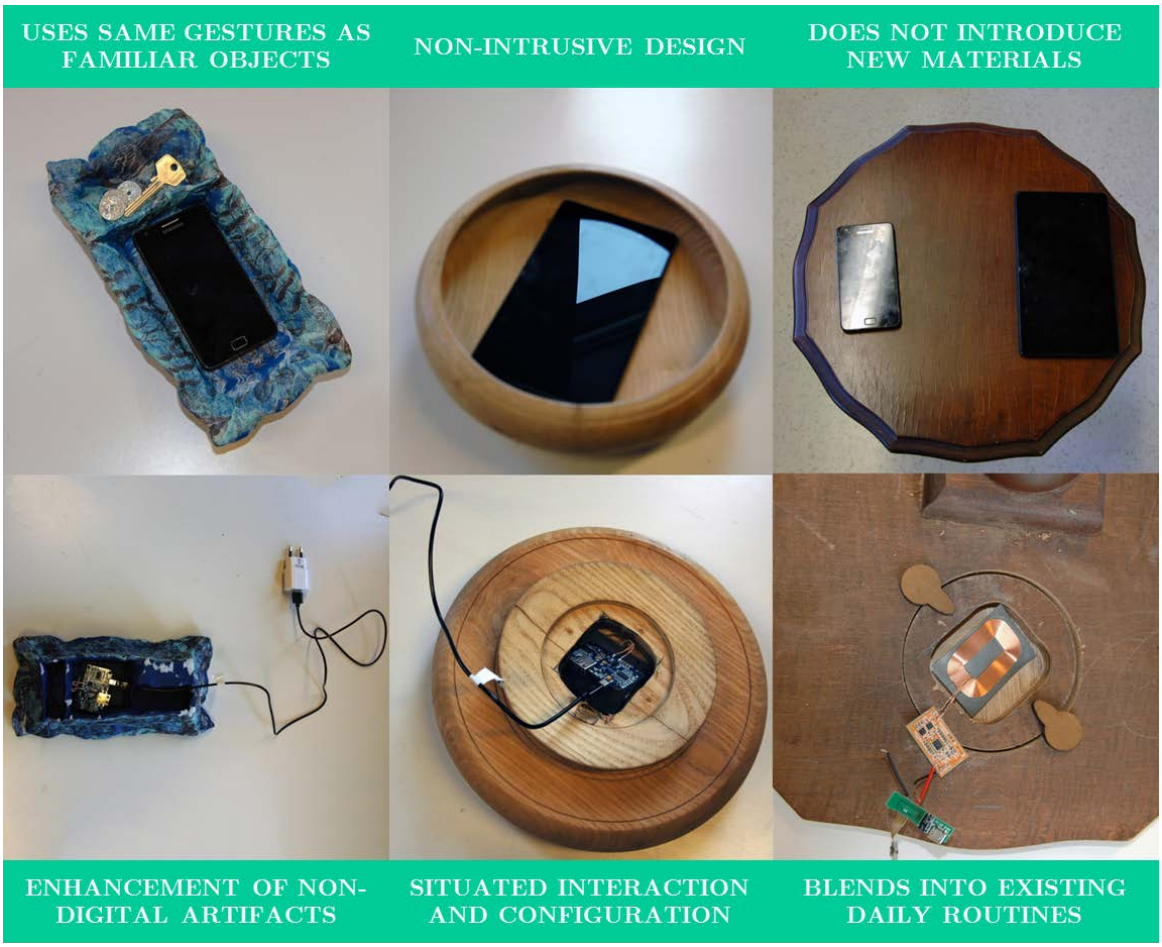

Figure 7.10: *Design outcome #2, #5, and #6*

The second theme illustrates how the design is supporting the users' everyday activities; people have spaces and routines that they associate with certain activities. The artifacts use these activities as a starting reference for interaction by situating the interaction to the appropriate spaces and configuring the interaction based on everyday routines. For instance, one lady had her telephone on a separate table in her home, something she referred to as her *"phone corner"* (woman, 81). To her, the only place it made sense to have any additional devices was in this corner. These artifacts demonstrate different ways of supporting her needs. One of the features of the design is enhancing non-digital existing objects – this allows people to bring the interaction to objects already residing in the space rather than introducing new own. She would always leave her tablet on the same spot on the table and by embedding the chargers into her table; the design demonstrates the idea of

anchoring the charging activity in the places and routines she knows. It is a non-intrusive approach to design, but more importantly, habitual gestures afforded by the context reinforce the movements required to perform the interaction. Activities associated with exact locations, for instance always leaving devices on a specific table, can support established spatial relations and prevent modifications of where objects reside in space.

The emerging considerations from the users dealt with intrusiveness experienced by introducing new artifacts that disturbed the harmony of their homes. One lady was particularly fond of the bowl because she felt it was the only design that blended in with her aesthetic desires: *"the design I like best is the one that lets my home look the same"* (woman, 81). However, I believe it demonstrated a larger and more important point of not forcing designs that take up undesired space in their home, especially in a personal space and context such as this; it could be a matter of introducing things disturbing the aesthetic harmony equally as much as taking up physical space. For the artifact to blend in with existing routines – it had to be a non-intrusive design.

7.3.3. Designing with what people have

Figure 7.11: *Design outcome #7-10*

The third theme demonstrates how the designs utilized the context of the home to offer for new opportunities. People have objects in their contexts that carry values, memories, and affordances of use, and such objects were used as a basis to find new ways of tailoring interaction. These four artifacts demonstrate ways of designing for continuous use by not introducing any new movements, but rather continue to rely on what they already have in their home; the designs do not introduce any new movements that have to be learned but instead takes advantage of the concrete moves already existing within the space. Familiar objects – even self-made everyday objects such as home-knit coasters – can be incorporated into the interaction experience and help the interaction remain material independent. This way, users can take control over how the interaction happens and to what degree it interferes with the aesthetic and homely identity of their personal space. For instance, the shape, fabric, and pattern of materials can provide familiar visual cues that guide the interaction. Not having to commit to one specific material or a predefined number of interaction points allows continuous reshaping of the interaction – it can be configured and extended as desired over time. One of

the users loved the option to extend the number of interaction point as he often had grandchildren visiting who would bring their own devices and could invite them into using his setup without interfering with his own use (man, 71).

One topic that emerged as users experienced use situations was that the feature they appreciated the most was the ability to hide away the technology from the space and from other people without losing the personal knowledge of its presence. One user expressed his satisfaction with the tablecloth design by saying that *"I know it is there, and I know where it is, but only I can tell"* (woman, 74). The balance between having clues to help your own interaction and simultaneously not inviting the rest of the world into that human-technology relationship was important to many users.

7.4. Revising the design framework

I will now revisit my design framework and use experiences and learning from the two analyses to introduce a revised version. The design framework presented in Chapter 4.4 was built on a theoretical understanding, but the knowledge generated from analyzing these design outcomes now allows me to interweave my theoretical and practical understanding and present the theoretical contribution of this dissertation, i.e., a final design framework for enabling interaction.

I will begin by explaining the specific changes I have made to the design framework based on knowledge generated from the two analyses of the design outcomes. Reflecting on the design outcomes as well as observing them being used in real environments have brought forward a lot of considerations that are not sufficiently articulated in the framework as it was presented earlier. In addition to suggesting some specific changes to the content of the existing framework, the main influence of the knowledge generated through design will be to scaffold the framework by introducing some general considerations to help direct the use of this design framework. I believe that as a theoretical contribution for design practitioners, this design framework should remain open enough for other researchers to expand or reshape it through their own interpretation and application rather than me reducing the many different types of intermediary knowledge (Höök et al., 2015, p. 34) to specific considerations or concepts.

7.4.1. Changes to existing concepts and considerations

Foreground/background

Separating foreground and background activities was – from a purely theoretically informed perspective – motivated by the desire to interpret the users' intentions by understanding their movements. As explained in Chapter 4, this mainly applies to passive or sensor-based systems that need to detect and react to movement. One of the common threads across all radios and chargers presented in this section – as well as with the design outcomes from other research explorations – is that the design only attempts at solving one task at a time. Thus, a system's ability to register and translate human behavior into interaction intentions is less relevant to my design space. In my search for designs contributing to an increased agency for the users, the designs have started by looking for opportunities to enable the capabilities we have rather than beginning the exploration by asking what the technology can do for us. This has been reinforced by the continuous involvement of users in all design activities: much of their frustration comes from ungraspable, invisible, and complex systems (**Paper 1**) and their desire has always been to have simplistic devices solving single tasks (**Paper 2**). As a result, I have removed the theoretical concept *foreground/background* from the framework. I should clarify that I still consider the underlying phenomenological idea of separating intentional and unintentional movements important to my design space, but I simultaneously believe there are better ways of approaching that particular problem than using the foreground-background phenomena to make the distinction. My approach has been to begin with the movements the body allow and disallow as suggested by Larssen et al. (2004) and using design features such as the snapping magnetic interface of the Magnetic Radio to let their interaction remain active while still addressing involuntary or unintentional movements.

The role of materials

The topic of materials is complex and remains a double-edged sword, and the different induction charger designs demonstrated this ambiguous role of materials: material properties can be a channel for the design to compensate for bodily challenges and support continued interaction, but it can

simultaneously disrupt the aesthetic nature of the home environment. It may also end up creating confusing or inappropriate associations that hinder the material properties to be understood as the designer imagined and may result in different human-object relationships than intended. The radios demonstrated that even when using heavily favored materials such as the wood used in the radios, the material itself can be a barrier for certain users or contexts. This complexity of materials within the context of the home and everyday tasks has sparked both continuous and new explorations into the role of materials, by me as well as my colleagues and master students.

In the design framework proposed in Chapter 4.4, the material dimension is tied to the interaction and the digital artifact's ability to speak to the body in a way that gives maximum grip of the situation. However, the material properties have proved themselves to be equally relevant to the two other dimensions. The weakness of making this artificial separation between space, objects, and bodies in the framework is that certain considerations may seem more confined to their related theoretical concepts than the intention of the framework is; having physical and material attributes as a channel for understanding specifics parts of the interaction, for instance, maximum grip, does not prevent it from being a way of understanding a larger scope of the interaction. In my particular design space, the *physical/material attributes* is a relevant consideration to all three phenomenological dimensions and have therefore been removed from the specific row in the framework and been moved to the general considerations that will accompany the reshaped framework. Rather than the framework suggesting a relevance of materials mainly applying mainly to one dimension, it will now be presented as a general consideration that extends across all three dimensions. Naturally, the applicability of the considerations as a way to address multiple theoretical concepts simultaneously is relevant for most considerations, but no other consideration has demonstrated such complexity in any of the design outcomes as the role of materials. This is reflected in the titles of the two publications made with master student Heidi Bråthen*: "Supporting New Interactions With Past Experiences Anchored in Materials"* and *"The Role of Materials in Design of Familiar and Contextual Assistive Technologies"* (Joshi and Bråthen, 2016c, 2016b). Nevertheless, to make any specific suggestions in

terms of materials in this specific context demands further investigation, both in terms of theoretical development and learning from design outcomes.

