

Embodied-self-monitoring

Embracing the emergent context for compliance in the design of pervasive self-monitoring technology.



PhD Thesis

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ABSTRACT

This thesis aligns with the field of designing and developing pervasive self-monitoring technology to encourage and support people undergoing physical rehabilitation comply with prescribed therapy at home. The works in this field are driven by an aim of integrating the technology as part of the ‘context’ where compliance happens. However, field-based works within the field highlight how compliance is shaped by the particularities of the setting of a home. These works call for considering the way rehabilitees comply with their therapy in the design of pervasive self-monitoring technology.

In response to this call, I take an embodied interaction perspective in the design of pervasive self-monitoring technology. Taking the embodied interaction perspective means considering the context as being emergent and constantly shaped by the rehabilitee’s actions of compliance; it is a *context for compliance*. I formulate the theoretical concept of ‘embodied-self-monitoring’ to orient the design towards *embracing* the embodied actions of the rehabilitees through which they make sense of complying with the therapy. The central argument of this thesis is that the theoretical concept of embodied-self-monitoring offers an a priori orientation to embrace the way rehabilitees engage with the particularities of a setting in order to comply with the therapy. I demonstrate the prospects of embodied-self-monitoring through engaging in two sets of design explorations—MagicMirror and ReHandles—set in Denmark and India.

I follow a concept-driven interaction design research process. This is a dialectic process where both the understanding of what is embodied-self-monitoring and what prospects it offers co-evolved through the two groups of design explorations presented in this thesis. A process of sketching -in -hardware drove this co-evolution in collaboration with the rehabilitees, their spouses, and their professional therapists.

The explorations resulted in a ‘compositional whole’. This compositional whole is constituted by the theoretical concept of embodied-self-monitoring; the various scenarios of possible ways of interacting and engaging with pervasive self-monitoring technology that were envisioned, experienced and enacted through the range of design sketches; and the design situations. The compositional whole primarily contributes to the field of designing pervasive self-monitoring technology at the conceptual and empirical levels. At a conceptual level, it firstly calls for a shift in understanding a context for compliance as being emergent. Secondly, it calls for considering self-monitoring as embodied actions to be designed *for*, through forming a design stance of embracing the ways of rehabilitee compliance. At an empirical level, the compositional whole offers three *inspirational-sub-patterns* for the design practitioners to embrace the ways of rehabilitee compliance.

To my father who shows me, everyday, how not to give up.

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1 INTRODUCTION

The domains of medicine, nursing and rehabilitation, which in most countries are funded by the state, are facing increasing pressure to reduce costs. The rise in health cost can be attributed to the longevity of life leading to a rise in the number of senior citizens requiring additional care and the increase in cost of medical and diagnostic equipment. In order to deal with the rising costs, these domains are moving parts of healthcare towards the home of the patients, which in turn means focusing on ways of encouraging the patients to comply with the prescribed treatment. This thesis looks at the case of physical rehabilitation and its ways of encouraging compliance with the prescribed therapy beyond the clinic. In particular, it explores the design of pervasive¹ self-monitoring technology that can support compliance with a physical rehabilitation therapy.

In general, a physical rehabilitation process involves consultations with professional physiotherapists, who recommend exercise therapies based on the particular diagnosis of the injury. The rehabilitation process also involves periodic sessions at the clinic where the rehabilitees² perform the exercises under the guidance of the physiotherapists. In between these periodic sessions, the rehabilitees are encouraged to comply with the treatment by performing the prescribed exercises at home on a daily basis. Performing the exercises at home is considered as a key element of being successfully rehabilitated.

Despite the key role that complying with the prescribed treatment holds for a successful rehabilitation, the therapists, however, report a lack of compliance amongst the rehabilitees³ when at home. Research [Sluijs et al, 1993; Campbell et al, 2001; Petursdottir et al, 2010] has found that it is difficult for the rehabilitees to comply with their treatment and perform the exercises at home consistently. These studies find that compliance is influenced by multiple factors, including the individual attitudes towards illness and exercises, support from physiotherapists, feedback about progress made, ability to integrate the exercises with everyday routines, and the broader social and physical environments of the individuals.

When rehabilitees find it difficult to comply with a physical rehabilitation, it leads to an increased cost to the society, particularly, in cases where healthcare is supported and funded by the state [Campbell et al, 2001]. A failed rehabilitation process leads to different kinds of costs to the society, not the least, a decline in the number of people in

¹ Pervasive in this thesis includes mobile technology.