Robustness

The solid wooden frame of the radios emerged as an important constructional feature that helped users focus on the digital object itself and indicating a move away from the commonly observed hesitance towards existing unfamiliar technology (**Paper 1**). Throughout all phases of traditional usability or performance testing (**Paper 4** and **Paper 5**) as well as during observation made of use in real environments, the participants demonstrated a less careful approach towards the technology than I had previously observed with existing technology (**Paper 1**) – despite dropping the radios on the floor multiple times. Returning to the design framework, the dimension of digital objects mainly addresses how the users are positioned relative to the object and how certain presentations of the interaction modes may yield more favorable configurations. However, how the object itself is perceived in terms of what the body can expect also related to the users' perception of the object's robustness: participants expressed a better understanding of how to approach the radios, for instance, the force required to lift and relocate them. As explained in Chapter 3, the attributes of objects are – according to the phenomenology of the lived body – provided by the relationship between the object and our being in the world, and the robustness of the object emerges as a way to provide our lived experience with clues that can trigger expectations in terms of how to approach and interact with it. As such, the design framework has been expanded with the design consideration *robustness* that can be used to make the digital object more familiar by triggering the appropriate expectations and not putting pressure on their behavior due to incorrect perceptions about the objects fragility.

Temporality and sediments

The design framework is intended to help me as well as other designers understand how we can design for changing capabilities. However, one confusing aspect of the original framework was its addressing of temporality. As I registered during the long-term observation of induction chargers, designing for changing capabilities is not only a matter of a slow but steady

decline; it is equally about supporting the fluctuating nature of our capabilities. People waking up with sore muscles one morning may only experience a temporary reduction of opportunities to act in the world that affects them momentarily without necessarily undergoing a permanent decline in capabilities. In retrospect, I see that including the consideration *capacity* in the framework as a way to acknowledge the present embodied manifestation of the dynamic nature of changing capabilities is more confusing than helpful. Adapting to changing capabilities is the intrinsic goal of the whole design framework, and positioning it to one row alone does not seem appropriate, especially considering the fluctuating nature of how our capabilities change over time. I have instead introduced the general consideration *sediments* as a way to pinpoint the temporality of changing capabilities. I want to quote Robertson's (2005) use of sediments in the context of technology design to accentuate the complex relationship between the past and present experiences in Merleau-Ponty's phenomenology:

> *"Just as Merleau-Ponty argued that the phenomenological body and the objective body are united through existence, so too are the sediment of the already existing and the spontaneity and novelty of the present. The meanings generated through the present become the next layer of sediment. No wonder that context is such a slippery concept for technology designers to grasp. Contexts belong to the present, they are always immanent to any action, just as they are always shaped and enabled by the sediment of an already existing world, including the always constituting human subject whose context it is." (Robertson, 2005, p. 8)*

The lack of addressing temporality in a more direct manner in the design framework is definitely an opening for further development. However, similar to most of Merleau-Ponty's phenomenology, concepts and relations are intertwined and cannot escape each other or exist alone.

7.4.2. Introduction of new general considerations

Besides the previous points of materials and sediments that both motivated changes to the existing framework as well as introduced new general considerations, the knowledge gained through the reflection of these digital artifacts has brought forward additional general considerations.

Non-stigmatizing design

One of the major challenges of current technology within my empirical context is stigmatizing design, i.e., how the digital artifact by design stigmatizes either the user directly or through how they experience other people perceiving them as a user of the particular device. **Paper 1** sheds light on ethical issues such as privacy, safety, and intrusion as reasons behind this stigmatization and **Paper 2** discusses how oversimplifying designs have resulted in a similar experience for many users. However, the design artifacts analyzed demonstrate one specific countermeasure against stigmatizing design, namely avoiding designs that radiate *"helplessness"* or embodying a nature of vulnerability in the design. This observation is supported by my theoretical perspective because according to Merleau-Ponty, the intrinsic attributes of objects belong to the phenomena rather than the object itself. The users reacted positively to design artifacts that upheld a balance between providing them enough support to continue interacting while not exaggerating the design to the point where it signaled vulnerability to other people, e.g., visitors, caretakers, and residence staff. The design artifacts analyzed did not only avoid such a signaling effect, it masked the specific interaction mechanisms into a more generic construction: the radios represent multiple examples of designs tailored for various sensory-motor challenges – used successfully in real environments by real users – that still piqued the interest of people who were unaware of the design's original motivation. As such, I believe there is a symbiotic relationship between generating non-stigmatizing design and the design artifact's ability to blend into the context, including existing habits and routines. Non-stigmatizing design is added as a general consideration to emphasize that letting users be who they are where they depend on the artifacts ability to understand, support, and respect the pre-existing circumstances and reflect this in the design. Finally, the observation of piqued interested among people outside of the scope of this dissertation demonstrate a possibility to inform larger design challenges such as universal design by beginning with the specifics found within my design space.

Autonomy over the final manifestation

As mentioned in the analysis of the radios, solving the challenge of designing for individual changes over time through traditional means became both an

impossible and undesired exercise. One of the most prominent features across all research explorations was giving the users decision-making power over the final manifestation of the various designs so that they could close the gap between our understanding of their lived experience and their actual lived experience. If I had assumed control over the final manifestation, I would basically be advocating two perspectives that would contradict the rationale of my overall approach: first, it would imply that I believe that design should be a deductive exercise where the designer predicts needs and tweaks each design feature in search of the perfect fit rather than letting the users draw on their own lived experience to look for new opportunities. Second, it would hold a lesser potential to remain purposeful over time as they have direct access to the sediments that have created meaning in the past and will create meaning in the future. While I believe this design framework gives other researchers good indicators on how to get closer to the lived experience of the users, it will ultimately remain a subjective experience that can only be understood by the person living through the body. As such, the person who has direct access to the lived experience, i.e., the individual user, should have some agency over the final manifestation of the design to make sure it has the best chance of remaining purposeful over time. It will further reinforce that this design framework is intended to be a phenomenological tool that begins with the lived experiences of the users to look for interaction opportunities with the bodies they have and the situations in which they reside. While I have argued for increased agency throughout the dissertation, this consideration is not only a matter of giving the users the capacity to act; it concerns increased space for action motivated and informed by the lived experiences of the users. I understand *autonomy* as something more than agency. For me, autonomy represents the freedom to guide actions through self-governing motivations – which says more than having the capacity to act – and that is what I want to emphasize through this consideration. For that reason, I am introducing autonomy, rather than the agency, over the final manifestation as a general consideration.

Aesthetics

Designing for everyday life in a personal space such as the living room demands considerations of the aesthetics of the design. The artifacts' ability to

blend into the home environment was almost unanimously brought up as a decisive criterion for the artifact to be used over time. The classical principle of *"form follows function"* is not a valid argument when the design enters the personal sphere of the home. People have strong relationships with the objects residing in their personal space and introducing new designs requires a graceful approach. The original design framework contained adaptability as a consideration focusing on how the new artifact blends in with the existing context. However, from a phenomenological perspective, it is not only a matter of creating an aesthetically pleasing design but also about not affecting the users' relationship with other pre-existing items. According to Merleau-Ponty, all objects are the mirror of all other objects; engaging with an object becomes a phenomenon in which the qualities visible to all surrounding objects are of equal importance as the intrinsic qualities of the object itself (Merleau-Ponty, 2002). As such, I have let adaptability remain in the design framework because it addresses contextual considerations beyond aesthetics, but I have simultaneously introduced aesthetics as a general consideration since the observation of real users demonstrated that the artifacts would just be hidden away in closets if not found aesthetically pleasing – regardless of functionality.

7.4.3. Summary of changes introduced through practical concerns

1. The theoretical concept of *foreground and background activity* has been removed due to lesser relevance to the overarching research question
2. The design consideration *physical/material attributes* has been removed from the framework and has shifted to a general concern that applies to all phenomenological dimensions rather than one specific dimension
3. The design consideration *robustness* has been introduced to address how the perception of solidness, sturdiness, and tactility triggers embodied expectations
4. The design consideration *capacity* has been removed due to its confusing placement and does not need to be repositioned due to its intrinsic presence across all phenomenological dimensions

5. The four topics *stigmatizations*, *sediments*, *autonomy*, and *aesthetics* have been introduced as general considerations that accompany the design frameworks and helps direct attention towards related concerns that do not fit structurally into the design framework

7.4.4. The final design framework

The changes introduced through practical concerns have contributed to refining the design framework with either direct changes to the framework or with new general considerations that can accompany the framework. The revised version is presented in **Table 7.1**.

Table 7.1: *The final design framework*

Pheno-menological dimension	**Theoretical concept**	**Design consideration**	**Design opportunities**
Everyday living space *(Space)*	Spatial awareness Concrete/abstract movements	Adaptability Arrangement Movement	Blending in with existing context; Situating interaction and configuration; Incorporating familiar movements and gestures
Digital artifacts *(Objects)*	Maximum grip Incorporated objects	Relative positioning Interaction mode Robustness	Allowing spatial reconfiguration; Building on lifelong habits and routines; Triggering appropriate expectations
Changing bodies *(Body)*	Bodily schema Bodily space Bodily skill	Configuration Response	Supporting multiple configurations; Adapting to changing capabilities; Providing embodied feedback

General considerations:

Materials: The use of materials is related to embodied experience and can create confusing or inappropriate associations if not included organically into the exploration. It can be contextual concerns such as the role materials play in adapting to the home setting, or it can be about how the materials support the desired embodied experience upon physical contact between user and technology.

Stigmatization: The final manifestation of the design should be explored in terms of how it radiates *"helplessness"* or to what degree it embodies a nature of vulnerability in the design. The pre-existing circumstances should be respected and appropriated into the design to avoid stigmatizing the users through the design.

Sediments: The dynamic nature of bodies is not addressed directly through the design framework. The design should acknowledge that bodily changes unfold over time as varying opportunities to act by adapting accordingly. As a phenomenological metaphor, sediments represent the tight relationship between time and action, and that this needs recognition to design for long-lasting interaction.

Autonomy: The final manifestation should allow adaptation over time to support the individual nature of lived experiences. Designing for capabilities does not automatically generate meaningful relationships. Users should have autonomy over the technology part of the human-technology relationship to assure that the technology can remain purposeful over time.

Aesthetics: The aesthetic nature of the design is related to all dimensions. How the design harmonizes with existing objects as well, as the pre-existing personal and contextual relations, directly influences how the qualities of the design unfold in space and are perceived in use.

7.5. Salient research questions

While the analyses in this chapter have been directed towards the development and finalization of the design framework, the knowledge generated along the way has raised important concerns and motivated further inquiries. The emerging issues are of both theoretical and practical nature and range from specific concerns in individual research explorations to larger questions concerning the overarching research question. One such example is how the emerging importance of materials through this analysis has sparked a new research exploration that specifically investigates the role materials play in how users understand the interaction opportunities of a design artifact (Joshi and Bråthen, 2016c). I end this chapter by listing some of the concerns

that have surfaced as worthy of further exploration, and that can hopefully motivate future research:

- Can the idea of designing for capabilities be elevated into a strong concept? (Höök and Löwgren, 2012)
- What qualities in the design artifacts generated with this design approach lend themselves to opening up a new design space? (Wiberg and Stolterman, 2014)
- How do the designed artifacts integrate with existing social relationships? (Forlizzi, 2008)
- How can following a *"designerly practice"* further contribute to research like mine? (Stolterman, 2008)
- Can this design approach and the design outcomes be used to construct a more generic framework for tangible interaction tailored specifically towards older adults? (Hornecker and Buur, 2006)
- Can the design artifacts suggest new spaces for participatory creativity when collaborating with older adults? (Bratteteig and Wagner, 2012)

Chapter 8

Discussion

The discussion consists of four sections. The first section draws on statistical analysis of performance data from a real use context to discuss the appropriateness of the design approach, while the second section reflects on ethical considerations. The third section summarizes the answers to the three research questions, and the fourth section presents my final reflection on the overarching concerns of this dissertation.

8.1. Credibility

I stated in my introduction that generating design outcomes was a necessity in my research procedure to exploit the full strength of the interplay between theory and design. Rather than just theorizing or speculating on the applicability of my overall design approach and its ability to help us meet the caretaking needs of the future, I have – along with the collaborators in the various research explorations – devoted time and effort to co-design and develop research prototypes and research products that can demonstrate the potential outcome of my approach. But looking back at the argument made by Krippendorff (2005) of how we design artifacts for the purpose of introducing changes to the world of the users, it was equally important to me that my approach could not only generate design outcomes but also generate research products that could be evaluated by users in real environments. Only then would I be able to express an opinion on its appropriateness that was grounded in empirical observations and results. Testing in real environments as a method of verification became increasingly important to me as I gradually immersed myself more into the context and discovered how little we as designers know about this complex domain. In a paper published on the *Collaborative Change Experiment (RE #2)*, we stress the importance of including real environments before making any final conclusion about the design:

> *"It is only then, when real users adopt the technology into their everyday life activities, researchers can gain knowledge of the sustainability of their design, and whether it can work in everyday practice with regards to necessary infrastructure, design and simplicity of use." (Joshi and Woll, 2015a)*

It was also important for me to stretch my research all the way from theorizing to the evaluation of actual use in order to demonstrate the originality of this dissertation to the PD community. I believe my approach makes an important contribution to the PD community by exploring the technological aspect of PD research – a topic that researchers have claimed has largely disappeared from PD research (Korsgaard et al., 2016). My claim is that this dissertation addresses exactly what is advocated by Korsgaard et al. as a necessity, i.e., to address the relationship between theory and implementation*: "we not only miss out on an opportunity for examining the implications for systems design in detail, we make the theoretical contributions less relevant by not being able to show how our research findings might have an impact on technology design"* (2016, p. 72). Their work draws on ideas put forward by literature that have heavily influenced modern research through design practice (e.g., Lim et al.'s (2008) work on the role of prototypes), which also aligns well with the role the design outcomes have had in my research – as generators of knowledge.

The design outcomes from multiple research explorations have been subject to testing in a realistic use context, i.e., a study of use after design (Bratteteig and Wagner, 2016, p. 148). Besides the *Collaborative Change Experiment (RE #2)* mentioned above as an exploration where we conducted such testing, most of the other explorations also involved some level of testing in real environments – the only exceptions being *HomeCare Expected (RE #4)* and *Materiality (RE #13)*. However, in this discussion, I would like to focus on the same two specific set of design outcomes as I previously analyzed, namely the radios and the induction chargers.

8.1.1. The radios as examples of enabling technology

As I presented in **Paper 4**, three of the radios were included in a performance testing of psychomotor abilities. The fourth radio is presented in the paper as a reflective tool to support the performance testing results with qualitative

data, and the fifth radio was not developed at the time. The participants consisted of people who due to psychomotor challenges were no longer able to operate commercial radios, and these radios were tested as enablers of technology that could reconnect them with the use of radios. Through a statistical analysis of the performance data, I demonstrated how every single participant – who all had either fully or partially lost their ability to interact with the three most popular commercial radio brands – could use at least one of the radios from this dissertation to reestablish their use of radios. The two graphs in **Figure 8.1** below are borrowed from **Paper 4** to demonstrate how participants with different psychomotor challenges found different radios most suitable for their needs; no single radio was perceived as uniformly better than the rest despite narrowing down the target group to older adults with psychomotor challenges in hands. I included the figure to the left to emphasize how the different radios could not satisfy the needs of everyone and that no radio managed to remain purposeful across all the psychomotor challenges. However, with a selection of radios available, everyone was able to find one suitable design. The rightmost figure further demonstrates that with these designs, the participants were able to rediscover interaction opportunities as well as performing at levels comparable to people without psychomotor challenges operating commercial radios. This was an important finding in terms of the prolonging nature I seek with my overall approach – the users performed at a level that at least suggested a potential of the radios remaining purposeful over time.

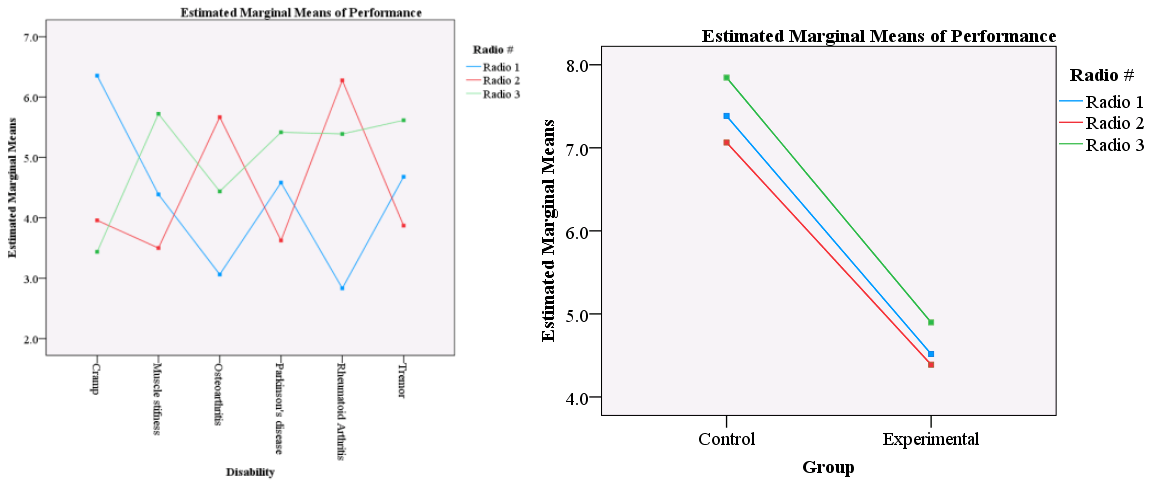

Figure 8.1: *Two graphs from* ***Paper 4*** *demonstrating difference in performance*

The statistical analysis from **Paper 4** further revealed two important considerations. First, these radios are only examples of how we can reconnect older adults with lost relationships with technology. As mentioned in the last chapter, these radios are not made to manifest a falsifiable or final statement; they are intended as different examples of generative design that have been verified and thereby demonstrate how my design approach has indeed been sometimes right (Gaver, 2012, p. 940). It is important for me to make this point because the phenomenological lens I have applied to focus on embodied experiences and capabilities holds a potential to continue generating additional designs – both from my own and other researchers' interpretation of the presented design framework.

Second, the analysis illustrates how the problem of designing enabling technologies for older adults requires both depth and width. If I had stopped after only one or two design outcomes, the analysis would have suggested a less definitive conclusion about the appropriateness of my design approach as I would not have been able to register enabled interaction for all participants. As such, to assess the overall suitability of my design approach, it was necessary to have a range of different design manifestations that could complement each other and provide different opportunities by approaching the design space from different perspectives. Seeing all these radios as outcomes of my approach also leaves me optimistic about its impact: by constructing additional radio designs, there is a likelihood of finding designs that suit the target demographic even better, and that can raise the performance to even higher levels. Similarly, there is a potential to continue the exploration in terms of depth. My approach emphasizes close cooperation with users in all phases of construction, and finding new ways of getting closer to the lived experiences of the participants will further enhance the probability of finding meaningful and long-lasting interactions.

8.1.2. The induction chargers as examples of enabling technology

I presented the design process and the results from the exploration *Induction Charger (RE #10)* in **Paper 5**. The statistical analysis focused on five selected designs that the users picked themselves after exploring all ten design ideas. The evaluation was carried out in the homes of the participants to contextualize the evaluation to real environments, and the participants

decided the configuration and placement of the device themselves. The reason behind only testing with five chargers was considered a methodic compromise that allowed broader explorations while simultaneously respecting the participants' capacities to participate, mainly limited endurance and stamina. As such, one weakness of this analysis is that it is not an exhaustive testing but the goal of the analysis, i.e., co-exploring new opportunities for interaction anchored in embodied experiences and studying the design outcomes' effect on their daily interaction, was not compromised. The two-level analysis began by examining the performance scores across all participants and compared the performance of each individual against their performance with currently available technology. The second part of the analysis studied individual differences across the five chargers to investigate whether a single charger would yield unanimously high-performance scores.

The analysis indicated similar patterns as with the radios. No single charger performed best across all participants due to within-group differences; different participants found different designs better suited to their home context. The important discovery was that by using one of these five designed chargers, all participants experienced a clear decrease in performance time. The leftmost graph in **Figure 8.2** demonstrates the average performance time with the old model (red color) compared to the five designs. On average, all five chargers performed better than the old model. Beginning with embodied experiences allowed participants to rediscover preferred ways of situating and configuring the interaction that increased their performance by 45.35 % on average.