² Rehabilitees are people who are undergoing physical rehabilitation treatment.

³ For example, an American study [Sluijs et al, 1993] reports non-compliance with prescribed exercises to be as high as 70%.

the workforce. Further, retired senior citizens may require additional care and support from the public health system for performing their activities of daily living if they are not successfully rehabilitated. The costs to the society may also be in the form of transportation that the clinic has to organize to pick-up and drop the rehabilitees for their periodic treatment sessions. In addition, the state's expenditure on setting up and running a good infrastructure for physical rehabilitation—physiotherapists, equipment, transportation, etc.—will not yield expected results if the rehabilitees are not successfully rehabilitated from their injuries. Hence, efforts are on to explore ways to reduce these costs to society incurred due to lack of compliance with a prescribed rehabilitation process.

1.1 ADDRESSING REHABILITEE NON-COMPLIANCE

The medical and nursing domains, to which the domain of physical rehabilitation belongs, are increasingly looking for an answer to the challenge of supporting the patients to comply with their prescribed treatment at home. While physical rehabilitation is moving towards a more holistic and localized therapeutic approach, the medical domains focus on self-monitoring as a key-enabling concept shaping compliance.

1.1.1 Holistic and Localized therapeutic approach

The physical rehabilitation domain is moving away from direct application of therapy to an approach where the therapy is fine-tuned to suit the holistic social, physical and psychological situation of the individual rehabilitee [National white paper, 2004; Nicholls & Gibson, 2010; Mastos et al, 2007]. This approach can be summarized as one where the physiotherapists prescribe individual rehabilitation therapy procedures and goals that are conducive for the rehabilitees to integrate them with their everyday routines. Further, these therapy procedures are arrived at in close collaboration with the individual rehabilitee.

1.1.2 Self-monitoring: a theoretical concept to address lack of compliance

Meanwhile, the medical and nursing domains have identified that the ability to self-monitor is the central element for supporting the patients to comply with prescribed medicinal treatment [Korotitsch & Nelson-Gray, 1999; Wilde & Garvin, 2007]. Case in point is how Wilde and Garvin, drawing from a systematic literature review, model self-monitoring as being central to the different actions involved in complying with a treatment process at home. Self-monitoring directly influences self-awareness, goal setting, and the sharing of the symptoms with peers and caregivers. They argue that self-

monitoring leads to a better self-management of a physical rehabilitation process (along with other chronic diseases) and an enhanced quality of life, in general. The authors define self-monitoring as, “*the awareness of symptoms or bodily sensations that is enhanced through periodic measurements, recordings and observations to provide information for improved self-management*” [p 343, 2007].

1.1.3 Digital technological initiatives to address lack of compliance

Increasingly digital technology, in particular pervasive and mobile technology, is explored as a tool for supporting the rehabilitees to comply with the treatment at home. The works predominantly explore the quality of playfulness and the immersive environment of the gaming world as a possible motivation for people to engage with their physiotherapy exercises [Alankus et al, 2010; Geurts et al, 2011; Grönwall & Kramp, 2011]. At the same time, there are works that aim to address compliance with medicinal treatment [Pavel et al, 2010; Lee & Dey, 2010; 2011; Chen et al, 2011; etc.] and general fitness regimes [Consolvo et al, 2006; 2009; Maitland et al, 2006]. These works, implicitly or explicitly, rely on the clinically well-established concept of self-monitoring to guide the design and development; they focus on the design of digital technological tools that, either automatically or manually, measure and record how the patients comply with their treatment, process the data collected and present the data to the patients to make them aware of their compliance. In other words, the focus is on the design of ‘pervasive self-monitoring technology’.

Driven by the ubiquitous computing vision of integrating technology as part of everyday life, these initiatives aim to transfer the tools, prescriptions, and treatment routines from the clinic and integrate them as part of the ‘context’ where the patients comply with their treatments. The aim is to make the clinical tools accessible to the patients at home to self-monitor and, thereby, manage their treatment procedures successfully.

However, there is a growing concern to take into consideration the complexities of complying with prescribed treatment at home, which is a ‘lived’ everyday setting. Recent works [Axelrod et al, 2009; 2011; Balaam et al, 2011] urge the researchers in the domain to consider the home as a distinct, and yet a rich setting for rehabilitation and treatment activities, rather than an extension of the clinic. They particularly highlight how compliance at home is *situated* in particular social and material context that is different from the clinic.