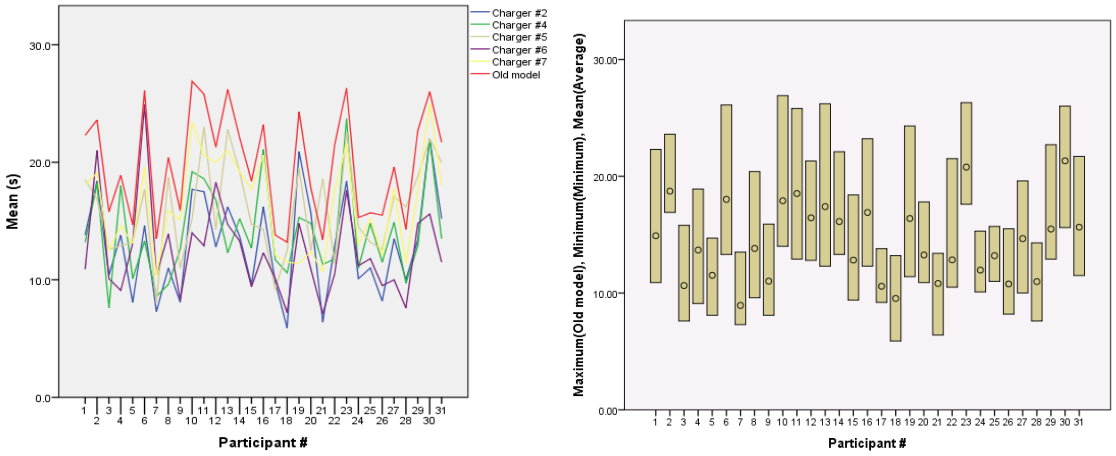

Figure 8.2: *Average performance per charger and per user (**Paper 5**)*

With a statistical analysis that indicates a better performance for all designs when compared to the old model, it would be easy to conclude the analysis at that. However, my phenomenological perspective is mainly concerned about tailoring designs to the individual, and the average performance scores may indeed camouflage some important details. I wanted to perform a second analysis to reflect critically on the implication of this approach to the individual user. The right graph demonstrates how the performance time for each participant varied greatly depending on which charger they used. The inner circle marks their average score across all chargers while the bottom of the bare denotes their peak performance (in seconds). These results illustrate how designing for an average increase rather than tailoring after individual considerations can yield clearer difference in performance for the individual. The qualitative data that accompanied the statistical analysis also revealed that while participants were able to perform better with these new designs, not all designs offered interaction mechanisms that they were comfortable with and would want to continue using over time.

As such, the use of statistical analysis of performance alone does not reveal the entire truth; the performance score alone confirms their capability to interact but does not say anything about the autonomy in doing so. Is it a desired interaction? Or does the interaction introduce additional challenges over time due to inadvertent consequences during long-term use such as straining issues? These questions were only confirmed by following up the performance testing with a brief interview where all subjective considerations could emerge, and I see that my design framework may give the idea that I am only concerned about the capability to act and not paying enough attention to whether it is the desired way of interacting. My design approach focuses on what people can do, but it should be clear from my design framework that I also believe designing for long-term use means that successful use should not come at the cost of enforcing interaction mechanisms that violate the users' preferences or needs. As such, one of the main motivations for including autonomy rather than agency as an accompanying consideration in the reshaped design framework was to emphasize that the users' opinions must not be overshadowed by positive performance scores.

8.2. Reflecting on the ethical considerations

I began my research by exploring emerging ethical human-technology relations from the perspectives of the users in **Paper 1**. The analysis of empirical data revealed four problem areas, and I introduced three specific considerations in the discussion: patience, adaptability, and openness. I want to return to these three specific considerations to reflect on my design approach's ability to address and counteract the ethical issues highlighted in the paper.

8.2.1. Patience

As argued in **Paper 3**, time was important to most of the participants in the study. The fact that many people thought otherwise was just one of the many examples of generalization they faced in their everyday life that contributed to the reduction of their lives into one homogenous group of people with similar needs. Similar to the argument of Light et al. (2016, p. 66) did being old by no means reflect the identity of the participants. However, it is a reported and discussed challenge to find characteristics for older adults that are not grounded in age and at the same time avoid stigmatizing their self-image (Malmborg et al., 2010).

One of the central aspects of my methodological contribution is the emphasis on time – both in the design of the process and in the analysis of participation. The analysis from **Paper 2** illustrates how returning to participants after only 13 months demonstrated major changes in capabilities, behavior, and preferences for each and every participant. The design process from Chapter 5 and **Paper 3** demonstrates one approach to giving people enough time even when the opportunities to participate are limited. Considering ethical issues a part of a contextually-defined environment than extends beyond the personal experience (Nissenbaum, 2009), I believe the use of contextual circumstances as an active component in the facilitation of the design process was helpful by not only giving participants enough time but also the right environment to identify and articulate own needs. I refer to multiple researchers in **Paper 3** when trying to demonstrate how PD literature has emphasized the importance of the context: as a general principle (Robertson and Wagner, 2012); when specifically working with older adults (Scandurra and Sjölinder, 2013); when focusing on an everyday setting

(Ballegaard et al., 2006); or when studying within a home setting (Eisma et al., 2003; Grönvall and Kyng, 2013). It was a deliberate move to give users time to extend their learning after the official design activities had ended, for instance by leaving behind artifacts. This gave the participants safety and space to explore without our hovering over them at all times and encouraging without judging (Keay-Bright and Howarth, 2012). More importantly, it helped to limit the danger of us designers dominating the process too much (Grönvall and Kyng, 2011). I believe the design process has indeed given the participants patience to discover and articulate own needs rather than us *"un-silencing"* needs on their behalf (Gramstad et al., 2013).

It has been a challenge to co-design with a long perspective in mind while organizing activities in multiple iterations of shorter sessions. Supporting the theoretical focus on embodied experiences has demanded a lot of time from me, my colleagues, and most importantly, the participants. Certain experiences shaped through long-term use are difficult to discover in short and intensive sessions. With a phenomenological lens, it is only the users who have direct access to the experience. The use of research products in their environment was my way of giving participants enough time to experience and reflect on the design as they gradually refined their response through repeated exposure (Dreyfus, 1996, 2002).

Time is a double-edged sword in my context. On the one hand, I have made the argument of why it is important to give participants time and space to let long-term issues unfold. But on the other hand, there is a danger of time conflicting with my overarching desire of designing for capabilities rather than disabilities. Van der Dam et al. (2012) argue that the ethical considerations are not similar for short-time care and long-term care as the latter face challenges related to deterioration rather than cure. It has been a constant matter of balance to support my salutary emphasis on capabilities rather than obstacles and deficits without compromising the ability to let participants experience important ethical concerns. As such, there is literature that suggests that my focus on capabilities restricts certain types of ethical considerations, that actually requires participants to assume a more pathogenic perspective, to properly emerge. I am, however, confident in my design approach's ability to provide participants with enough time for

articulation needs that require a *"prolonged and subtle*" process (Gramstad et al., 2013), to emerge.

8.2.2. Adaptability

Almost all related work mentioned in **Paper 1** recommends adaptability. One challenge with drawing on this literature is that it does not detail how the authors suggest this consideration should manifest itself in such a way that it is directly transferrable to my design space. It is also unclear from the literature whether this is only suggested as a functional move, i.e., making the end-result adaptable to changing needs, or whether it applies equally to the design process. I argue that my design approach demonstrates adaptability at a more nuanced level than just supporting adaptability as a design feature; the theoretical and methodological contribution in this dissertation is intended as a perspective on both understanding and involving older adults by adapting to their capabilities. Merleau-Ponty's work puts the lived body first when theorizing human behavior as it begins with the human experience and then attempts to develop a scientific account (Matthews, 2014, p. 32). My phenomenological lens inherently acknowledges a need for the individual to explore, discover, and employ the opportunities for human-technology relations by beginning with the capabilities of the body before assuming anything else.

> *"For my body has its own limits with which I must reckon, its own pacing to which I must adapt." (Aho and Aho, 2008, p. 18)*

My design framework contains eight design considerations that all are intended to help designers find ways to adapt to pre-existing human-world relationships. Adaptability is one of these design considerations I presented, but in the context of my design framework, it only refers to the design's ability to adapt to the context. This is only one aspect of the overall tailoring I am want to advocate with this framework; all the other design considerations contain some way of supporting users by seeing them for what they can and what they need. Furthermore, the reflection of the design outcomes as generators of knowledge brought forward the importance of allowing users to take control of the final manifestation. This point was

introduced as the general consideration autonomy accompanying the design framework. The increased decision-making power is a practical move, but its reasoning is anchored in my theoretical understanding of how designers will never be able to access the lived experience of users in the way that they can themselves.

That being said, the design framework can be extended to acknowledge the need for adaptation further. If I understand adaptability as the technology's ability to adjust and acclimatize to the user's changing capabilities, then there is a matter of temporality in the phenomenology of Merleau-Ponty that the design framework does not properly theorize in its current structure. While the framework contains changing bodies as a phenomenological dimension, it still does not properly describe how our situatedness and embeddedness in time connects with our autonomy to shape the future (Robertson, 2005, p. 12). As such, there is still room for critical reflection on the underlying theory in terms of adaptability.

I would also like to discuss adaptability in relation to my methodological approach. Using PD as my methodology was not only a matter of giving users a voice in shaping their own future but equally about demonstrating to the users as well as the municipality that the users' perspectives need to shine through the process to arrive at the specific design outcomes I wanted. The importance of user participation to the design outcome has also been raised by earlier research, e.g., by Aarhus et al. (2010) and Uzor et al. (2012). **Paper 3** summarizes how the PD process was facilitated as an adaptation to users' capacities and attempted to maximize the users' participation in mutual learning and co-construction activities on own terms. My attempt at avoiding known current ethical issues brought forward in **Paper 1** and **Paper 2** such as stigmatization through oversimplification involved increasing decision-making power through having a voice in the design process and thereby avoiding directing, limiting, or forcing unwanted decisions (Rosenberg et al., 2012). The argument of autonomy as a way to adapt to important ethical user perspectives is also supported by the research of Martin et al. (2010) and Harrefors et al. (2010) who discuss decision-making and paternalism.

One of the issues highlighted in **Paper 1** was how certain privacy concerns could only be understood across a user-defined and individual

threshold in a given context; for instance, observing users could be invasive in some situations while positive in others (Essén, 2008; Zwijsen et al., 2011). As a final point, I want to return to a design artifact to demonstrate how adaptation manifested itself in the design outcomes by discussing the matter of signaled vulnerability. By signaled vulnerability I mean to what degree the design allowed the users to communicate their own changing vulnerability state in a non-intrusive manner. As I am designing for changing capabilities, it might just as well be a case of signaling that it is a good day and the user is feeling strong and is not in need of invasive assistance. The idea is that privacy issues require adaptability by design to support the changing nature of privacy concerns. The conceptual prototype LightUp presented in Chapter 6.6 was a way for users to influence the number of home care nurses who during one day would have to touch them to measure their body temperature. By reflecting the body temperature of the users in the color intensiveness of the light in the room, the home care nurses could limit their visits to a minimal level on days when the users were feeling good. Similarly, on days where the body was feeling cold and stiff - and when the touching sensation from a stranger may seem exceptionally uncomfortable - the design of LightUp did not require any other actions from the user. The point I want to make is that beginning with the capabilities of the body and the lived experiences of the users opened up new ways of supporting adaptation in accordance with fluctuating privacy concerns. While the literature from **Paper 1** suggest that my emphasis on increased decision-making should allow participants to maintain dignity (Wright, 2011), the literature also suggests that maintaining dignity and integrity are highly important concerns for older adults (Eek and Wressle, 2011). My design approach would benefit greatly from a more nuanced discussion of its implication on ethical human-technology issues.

8.2.3. Openness

In **Paper 1**, I argued for honesty and righteousness as fundamental principles to any process involving older adults and technology. The main motivations behind this encouragement came from observations of participants who were feeling that technology was either oversold, as also stressed by Kanstrup et al. (2014), or that they were given false expectations about what the technology could be in their everyday life. There were also cases of participants having

very clear ideas about their own privacy needs and concerns that were neglected during the design. Both Eek and Wressle (2011) and Wright (2011) discuss dignity, and having an influence is suggested as a necessity in ensuring that both dignity and integrity are maintained. The emancipatory and democratic ideals of PD suggest that influence is a basic human right where those affect by changes introduced by technology *should "as a basic human right, have the opportunity to influence the design of those technology and the practices that involve their use"* (Simonsen and Robertson, 2012, p. 6). My methodological contribution consists of both specific changes to the organization that can support decision-making regardless of capacities for participation and multiple analyses of participation demonstrating actual influence over the end result (**Paper 3**). The tailoring was made to support these users, as users who were often marginalized, in having a say in a process through which they could reach important stakeholders. One example of their actual influence is how the municipality has seen the value of involving users already before the design phase begins and demonstrated willingness to extend their involvement of representative users.

I believe the infusion of phenomenology into PD has further brought out channels for personal experiences and perspectives to emerge. From a theoretical standpoint, all the research explorations began with the changing body, using an embodied language, acknowledging bodily capabilities, and building on embodied relationship with existing objects and environments. No exploration began with assumptions or requirements considering technologies involved or requirement specifications due to technical concerns. This provided the participants with a blank canvas. Those who had clear and strong opinions about ethical concerns (similar to points raised by Ziefle et al. (2011)) could engage in a design process where those concerns were addressed from the very beginning rather than discovered at a later stage. The goal was to support a process through which participants could avoid having to live with ethical compromises, such as sacrificing privacy for safety (Zwijsen et al., 2011).

While my technical background is solid, I would not have been able to realize all these different projects without the help of the various collaborators mentioned in Chapter 2.4.1 as it did involve technical facilitation outside of my own expertise at times. When considering the design outcomes we were

able to co-design without any technical considerations limiting the opportunities for design, I claim that I have avoided that the circumstances dictate certain directions of design that could compromise the openness the participants experienced. I also believe this open exploration of technology support the participants and me in thinking critically around existing and new design ideas. For instance, the conformity of existing and stable platforms as the technical foundation could have been one such issue – a point made by Korsgaard et al. (2016, p. 73).

Finally, one of the concerns that emerged during my earlier work was that many participants feared a future where they were surrounded by invisible and ubiquitous systems that monitored their every move without them even being aware of where the sensors were or what they were recording (**Paper 1**). This made a strong impression on me as it ultimately reflects how design supports agency. In the refined version of the design framework, I argue for removing foreground/background as a theoretical concept because of how it mainly applies to detection of intention in passive and ungraspable systems. As such, I have sought to avoid autonomy or privacy being compromised or violated by not using a shift of agency from the older adults over to technology as an automatic *"solution"* (Mort et al., 2013).

8.3. Designing for capabilities

In this section, I summarize my answers to the research questions one by one and then as a collection. The aim is to present an overall summary of my contributions.

RQ1: How can the phenomenology of the lived body be used to address capabilities rather than the disabilities in changing bodies?

To answer my first research question, I wanted to find theoretical concepts that could support an epistemic understanding of how we perceive, engage, and experience through the lived body. I drew inspiration from notable work within the field of HCI and ID, and related fields in search of a conceptual apparatus that could underpin my desire to design for capabilities. The work of other practitioners of the phenomenology of the lived body within HCI and related fields have mainly focused on interactions of movement, such as whole-

body interaction, and had limited transferability to my context. There are some notable exceptions, and the work of Robertson (2012) and Brereton (2013) are two such examples presented Chapter 4.2.1. I began the elicitation of concepts with the work of Dreyfus' (1996, 2002) on maximum grip and the intentional arc, and then gradually found additional concepts through related work, most notably in the work of Svanæs (2000, 2001, 2013), Robertson (2005, 2012), and Loke and Robertson (2007; 2010, 2013). Since my work also deals with older adults and changing bodies, I complemented the work on phenomenology in a design context with work on phenomenology from other related fields, such as nursing studies. This helped me address important considerations that would not be as relevant if my phenomenological lens was pointed at a general population or directed towards other target demographics, e.g., illness, loneliness, and sickness. The work of Sadala Adorno, Toombs, and Aho and Aho has been particularly helpful in this respect. I presented eight theoretical concepts in Chapter 4.2: (*1) maximum grip, (2) bodily space, (3) body schema, (4) incorporated objects, (5) spatial awareness, (6) concrete and abstract movements, (7) foreground and background activity,* and *(8) body skills*. I needed this particular combination of concepts to address and promote capabilities in bodies.

To verify whether these eight concepts could actually serve the purpose of directing a design practice that could result in enabling technologies, I had to operationalize them. My argument was that the distance between Merleau-Ponty's phenomenology as it was written and the intended purpose of its application in my research was too large to make any claims about the applicability of my concepts without any empirical investigation. I decided to investigate the practical application of the eight concepts I had chosen. The exact procedure of how I made a move from theory to practice is discussed as part of the next research questions, but I began by structuring a framework that used the concepts to point out important design considerations and the opportunities that followed (see Chapter 4.3-4.4). At this stage, the construction of this design framework became an intermediate result that reflected my theoretically informed arguments and choices on how the phenomenology of Merleau-Ponty could be adapted and applied to a design context involving older adults and revolving around capabilities.

To complement the theoretical understanding with knowledge gained through facilitating design activities and analyzing their design outcomes, the design framework was revised. Most theoretical concepts proved relevant and helpful, but there were a few exceptions: the concept of concrete and abstract movements was hard to investigate properly with the research explorations I chose, and the concept of foreground and background activities was removed as it proved less compatible with my desire to design for agency than the others. Subsequent modifications were also made to incorporate important considerations that emerged through use practice. What remained was a design framework for enabling interaction, which is presented in its final form in Chapter 7.4.4. To include important considerations that did not fit organically into the structure of the framework, it is accompanied with general considerations that will further help focus on capabilities rather than disabilities. This design framework – constructed with theory and refined with knowledge generated through design – is my first contribution in this dissertation (**Table 8.1**).

Table 8.1: *The final version of the design framework as presented in Chapter 7.4.4*

Pheno-menological dimension	**Theoretical concept**	**Design consideration**	**Design opportunities**
Everyday living space *(Space)*	Spatial awareness Concrete/abstract movements	Adaptability Arrangement Movement	Blending in with existing context; Situating interaction and configuration; Incorporating familiar movements and gestures
Digital artifacts *(Objects)*	Maximum grip Incorporated objects	Relative positioning Interaction mode Robustness	Allowing spatial reconfiguration; Building on lifelong habits and routines; Triggering appropriate expectations
Changing bodies *(Body)*	Bodily schema Bodily space Bodily skill	Configuration Response	Supporting multiple configurations; Adapting to changing capabilities; Providing embodied feedback

RQ2: How to design for capabilities when working with older adults?

The second research question concerns two main issues: how to use the phenomenological perspective with PD to facilitate a design practice that focuses on capabilities rather than disabilities, and how to implement such a practice when working with older adults. The design considerations from the design framework were used to direct the attention of the PD activities towards phenomenology-oriented concerns that allowed participants to remain focused on their capabilities rather than their disabilities. I mainly concerned myself with making methodological adaptations described through three main characteristics (presented in Chapter 5.2-5.3): capturing embodied experiences, communicating through an embodied language, and thinking through physical objects. To let the participants anchor their choices in embodied experiences and expectations the organization of all activities required continuous re-adaptation as practical concerns emerged throughout the design process. Examples of specific adaptations made included using existing artifacts to support decision-making, bringing in everyday objects to capture and share experiences, and shifting the language from a technical nature to an embodied one. I used the theoretical concepts from the design framework to find related research methods (summarized in **Table 5.2** in Chapter 5.3.1) that could inform my own phenomenological practice. I made several adaptations to traditional HCI methods such as shifting from interviews to demonstrative interviews or moving the design activities into the homes of the participants (**Paper 5**). My phenomenological perspective also provided the basis for the development of new methods such as the material testing and the blindfolded testing described in Chapter 5.3.2. These methods highlight how connecting the design process to the individual embodied experiences requires both adaptations of existing methods as well as the introduction of new ones.

However, finding the appropriate facilitation has not only been a theoretical concern. Involving older adults in co-design required adaptation to respect their limited capacities to engage in design activities. The crucial challenge was to find the balance between respecting participants' reduced capacities while still focusing on the capabilities they embodied and that could be prolonged. The radios presented earlier in this dissertation exemplify this point; participants who had lost their ability to use traditional radios due to

bodily changes were able to re-discover other capabilities in one activity and use those same capabilities as the basis for the design of alternative radios in a later activity. As such, it became equally important to refine the theoretically informed activities and facilitations in accordance with the practical concerns of involving older adults. The intermediate results presented as the contributions of **Paper 3** started out as practical considerations rather than theoretical, and I used those to reflect on the idea of designing for capabilities. My analysis of the older adults' preconditions for active PD as well as the analysis of their decision-making and actual participation resulted in five principles: recruiting, timing, continuity, representativity, and immediacy. These principles describe how the process was organized to support decision-making when designing for capabilities. For instance, the principle of continuity summarizes how continuity was built through the use context rather than the design context, and timing describes how activities were organized as smaller fragments that allowed participants to make smaller commitments over time. We assembled these fragments into a complete picture and allowed the many smaller commitments to ascend into meaningful influence in the larger context. The same five principles were used in Chapter 5.4 to connect the facilitation of specific activities to the higher-level concerns of what a PD process should be (Bratteteig et al., 2012). To verify that this approach actually allowed participants to influence their own circumstances through participation, I presented an analysis of participants' influence in Chapter 6 by looking at the design outcomes as PD results.