Figure 1.1: Left is a physiotherapy clinic in Mumbai, India. Right, images of rehabilitees at home

For example, the Figure 1.1 shows the two settings: a physiotherapy clinic on the left hand side and rehabilitees in their homes on the right hand side. The images on the left show some of the particularities of a clinic—monitoring and other rehabilitation technology, exercise machines, trained physiotherapists, etc.—that help the rehabilitees to be rehabilitated successfully. On the right, the images show some of the particularities of a home—a caring spouse, personal memorabilia representing rich stories about life lived, the living rooms and other spaces for socializing, reminiscing, relaxing, etc.—that help the rehabilitees to comply with their treatment. The images represent the obvious differences between the two settings, right from the colors of the walls, to the objects present, and the social relations being enacted.

The recent works [Axelrod et al, 2009; 2011; Maitland & Chalmers, 2010] urge the designers of digital technological tools for physical rehabilitation to take into consideration the way the rehabilitees engage with the particularities of a setting in order to comply with their treatment. In this thesis, I read this urge as a call for exploring how to *embrace* the ways in which the rehabilitees comply with the prescribed treatment through engaging with the particularities of the setting. By embracing, I mean not just acknowledging but taking advantage of the rehabilitees' ways of compliance.

1.2 EMBODIED INTERACTION PERSPECTIVE

I turn to a phenomenological understanding about context [Dourish, 2001; 2004; Svanaes, 2001] in order to embrace the ways of rehabilitee compliance.

Over the past two decades, the field of Human Computer Interaction (HCI) and Interaction Design (IxD) has increasingly searched for a theoretical foundation that goes beyond the information-processing model of human-computer interaction. This search has been partly driven by the increasing push of technological development from a desktop computing model to computing as part of a mobile and pervasive everyday life. The search has been on to look for a theoretical foundation that can explain and provide a handle on the situated and emergent aspects of the context within which human beings act meaningfully. Activity theory [Nardi, 1996], Ethnomethodology [Suchman, 1987; 2007], Distributed cognition [Hollan et al, 2000], and Phenomenology [Winograd & Flores, 1986; Svanaes, 2001; Dourish, 2001; 2004; Fallman, 2003] have been explored to understand the complex aspects of human interaction with computation as part of everyday life.

Interestingly, no one theoretical approach has established itself as the framework for designing for the situated and emergent aspects of context of human action. As recent works argue [Fallman, 2003; Harrison et al, 2007], the theoretical foundations of HCI are still in the process of emerging and evolving. This thesis looks towards phenomenology and ethnomethodology for developing its theoretical position about everyday compliance. While taking any of the approaches may have been equally fruitful for developing the theoretical concept that the thesis is after, restraining the theoretical deliberation leaves room for actual design work through which the thesis can demonstrate the fruitfulness of the concept. Rather than looking at each of these theoretical candidates in depth and then choosing the best, I discuss those approaches that have actually been engaged with in this thesis, offering my critique along the way.

Dourish [2004] draws from phenomenology and ethnomethodology to highlight how human beings engage with the social and material world in order to make sense of their actions. This perspective offers *an alternative view about context*. A context *comes to being*, and constantly evolves, due to the interplay between the particular ongoing actions of people and the particularities of the setting within which these actions happen. When a person acts by engaging with other people and things in a particular setting, he/she produces a context within which his/her actions become meaningful. Hence, the context is always *for* performing a set of particular actions by engaging with the particularities of a setting; context is an enacted relation rather than a fixed entity.

According to phenomenology, this way of acting by engaging with the particularities is at the core of our being: we are embodied-in-the-world. Embodiment is the nature of how we always act in the world *in concert with* other people and things within a setting, engaging them as resources in order to achieve a particular purpose. Based on this understanding, Dourish defines embodied interaction as “*the creation, manipulation, and sharing of meaning through engaged interaction with artifacts*” [Dourish, 2001; p. 126]. It is important to note the focus on the ongoing action: creation, manipulation and sharing. Embodied interaction is a focus on the action as it unfolds, rather than any pre-conceived mental representation of the action. As Dourish notes, “*The embodied interaction perspective begins to illuminate not just how we act **on** technology, but how we act **through** it*” [original emphasis, Dourish, 2001; p. 154].