The second research question has combined phenomenological concerns with practical concerns to arrive at the methodological approach outlined in **Paper 3** and throughout Chapter 5. I have used analyses at different levels to shape this process, and these analyses used to scaffold my PD approach are all important components of the second contribution. Similar to my first research question, my answer has been theoretically informed and then reshaped through practical concerns. My phenomenological PD process tailored for older adults, along with the analyses of preconditions for participation (**Paper 3**), influence and decision-making (**Paper 3** and Chapter 6), and how it all relates back to core principles of PD (Chapter 5.4) constitute my second contribution.

RQ3: How can the design outcomes be interpreted and situated within the design space of enabling interaction?

The third research question deals with the design outcomes. The various research explorations have generated a range of prototypes of different quality – ranging from conceptual prototypes to fully-functional research products. As design outcomes, they represented examples of the final manifestations that my theoretical and methodological reasoning can yield, but the goal was not to generate final *"solutions"* to the overarching problem; the design outcomes represented different ways of responding to their respective lines of inquiry into the same design space. These design artifacts have served multiple purposes in my research. As mentioned, they were helpful when tracing the influence of participants in terms of participation in RQ2.

I structured Chapter 7.2-7.3 around two analyses of selected artifacts using annotated portfolios to explain and reflect upon the characteristics of the designs. Through these analyses, new lines of inquiry were opened. For instance, the research exploration *Materiality (RE #14)* grew out of emerging issues revolving around materials' role in embodied experiences. Chapter 7.5 listed salient questions that emerged out of the analyses of design artifacts. The final section of Chapter 7.4 demonstrates how these two analyses helped refine the design framework, which was originally motivated solely by theoretical concepts. Specific changes were made to the design framework based on observations from real use contexts as well as the qualitative data gathered from these observations, e.g., shifting material/physical attributes into a general consideration that is tied to the whole design framework rather than only associated with specific theoretical concepts. The changes also involved a restructuring of existing theoretical concepts, adding and removing design considerations, as well as the introduction of new general considerations that could accompany the design framework.

Finally, in Chapter 8.1, I returned to selected design outcomes to demonstrate how they have allowed me to verify that the design outcomes serves a purpose in terms of enabling interaction. Both **Paper 4** and **Paper 5** use performance evaluation and statistical analysis to demonstrate – through the use of the design outcomes in the real user setting – that this whole design approach has enabled interaction for older adults. As such, the design

outcomes have been an important part of how I have verified that my design approach can be a viable solution to how we can design enabling technology.

Answering this research question has been necessary to construct the final answers to both the other two research questions. However, the independent contribution from this research question is the presentation and analysis of selected design outcomes. As artifacts, they themselves hold an implicit contribution that within the designed object captures my understanding of *"the current state, including the relationships between the various phenomena at play therein, and the description of the preferred state as an outcome of the artifact's construction"* (Zimmerman et al., 2010, p. 312).

How to design enabling technology for and with older adults based on their capabilities rather than disabilities?

My answer to the overarching research question starts with a theoretical apparatus I shaped myself. It was important for me to follow my reasoning into the design practice to observe what the consequences of seeing the world through capabilities entailed for the participants and for me as a designer. One of the strengths of my research is this tight connection between theory and methodology: they are shaped with the same philosophical foundation. My interpretation of Dourish's point of the *"phenomenological backdrop"* (2004, p. 103), i.e., the underlying relationship between theory and methodology, needs to be interweaved to fully let the ontological and epistemological reasoning of phenomenology direct the operationalization of the theory. If I had applied a theoretical framework from someone else's research or combined my theory with someone else's methodological process, certain aspects of my research would not have been possible. For instance, the facilitation of design activities that revolves around embodied experiences required a symbiotic interplay between theory and practice, which would not be possible without allowing the emerging theoretical and practical concerns to mutually inform each other. The introduction of new methods such as blindfolded testing or material testing is a direct result of experiences shaped by seeing how the application of the theory unfolded in concrete design activities.

By using an embodied philosophy as the basis for design activities, it became particularly important to complement the development of theory with knowledge gained through use practice. I argue that phenomenological

concerns such as embodied experiences are hard to understand by means of theory alone because the idea of lived experiences so explicitly stresses that what we make of situations trumps any predetermined essence about our potential to engage in interaction (Matthews, 2014, p. 102). Involving older adults in more active roles where they made decisions based on their own experienced capabilities became an important step in ensuring that lived experience of users took precedence over the imagination I held as a designer. However, to help verify that the design outcomes represented examples of solutions to the overarching research concern, I needed to investigate the design outcomes further. The complexity involved with transferring theoretical embodied concepts to design practice was mainly that I was designing for embodied experiences that I could not access myself. My claim remains that theory such as mine, which intends to deal with a societal challenge, cannot be verified by theory alone. Regardless of how well we understand the phenomenology of the lived body, it will still impose that validity will ultimately be tied to use experience. As such, any verification claims had to originate from real users' experience of engaging with the design outcomes in their everyday life. I would not have been able to comment on my design approach's ability to respond to the overarching problem without studying use after design (Redström, 2008, p. 410).

I have described why it was necessary to construct the answer to the overarching research question with theory and follow it into operationalization that allowed me to verify the applicability of the theory. However, the final piece of my answer is concerned with understanding exactly how my approach addresses this challenge, i.e., how exactly the design outcomes are solving the phenomena under investigation. I would argue that properly addressing future caretaking requires not only that we find solutions in the present, but understand them well enough to inform design activities in the future. I say so because I want to respect the complexity of the overarching challenge by acknowledging its evolving nature (Kyng, 1995, p. 46). The demography of older adults is not static, and new generations will introduce new needs; I want my research to remain valid and relevant for as long as possible. Thus, the third and final piece I needed was analyses of the design artifacts to learn from the knowledge residing within the artifacts. This knowledge helped me mature my theoretical understanding by refining the design framework with

practical concerns and also helped to raise concerns that could not be understood or predicted by theory alone. In a larger context, the design outcomes became important means of communication as descriptive artifacts (Muller and Druin, 2010) that helped relay the story of how my approach can be a viable alternative through new use practice (Bratteteig et al., 2012, p. 135).

With these three components, I have answered my overarching research question of how we can design enabling technologies using capabilities rather than disabilities. The proposed design approach has been followed from conception of theory to long-term use practice. The theory, the methodology, and the design outcomes have mutually influenced each other. I find that the interplay between theory and design remains as the scientific strength of this dissertation.

8.4. Final reflections

As I now end my dissertation by elevating the discussion to a larger context, the focus shifts over to how the specific combination of (1) the theory of the lived body, (2) the phenomenological PD approach, and (3) the responses to the practical concerns of involving older adults, all helped inform a design approach that I believe addresses the design of enabling technology in a respectful manner. I want my final reflection to revolve around how my design approach can contribute back to the overarching problem of meeting the caretaking needs of the future. There are three different components of my design approach that I would like to discuss.

First, the motivation behind my salutogenic focus on capabilities rather than disabilities grew out of a desire to introduce a more respectful way of understanding the complex human-technology relationship. At the time, I was unaware of the methodological and practical consequences of structuring my understanding through Merleau-Ponty's theory of the lived body. It has been a time-consuming effort to support my phenomenological backdrop throughout the study, but I believe it has unveiled benefits in terms of respectful engagement, easier recruitment, and increased agency. I would, therefore, like to begin by discussing the experienced benefits of designing for capabilities rather than disabilities when addressing the design of enabling interaction.

Trying to find the right balance between my phenomenological foundation and the practical and value-driven concerns of PD was not easy. Chapter 5 described how the methodological approach was informed by theoretical considerations and then structured around the practical concerns of the participants, but related to the overarching research question one particular topic emerged as challenging: how do we design enabling technology without asking participants to imagine the future? This is an issue involving theoretical, methodological, and practical concerns, and I want to discuss how this issue brought forward the need to actually produce research products as part of how I constructed my answer to the overarching research question.

Finally, I want to discuss my design approach in terms of credibility and how communicates to stakeholders who may need different or additional types of validation compared to what research communities may seek. I believe the combination of theorizing design, facilitating design activities thereafter, and then reflecting on design outcomes was a necessity to answer my overarching research question. At the same time, I also believe it interplay between theory and practice generated types of results that can better communicate with important non-design stakeholders who are vital to solving the caretaking needs of the future.

8.4.1. Designing for capabilities rather than disabilities

An important characteristic of my approach involves giving everybody – regardless of who they are and what they can – the opportunity to influence the technology intended to become a part of their everyday life. The choice of using the lived body as the theoretical lens and using PD as the methodology reflects a genuine attempt at giving all participants the necessary language and space to have not only a voice but also a say (Bratteteig et al., 2012, p. 129) by focusing on capabilities. The use of embodied experiences as a way to restructure our understanding of human-technology relations and the flexibility in participation has given participants influence and ownership over the design process as well as the outcomes produced. I hope this dissertation can serve as a valid example of how people can continue, extend, or re-establish meaningful relationships with technology by shifting the way we think from disabilities to capabilities. This excerpt from **Paper 4** sums up

how I have focused on incompetence or inability in use as a problem with the technology rather than the user:

> *"We should never exclude any people as potential users just because their capacities prevent them from using a given interface. Incompetence or inability in use should not be tied to technologies, but instead, be a use dimension related to the specific interaction mechanisms that the technology provides. [...] The results in this paper have demonstrated that people can re-establish meaningful relationships with technology by shifting the way of presentation." (**Paper 4**, p. 575)*

My perspective does not neglect that aging introduces changes that limit us in our everyday life. While people experience disabilities, they are also experiencing capabilities, and my choice has been to focus on the latter. As I argued in Chapter 4, disabilities will ultimately enter our lives, but I do not believe in attributing certain traits or characteristics to participants simply because they are *"being old"* (Light et al., 2016). People experience the process of aging differently (Aarhus et al., 2010; Huldtgren et al., 2013). While it is difficult to find common grounds amongst older adults without using age as the common denominator (Malmborg et al., 2010), I have focused on using commonly observed disabilities as a way to understand how to compensate for typical challenges and let the users focus on their capabilities. The practical nature of the design activities and the theoretically informed considerations in the framework are both examples of how one of my motivations has been to introduce a more salutogenic approach to the design of enabling technologies.