1.2.1 Taking an embodied interaction perspective on ways of complying with physical rehabilitation

In this thesis I take the perspective of how context is a relation enacted by people in concert with the particularities of a setting as the core theoretical ground for the design of digital technology supporting the self-monitoring of physical rehabilitation.

Taking the embodied interaction perspective, I propose that a *context for compliance* to be defined as:

An emerging relation between the particular actions that the rehabilitees perform in order to comply with their treatment and the particular settings within which these actions are performed.

The definition highlights how a rehabilitee engaging with the particularities of a setting, so as to comply with the prescribed treatment, produces a particular context for compliance. Here, by context I mean a *continuously evolving and enacted relation* between the particular human being, artifacts and activities involved in complying with the rehabilitation process at hand. That is, the particularities of the social and material setting at hand become part in shaping how the rehabilitation process unfolds. This suggests that rehabilitees understand their current condition, what they need to do in order to get better, and how to get there by engaging with the prescribed treatment in concert with a larger socio-material fabric. This is regardless of whether rehabilitation activities are played out at home or at the clinic.

Hence, the home or clinic *becomes* a context for complying with rehabilitation due to the way a rehabilitee constantly engages with other rehabilitees, therapists, family members and exercise machines, instruction sheets, furniture, etc. across home and clinic in order

to enact and make sense of her/his rehabilitation activities. This engagement with the exercises in concert with the particularities, in turn, modifies the setting; for example, the stairs become the stepper and a living room becomes a place for exercising for a brief period of time. A context where complying with exercise prescription makes sense thereby emerges through this inter-relation between actions and settings.

In this sense, I see the rehabilitee's engagement with the prescribed exercise instructions and tools as *embodied actions* through which the rehabilitees take advantage of the opportunities for adoption and appropriation of the prescribed treatment in context. Hence, I consider how complying with the exercise instructions are enacted in-situ and in concert with the many other social and material resources for action (e.g. using the particular curve of a chair as a support, or a flight of stairs to perform stepping exercises) that the rehabilitees engage with, in a given setting.

1.2.1.1 Embodied-self-monitoring: embodied actions of self-monitoring in context

As a result of taking the embodied interaction perspective, I focus on how self-monitoring is not a feature to be imbued by digital technology, but an *ongoing, embodied action* to be designed for.

Through the perspective of embodied interaction I see self-monitoring as embodied-in-the-world. I focus on how the particular actions that the rehabilitees perform in order to comply with the treatment—such as, measuring, recording, observing, reflecting, sharing, etc.—are shaped by the particularities of a setting within which these actions are performed, and in turn these actions shape the setting.

In order to sensitize the design towards how self-monitoring is embodied in the particular context for compliance, I propose the theoretical concept of *embodied-self-monitoring*. I define embodied-self-monitoring as:

Measuring, recording, observing, and performing other such self-monitoring actions through engaging with the particularities of a setting for complying with a prescribed treatment.

Embodied-self-monitoring is a particular case of embodied interaction, where the focus is on the embodiment of the actions that are done for the purpose of self-monitoring. I consider it as the nature of a rehabilitee's engagement with self-monitoring in his/her everyday life.

1.2.1.2 Designing for embodied-self-monitoring

Moving towards design from this understanding about embodied-self-monitoring implies taking a stance to embrace the way a particular context for compliance emerges. In line

with Dourish, I propose that designing for embodied-self-monitoring refers to foregrounding the embodied nature of self-monitoring in the design of pervasive self-monitoring technology. Foregrounding the embodied nature suggests a focus to facilitate rehabilitee engagement with the designed technology as one of the resources that works in concert with the already engaged particularities of the setting in order to shape the rehabilitee’s ways of compliance. Hence, I understand designing for embodied-self-monitoring as,

Designing pervasive self-monitoring technology for offering opportunities for the rehabilitees to engage with the technology and through this engagement, make the technology become a part of how they comply with their therapy.

Embracing the ways through which the rehabilitees comply with their therapy is my focus while designing for embodied-self-monitoring. By embracing I mean not just acknowledging that the context for compliance is emergent, but to *take advantage of* this emergence in the design of pervasive self-monitoring technology. I position that embracing—acknowledging and taking advantage of—the way a rehabilitee engages with the particularities of a setting as resources in order to comply with their therapy is a fruitful *design stance* to take in order to design pervasive self-monitoring technology.