If one considers capabilities and disabilities as components of a dualistic relationship where one always mirrors the other, one argument against my approach would be to say that I have only shifted the sign from a negative notion to a position one. I would like to argue for how it has been much more. First of all, how we approach people – especially in research like mine that enters their most personal sphere – says a great deal about how we respect them and their ability to contribute to the problem-solving. Observing various examples of stigmatizing, e.g., perspectives on older adults as a demographic (**Paper 1**) or through how the design of technology was presented to them (**Paper 2**), made a strong impact on me and reinforced my motivation to find a design approach that included a more graceful way of addressing and

including participants. I strongly believe that involving 542 participants, most out of which were older adults, would not have been possible if the design process and the facilitated activities revolved solely around disabilities. The participants I worked with experienced enough unavoidable confrontations with their own vulnerability in their everyday lives to find any excess motivation to enter a design process that just augmented a bad self-image. The extent of their participation, both in the duration of the commitment and the energy they were willing to put into the process supports my claims. Participants were approached and recruited not because they were *"old"* (Vines et al., 2012b), but because I genuinely believed they could have a significant impact on the development that could expand on the knowledge I and the rest of the researchers held.

Second, and most importantly, this shift from disabilities to capabilities involves an important change of agency. The phenomenology of Merleau-Ponty sees the older adults – as both participants and end-users – as defined not by a predetermined essence but rather by what they make of situations (Matthews, 2014, p. 102). With this perspective on human beings, the focus shifts from an externally-defined context-detached understanding of *"being old"* to a subjectively-defined and experience-based understanding of how participants can *"feel"* about a given situation. It is no longer their age, their medical history, or an external municipal assessment that determines their state – the defining power of who they are and what they are is returned to them. Participants were approached for embodying a capacity to act, and the first decision I wanted them to make was to define their own eligibility to participate. Similarly, the five user stories presented in Chapter 5 and in **Paper 3** describes participation on own terms where the decision about what to prioritize and when to participate is defined by the participants. Finally, the heavy emphasis on generating many outcomes quickly gave participants the necessary confirmation of their contribution to the process and also let them show the world that they still inhabited capabilities. Showing everyone through the use of co-design artifacts that they still embody the potential to continue a strong human-technology relationship remains the most impactful way of conveying the significance of my approach. With that, I want to accentuate the participants' role in my design approach as the single most important and convincing source for credibility. Their participation, in co-

designing artifacts and by demonstrating continued or re-established interaction, constitutes the strongest and most honest voice of trustworthiness in my research.

8.4.2. Changing bodies as a way of dealing with uncertainty

Creating a space where participants can freely explore and imagine a better future has always been a central part of PD (Brandt et al., 2012) as *"Participatory designers have consistently sought ways to fully engage people in the design of their own futures"* (Robertson and Wagner, 2012, p. 70). Already in the UTOPIA project during the 1980s did designers make a move from the workplace environment into a joint space that could better spark the imagination of future alternatives (Kensing and Greenbaum, 2013, p. 29). However, imagining the future is easier said than done within my design space. One of the points I raised in (Joshi and Bratteteig, 2015) that later resurfaced in **Paper 3**, was the uncertainty of what the future held for the participants. As such, my phenomenological focus on embodied experiences introduces both challenges and opportunities to the facilitation of the design process. The subjective nature of the lived body enriches the space by providing users with direct access to their own needs and opportunities, but it simultaneously complicates the space in which the participants can think of their own futures. The experience of our own actions, as well as how we experience own and other's actions as meaningful through mutual interpretations, shapes the agency of our future actions (Robertson, 2005, p. 7). I believe I have found a way to inherently address future needs by focusing on the changing body as the basis for my theory development.

Acknowledging capabilities as something that continuously evolves through time and that develops with every new action we make, is my way of designing for the future without having to depend on the users' imagination. Whether our potential for interaction in the future manifests itself as reduced capabilities to act or as more refined responses due to repeated exposure, the design framework encourages dynamic interaction mechanisms that can be customized and adapted over time as the users' potential to act inevitably changes. The design considerations of the framework direct the attention towards both contextual and embodied relations that affect how interaction unfolds in a given situation. The long-term testing was not only about

generating additional credibility, but it was also about exposing the users to different design outcomes over long enough periods for them to experience how repeated exposure to interaction can manifest itself as more refined responses to similar situations (Dreyfus, 1996, 2002). However, as I mentioned in the final version of my design framework, the temporal aspect of Merleau-Ponty's phenomenology deserves to be further investigated as a theoretical component in how we structure our understanding of the changing nature of aging. I believe this to be the appropriate way of revisiting the idea of imagined futures within phenomenological PD.

Not asking participants to imagine the future was also a matter of respect. From a practical standpoint, the challenge with imagining the future was related to the technology we were exploring. The highly technical, and often unfamiliar, nature of the technology posed challenges to the participants' ability to incorporate them in speculations and imaginations about the future. There was a shared understanding among the participants that the future was uncertain (**Paper 3** and **Paper 5**), and as I described in **Paper 2**, I wanted to shift the focus from what we as designers imagined were the needs and opportunities to that which the users experienced as the actual needs and opportunities. One reason for the uncertainty was that speculating into future use scenarios required that the participants had first reflected upon who they themselves would be in this imagined scenario. This was both difficult and undesired for many participants – the future is known for being a sensitive subject among older adults (Anderberg and Berglund, 2010). As such, the practical matter of involving users in a respectful manner suggested that I directed my attention mainly towards what *is* rather than what can *be* (Odom et al., 2016) during the design activities. The exact compromise consisted of facilitating activities where the past and present embodied experiences informed choices, and then use the design outcomes to discuss what design should be in terms of understanding how the human-technology relationship evolves through time. Co-designing enough examples of correct *"tools"* for a particular design space like mine was my way – from a PD perspective – to improve the knowledge upon which future systems can be built (Bratteteig and Wagner, 2016; Ehn and Kyng, 1986).

However, the main motivation behind organizing activities that could produce a set of mature designs was to support a generative investigation. As

I have mentioned, with research products, I could study use after design (Redström, 2008, p. 410) which uncovered cases of alternative use, unintentional use, or re-defined use that allowed further reflective exploration into the future. My justification of the time-consuming efforts of co-designing actual research products in addition to the placeholder prototypes (Lim et al., 2008) draws on an old idea of challenges with imagining the future. In the same way that the users have never had any experience in *"reading descriptions of potential computer support"* (Kyng, 1995, p. 48), they do not have any experience imagining their future lives with said computer support either. To capture all sensations of the everyday relationship with the technological ideas we explored, the design outcomes put forward to invoke these experiences needed to convey their intentions so clearly that the embodied nature of the human-technology relation was sufficiently understood and experienced. From a phenomenological perspective, the ability of the design outcomes to invoke the appropriate embodied experience is directly related to how the design outcomes unfold their qualities in a given context. The design considerations I have listed in my design framework relate not only to how digital artifacts are understood by the body, but also to other artifacts, other people, and the environment, as well. These considerations, both from a theoretical and practical perspective, are hard to study because they are hard to imagine. As such, my design approach uses research products not only as a source of credibility but also as a design practice that can support reflections capable of informing my overall process all the way back to the development of theory. As such, by using the design artifacts to discover new questions and to open up doors for speculations of the future, they have constituted a vital source to the combined knowledge that ultimately answers my overarching research question.

8.4.3. Research that reaches new corners of the audience

My own research was motivated by the larger ideas of what technology can become in the lives of older adults. Visions such as *"aging-in-place"* ignite researchers from various disciplines in search of directions on how to elevate technology to have an increasingly more prominent role in caretaking. However, the future of caretaking as an overarching societal problem is not fully addressable without involving those who will eventually manufacture and

maintain the types of solutions or services advocated in the research. As such, my target audience is not only composed of research communities but also by health care workers, architects, physiotherapists, managers, politicians and so on. I want to reflect on my research approach's ability to generate credible results that can reach beyond research communities and appeal to industrial and municipal stakeholders as well.

My general impression after working very close with both the industry and municipality for the last few years is that nobody considers the caretaking problem to be resolved and that everyone is increasing the resources or efforts set aside to understand, predict, and respond to this problem. I have seen a lot of design research – including my earlier work – struggle to communicate and maybe even convince these stakeholders due to how the research is conducted and scoped, but most importantly how we argue for the trustworthiness of my findings. The industrial and municipal stakeholders within my empirical context are indeed willing to learn from design research, but I also believe they are justified in expecting said research to demonstrate the full potential of the advocated theoretical and methodological perspectives before being asked to adopt any new practices. It is here I believe my research demonstrates a novel way of producing multiple types of credibility to support the important findings.

My dissertation has presented a design strategy that has focused on both depth and width; the depth comes from the theoretical development of a new perspective on enabling interaction, and the width comes from involving 542 participants in co-design activities that have resulted in a range of examples of outcomes. I do not believe in forcing design research to be reduced down to numbers and statistics, but I also think that we as designers have a strong potential to extend the design process to a point where there is enough *"evidencing"* to convince those stakeholders whose world revolve around numbers and figures. In my context, communicating to industrial partners or important decision-makers such as politicians required finished research products, it required testing in real environments, and it required the inclusion of a significant amount of participants. My whole design approach revolves around highly subjective and personal experiences as the basis for all understanding and facilitation, but one of the strengths of having access to a set of design outcomes has been that they can be subjected to comparative

and long-term testing. These types of evaluations have yielded another type of validity that resonated better with those who value other types of credibility than what design research often use in its argumentation. Lincoln and Guba (1985) attributed trustworthiness to credibility defined through four criteria: credibility, transferability, dependability, and confirmability. I believe I am justified in claiming good coverage on most of the techniques they claim ensure credibility in qualitative research such as prolonged engagement, thick descriptions, reflexivity, and persistent observation. However, the statistical analysis presented earlier in this discussion chapter adds to their advocated member-checking technique – which they state is the most crucial technique for establishing credibility – by seeking validity amongst *"members of those stakeholding groups from whom the data were originally collected"* (p. 314).

As a response to the wicked problem of future caretaking, my approach demonstrates a strategy that acknowledges the complex nature of the problem. The goal has not been to solve this problem or to find the *one solution* (Blythe et al., 2015). It has been to demonstrate one way of dealing with the problem by introducing a theoretical perspective and methodological approach that can produce concrete manifestations of potential solutions to the problem by restructuring the way we understand and facilitate the design of enabling technology. The emphasis has been on finding the perfect interplay between theory and design as a strategy to address the problem. If I had stopped after only developing the theoretical framework, or if I had only engaged participants in co-design of conceptual low-fidelity prototypes, I would not have possessed actual design outcomes and therefore not been in a position to communicate the values of my approach as clearly as I now believe I can.

As such, my approach aligns with contemporary and positive-oriented approaches (e.g., (Blythe et al., 2010, 2015, 2016; Leong and Robertson, 2016; Light et al., 2015, 2016, Vines et al., 2012b, 2012a)) rather than the historically seminal work found within HCI. One of the historically significant research programs at the intersection of aging and HCI has been the Aware Home Research Initiative established in 1998 at Georgia Institute of Technology. Similar to my research, their long-term exploration with a living laboratory was created to study aging in place with a focus on everyday activities (Abowd et al., 2002, p. 2). Many of their research interests were also

tied to relevant concerns for this dissertation, e.g., compensation for physical decline (Mynatt et al., 2004, p. 36) and privacy concerns (Hayes et al., 2004, p. 169), and also involved interesting cases or technologies such as tracking of indoor positioning (Köhler et al., 2007) or digital family portraits (Mynatt et al., 2001). I shift away from the binary and deficit-driven approach (Carroll et al., 2012) by offering new perspectives on important issues such as agency and participation. Rather than using state-of-the-art ubiquitous technologies to create an environment *"capable of knowing information about itself and the whereabouts and activities of its inhabitants"* (Kidd et al., 1999, p. 191), my focus has been on shaping the introduction of technology after the capabilities of the users without shifting the agency. Building on capabilities only makes sense if the users are allowed to retain their agency as new technologies are introduced, and this has been an important focus of my enabling perspective. As such, my attention has been devoted to the users who will live with the technology and my approach demonstrate the use of a bottom-up approach beginning and ending with the personal experiences of the users rather than a top-down gerontological approach (Mynatt et al., 2004, p. 40). While their extensive research included several relevant awareness-oriented technologies (Essa, 2000, p. 49), the users were predominantly involved in evaluation rather than being co-designers through the whole design process like my approach.

8.4.4. Limitations of the research

I would like to end my final reflections by highlighting three limitations of my research. As stated in the introduction, I wanted to make the full cycle from theory to design and back to theory. This choice of broadness limited the opportunities to study each of the different components in depth. I have accomplished with the design framework what I wanted to with this dissertation – it has guided my design practice and helped me design for capabilities rather than disabilities. However, the design framework is not to be considered an absolute statement. The theoretical concepts used to shape the design framework only touches upon some of the topics covered by Merleau-Ponty's portfolio on phenomenology. I have also pointed out that the division into three phenomenological dimensions was mainly motivated by structural purposes rather than ontological. This became more evident with

the emerging concerns from the analyses of the design artifacts that did not necessarily fit seamlessly into the current theoretical framing of the design framework. As such, there is room for further maturation of the framework. I would want to continue the exploration and development of this framework by expanding on the underlying phenomenology as well as to use additional design artifacts to revise the framework.

While certain research explorations have investigated interactions that include additional people, e.g., the two-sided interaction between older adults and health care nurses in the *Collaborative Change Experiment (RE #2)*, the main focus has remained on the relationship between the older adults and the technology. Enabling technologies that involve care personnel or other forms of medical assistance to complete the interaction have not been studied extensively. I have mainly concerned myself with research explorations that have resulted in designs that target single tasks, e.g., listening to a radio or charging a tablet. Whether this design approach can yield more complex designs attempting to solve multiple tasks with a single artifact has not been investigated as the participants did not want to explore in that direction.

One of the underlying goals with my design approach has been to facilitate human-technology relations that can yield long-lasting interactions. My evaluation of performance in real use contexts was intended to investigate whether designing for capabilities can lead to interactions that are perceived as meaningful. This required giving participants enough time to incorporate the research products into their daily lives and verify that it harmonized with their everyday activities and habits. However, my research has had a design-oriented focus which did not include time to conduct longitudinal studies of how the design supported bodily change over longer periods. As such, the aspect of whether my design approach can produce design outcomes that can remain purposeful over time has not been empirically verified.

Chapter 9

Conclusion

This dissertation has presented an approach to how we can design enabling technologies for older adults. In the introduction, I postulated that finding new ways of understanding the nature of aging in the human-technology context may open up new opportunities to design long-lasting relationships between users and the digital artifacts they employ in their everyday life. I have constructed an approach that focuses on capabilities rather than disabilities by shifting attention from what user can no longer do to what they are still capable of doing. As the overarching issue of enabling technology for older adults is a complex topic, it became necessary to combine the strengths of both theory and design to address this matter. I structured my research questions so that each question would address a component of knowledge:

- A theoretical component that addressed how the phenomenology of the lived body could help me understand capabilities rather than disabilities;
- A methodological component that described how PD was infused by a phenomenology perspective and how it was organized to support older adults in participation;
- A reflective component that used the generative properties of the design outcomes as a tool for analysis of theory and to raise new questions

To inform and answer these three components, I have carried out 14 research exploration involving 542 participants over four years. The various research explorations have had different research objectives but remained within the same design space. They have all played various roles in arriving at the specific contributions presented.

The first contribution was a design framework consisting of seven theoretical concepts support by design considerations and design

opportunities. The final version of the framework was presented in **Table 7.1** (Chapter 7.4.4) and **Table 8.1** (Chapter 8.3). The framework was constructed by combining and analyzing theory and related work within the fields of phenomenology, sensory-motor challenges, aging, and TI. It was later refined with practical concerns elicited through two analyses of selected design outcomes that could complement the theory. The main strength of this design framework is that it draws on both the theoretical and practical concerns of designing for capabilities. It is also an open framework in terms of how people want to apply it; it can be used top-down or bottom-up, and it can be used right-to-left or left-to-right. Regardless of starting point or direction, the framework guides the researcher from body outwards to the space or from space inwards to the body to keep the focus on the human-world connection as a way to understand capabilities.

The second contribution revolved around a description of how PD can support the phenomenological backdrop and while respecting the older adults' capacity for participation. The description of the procedure was explained in **Paper 3** and Chapter 5. The structure of the process was illustrated with the model in **Figure 5.8** in Chapter 5.4.9. The description was complemented with multiple analyses of important practical concerns such as participation and decision-making. These analyses were used to signify how I balanced the phenomenologically-directed embodied experiences by adapting the practical and organizational facilitation of activities. The main characteristics of the adapted phenomenological PD process is a fragmented organization with pieces being assembled later to elevate their bits of participation into meaningful influence in a larger context.

The third contribution was a presentation and analysis of selected research products. The two analyses were conducted as two variations of annotated portfolios to support the argumentation. The design outcomes also contributed by raising new questions and concerns. The emerging concerns that surfaced through the analyses helped develop the final version of the design framework by shedding light on how the qualities of the design unfolded in the everyday use context. The analysis resulted in modification of specific components of the design framework and simultaneously accentuated concerns that were added to the framework as accompanying concerns that could guide any future use. The analysis also contributed to the overarching

research questions by opening up new spaces for exploration by pointing out important concerns that should be investigated further. One such example is the topic of materiality which has already resulted in multiple independent publications, but also salient questions for future work such as those listed in Chapter 7.5.

Observations of older adults incorporating selected design artifacts into their daily lives have confirmed that my design approach of designing for capabilities holds the potential to facilitate human-technology relations that can harmonize with everyday activities and habits. Statistical analysis of performance data has demonstrated that older adults have found new opportunities for interaction that they did not have before, e.g., re-establishing lost interaction with radios. The wide range of design outcomes has demonstrated that the open nature of this design approach can help both reconfigure existing interactions as well as generate new designs.

The complexity of the overarching research question requires acknowledgment of its evolving nature, and the combination of these three research questions has allowed me to follow my perspective on designing of enabling technologies from conception of theory to long-term use practice. Both in terms of methodological focus and practical facilitation, I have strived to give participants and myself time and space to let concerns emerge and shape the understanding as well as to inform the practice. As mentioned at the beginning, the linear narrative of this dissertation is structured for the reader, but in reality, both the theory and design matured and mutually informed each other throughout the whole study. Both of the two first contributions have been constructed with theory and related research and then been refined and reflected upon through empirically-gathered learning. Similarly, the design outcomes addressed in the third research question have been important tools for reflection when finalizing the answer to the two other research questions. As such, I believe the interplay between theory and design remains the strength of this dissertation.

This dissertation ends as it began. The introduction stated that the motivation for this study was a desire to find a more respectful way of addressing and engaging older adults. Many of the participants from my research explorations are no longer with us, but their influence can be traced in the concerns raised in my research, and their voices are embodied in the

various design outcomes presented throughout my work. I consider it a privilege as much as a strength that I could include the older adults in arriving at the contributions presented in this dissertation. As such, my work should be considered a position statement on how I believe designers should respect older adults as capable, knowledgeable, and creative individuals who in the capacity of being the ultimate experts of users, use, and use experience. There are many ways to accommodate this call; my approach is only one. But it remains true that this dissertation would not have been possible without the efforts of the users.

9.1. Future work

Due to the broadness of my research, this dissertation has not covered deeper explorations. As such, all three components, i.e., the theory, the methodology, and the design outcomes are all good starting points for further investigation – there are opportunities for theoreticians as well as designers. A general starting point for future work would be to examine the transferability of the idea of designing for capabilities to other demographics or domains. This relates to one of the questions raised in Chapter 7.5 of whether this approach could be the first building blocks towards framing some strong concepts. I would be particularly interested in seeing the design framework being adapted to other user groups who are often labeled as marginalized or vulnerable due to generalized ideas about their capabilities.

I am convinced that the theoretical concepts in the design framework can be expanded or better articulated by further studying underlying phenomenological ideas and concepts. Besides exploring other components of Merleau-Ponty's work, there is also a potential to learn from other phenomenological and postphenomenological views that are specifically concerned with technological mediation, e.g., the work of Don Ihde or Peter-Paul Verbeek.

PD as a methodology will always need adaption to the specific nature of the contexts and users involved. It would be interesting to see if any of the practical adaptations made to support participation among older adults in my research are transferable. I also believe there should be some more investigation into the value of participation. The PD process has been adapted to support participation on own terms, and all participation has been

voluntary. However, I would like to learn more about what the participant value about engaging in these activities. In what way is this process rewarding to them?

I analyzed a selected set of research products to reflect on the theoretical concepts and the associated design considerations, but this was not an exhaustive analysis. The design space of this dissertation remains a canvas for endless explorations in various directions and constructing additional design outcomes would be an important step in reaching into corners of the design space that I have not covered through my 14 research explorations. Additional analyses of design outcomes, especially if conducted by other researchers than me, would surely be able to bring out supplementary concerns that can further refine the design framework. Additional generative artifacts would also help raise other questions that can complement or refine the salient questions from Chapter 7.5.

While I have followed the design ideas into long-term use cases, there is still room to appropriate more systematic long-term testing with participants. Since my approach builds on the idea of designing for changing bodies, increased time will help further assess my perspective's ability to prolong and maintain meaningful human-technology relations.

Regardless of which aspect of my research that others may find the most appropriate or interesting, I hope this dissertation can spark some more interest in the design of enabling technologies. I believe we have a reciprocal responsibility as designers to design and practice design in this world as if we were designing for ourselves. To me, that means treating the users with respect and inclusiveness – because one day it will be our own turn to live with enabling technologies.

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Appendix: Papers