1.3 METHODOLOGY

I follow an ‘in-situ’ version of the concept-driven interaction design research methodology [Stolterman & Wiberg, 2010] to demonstrate the claims of the thesis.

Design as a way of inquiry has been gaining ground in the field of HCI and interaction design research, with an increasing number of designerly approaches to HCI research being published. In this thesis I follow an approach termed as ‘concept-driven interaction design research’ [Stolterman & Wiberg, 2010], where the design efforts are driven by the aim of exploring and demonstrating the fruitfulness of the proposed theoretical concepts. This is done through the creation of artifacts, which manifest the theoretical concept in different forms. Through this act of creating artifacts I explore the possible scenarios about interaction that the theoretical concept opens up and, thereby, contributes to the theorizing about the human interaction with pervasive self-monitoring technology.

In this vein, my focus is on the *act of theorizing*—an act of creating artifacts that demonstrate the fruitfulness of embodied-self-monitoring—rather than contributing with abstract theories and models of the world. This act of theorizing is a dialectic process of co-evolving the theoretical concept and the design examples that address particular design situations. In line with the conception of design as a way of co-evolving the

problem-space and the solution-space [Schön, 1983; Nelson & Stolterman, 2003; Cross, 2007], both, the understanding of what is embodied-self-monitoring and what are its prospects for the design of pervasive self-monitoring technology, co-evolved through the two groups of design explorations: MagicMirror and ReHandles.

A process of sketching-in-hardware [Buxton, 2007] drove this co-evolution in collaboration with the rehabilitees, their spouses, and their professional therapists across different design situations in Denmark and India. We used Arduino and Flash, in combination with Wizard-of-Oz techniques to make different interactive sketches that were available for experience. The sketches were intended as early suggestions of possible solutions to help inspire further exploration and co-exploration with the rehabilitees, their spouses, and therapists. We took these interactive sketches to the clinics and to the homes of the rehabilitees asking them to engage in a series of in-situ enactments of how our sketches could be become part of their how they comply with the prescribed treatment.

1.4 CONTRIBUTIONS

The primary outcome of the thesis is the ‘compositional whole’ that is constituted by the theoretical concept of embodied-self-monitoring; the various scenarios about possible ways of interacting and engaging with pervasive self-monitoring technology that were envisioned, experienced, and enacted through a range of design sketches; and the design situations. The compositional whole primarily contributes to the field of designing pervasive self-monitoring technology at the conceptual and empirical levels.

1.4.1.1 *Conceptual contributions*

- Proposes the theoretical concept of embodied-self-monitoring as a fruitful theoretical ground to explore new ways of supporting the rehabilitees to comply with their treatment through engaging with digital self-monitoring technology in concert with the other resources as part of a setting.
 - The concept reminds that a context for compliance emerges through the rehabilitees’ engagement with the particularities of a setting,
 - The concept reminds that self-monitoring is an embodied action that has to be designed *for*, through forming a design stance of embracing the ways of rehabilitee compliance
- Demonstrates the fruitfulness by highlighting how designing for embodied-self-monitoring offers seven of the possible opportunities (discussed in chapter 11) for the rehabilitees to engage with the designed technology as one of the many

resources—which works in concert with the other already engaged resources—in order to shape and influence their ways of compliance.

1.4.1.2 *Empirical contributions*

- Proposes embodied-self-monitoring as a theoretical concept that gives a design practitioner an a priori orientation towards *embracing* the embodied ways of rehabilitee compliance with treatment.
- Presents three *inspirational-sub-patterns for embodied-self-monitoring* that provide concrete design suggestions for the designers to embrace the ways of rehabilitee compliance in the design for embodied-self-monitoring.

1.5 CREDITS

The thesis is a team effort, as can be made out from the below list of publication. The team effort particularly came alive during the design explorations of MagicMirror and ReHandles. This is also reflected in how the thesis is organized. While the initial chapters on the theoretical foundations are described in a first person “I”, the design explorations and the findings move to the collective “we”.

The explorations presented in this thesis are published as peer-reviewed conference papers and work-in-progress papers. These publications are:

1. Lutz, P., Bagalkot, N., Green, W., Yndigegn, S. (2013, forthcoming) Participant-Aspired Moves with Senior Patient 2.0 Design. Accepted with revisions for *publication in Science Studies journal, special issue on the shaping of Patient 2.0*.
2. Bagalkot, N., Sokoler, T., (2012), Unboxing the Tools for Physical Rehabilitation: Embracing the Difference between the Clinic and Home. Accepted for publication in *7th Nordic Conference on Human-Computer Interaction (NordiCHI'12)*. ACM.
3. Bagalkot, N. L., Sokoler, T., & Shaikh, R. (2012). Integrating physiotherapy with everyday life: exploring the space of possibilities through ReHandles. Proceedings of the Sixth International Conference on Tangible, Embedded and Embodied Interaction, TEI '12 (pp. 91–98). New York, NY, USA: ACM.
4. Bagalkot, N., & Sokoler, T. (2011a) MyReDiary: Co-Designing for Collaborative Articulation in Physical Rehabilitation. In S. Bødker, N. O. Bouvin, V. Wulf, L. Giolfi, & W. Lutters (Eds.), ECSCW 2011: Proceedings of the 12th European Conference on Computer Supported Cooperative Work, 24-28 September 2011, Aarhus Denmark (pp. 121-132). London: Springer.

5. Bagalkot, N., & Sokoler, T. (2011b) MagicMirror: towards enhancing collaborative rehabilitation practices. Proceedings of the ACM 2011 conference on Computer supported cooperative work, CSCW '11 (pp. 593–596). ACM.
6. Bagalkot, N., & Sokoler, T. (2011c). ReHandle: towards integrating physical rehabilitation in everyday life. Proceedings of the 2011 annual conference extended abstracts on Human factors in computing systems, CHI EA'11 (pp. 1795–1800). ACM.
7. Bagalkot, N., Nazzi, E, and Sokoler, T. (2011) Magic-Mirror-Spiral: Looking into the role of ‘design ideal’ in interaction design research projects. Accepted for publication in Proceedings of Nordic Design Research Conference (Nordes'11), Helsinki, Finland, May 29-31.
8. Bagalkot, N, Nazzi, E, and Sokoler, T. (2010) Facilitating continuity: exploring the role of digital technology in physical rehabilitation. In Proceedings of the 6th Nordic Conference on Human-Computer Interaction: Extending Boundaries (NordiCHI '10). ACM

1.6 OVERVIEW OF THE CHAPTERS

In chapter 2, I discuss how the physical rehabilitation and medical domains study and conceptualize the factors influencing compliance with prescribed treatment, and the approaches they take in order to encourage compliance.

In chapter 3, I discuss the related work of designing and developing pervasive self-monitoring technology to support rehabilitees comply with a range of therapeutic treatment. I present the emerging concern within this field about a need to consider the how the rehabilitees actually comply with their treatment through engaging with the particularities of a setting.

In chapter 4, I present the embodied interaction perspective highlighting the alternative view about context it offers. I take a detour to Dreyfus’s phenomenology to highlight the nuances of a human being’s engagement with the particularities of a setting through which a particular context emerges.

In chapter 5 I take the embodied interaction perspective on the ways of compliance, to highlight the emergent context for compliance. I then introduce the theoretical concept of embodied-self-monitoring. In chapter 6, I move towards designing for embodied-self-monitoring by introducing the framing device of *ecology-of-resources*.

In chapter 7 I present the core aspects of a concept-driven interaction design research methodology, highlighting how the thesis aims to demonstrate the prospects offered by the theoretical concept of embodied-self-monitoring.

In chapter 8, I discuss the way the two explorations were set-up, highlighting the methods of recruitment, engagement and data collection and analysis. Chapters 9 and 10 present an in depth account of how the explorations evolved, through the envisioning, experiencing and enacting of possible scenarios of interacting with pervasive self-monitoring technology.

In chapter 11, I synthesize these scenarios to highlight how supporting embodied-self-monitoring offers seven of the possible opportunities for the rehabilitees to shape their ways of compliance. I position these opportunities as demonstrators of the prospects offered by the theoretical concept of embodied-self-monitoring.

In chapter 12, I articulate the three ways in which we embraced the way the rehabilitees engaged with the particularities of a setting—with the everyday activities, objects, and social relations, and package them in the form of three inspirational-sub-patterns for embodied-self-monitoring.

In chapter 13, I discuss the outcome of the thesis, primarily for the field of designing and developing pervasive self-monitoring technology, and draw conclusions based on this discussion. I also discuss the implications of the thesis for addressing some of the concerns in the broader field of designing for embodied interaction, and the domain of physical rehabilitation.

2 PHYSICAL REHABILITATION: addressing non-compliance

In this chapter, I discuss two strands of research that study and conceptualize the factors influencing compliance with prescribed treatment.

In the first section, I discuss the research works from the domain of physical rehabilitation that present various factors that influence continued, long-term compliance with a prescribed therapy. Broadly, these works highlight how compliance is influenced by various factors such as, the individual attitudes towards illness and exercises, support from physiotherapists, feedback on progress made, ability to integrate the exercises with everyday routine, and the broader social and physical environments of the individuals. These works recommend the physiotherapists to take the above-mentioned factors as a ‘check-list’ in order to fine-tune their prescription to consider the holistic situation of the individual rehabilitee.

In the second section, I discuss the role of self-monitoring in shaping compliance as established in the medical and nursing domains. In particular, I present the concept of self-monitoring as proposed by Wilde and Garvin [2007]. My main intention to go beyond the literature of the domain of physical rehabilitation is to draw upon how self-monitoring is well established as a key concept that influences compliance with medical treatment.

2.1 FACTORS INFLUENCING REHABILITEE COMPLIANCE

As described in the introduction chapter, non-compliance with physical rehabilitation therapy is a serious issue faced by the domain of physical rehabilitation. Hence, works within the domain have studied what factors influence compliance, particularly on a long-term basis [Sluijs et al, 1993; Campbell et al, 2001; Petursdottir et al, 2010]. I take these studies as representative of how the field is increasingly broadening its concerns and studying more holistic situations of the individual rehabilitees in search of factors influencing compliance.

Sluijs et al [1993] study shows if and how rehabilitee compliance with physical exercise therapy is related to individual rehabilitees characteristics and attitude, nature of illness, and to the physical therapist's behavior. The study finds three main factors influencing compliance: firstly, the barriers perceived by the rehabilitees to exercise at home, such as finding time to exercise amidst busy routines; secondly, the persistent and positive feedback that a physiotherapist provides; and thirdly, the degree of helplessness, defined as how helpful exercising is perceived and experienced by the rehabilitees.

Campbell et al [2001] find that along with how the rehabilitees' perceived the severity of their symptoms, the effectiveness of the therapy, positive support from physiotherapists, and the ability to incorporate it into everyday life also played a crucial role. Based on a qualitative study as part of an ongoing clinical trial of a physiotherapy intervention for people suffering from knee osteoarthritis, they recommend the therapists to engage closely with the individual rehabilitees so that their perceptions and social circumstances are understood and to support them to actively participate in deciding about their physical therapy.

Petursdottir et al [2010] further broaden the factors and propose a more holistic model of internal and external factors that influence the rehabilitees to comply with their treatment. The internal factors include individual attitudes towards exercise, past experiences about the injury, self-image, motivation levels to perform general well-being and fitness exercises, etc. These individual factors interact with the external factors that include the social and physical environments of the rehabilitees. The social environments are constituted by family and peer support, engagement of the physical therapists, and physical environments are constituted by availability and accessibility to proper clinics, transportation, etc. The authors propose these factors as a 'check-list' for the physiotherapists to understand the individual rehabilitee's holistic situation and fine-tune their prescription to suit the situation.

2.1.1 From direct application of therapy towards a fine-tuned and holistic therapeutic approach

For addressing rehabilitee non-compliance, the physiotherapists are increasingly moving away from a mere application and prescription of therapeutic exercises for a group of rehabilitees with a similar illness, towards a more holistic and localized approach. This approach can be summarized as one where the physiotherapists prescribe individual rehabilitation therapy procedures and goals that are conducive for the rehabilitees to integrate them with their everyday routines. These therapy procedures are arrived at in close collaboration with the individual rehabilitee, and the procedures take into consideration the rehabilitee's holistic situation—i.e. social, physical and psychological situation.

Case in point is how a Danish whitepaper on rehabilitation [National whitepaper, 2004] defines a successful rehabilitation as follows:

"A goal-oriented, cooperative process involving a member of the public, his/her relatives, and professionals over a certain period of time. The aim of this process is to ensure that the person in question, who has, or is at risk of having, seriously diminished physical, mental and social functions, can achieve independence and a meaningful life. Rehabilitation takes account of the person's situation as a whole and the decisions he or she must make, and comprises coordinated, coherent, and knowledge based measures."

This definition emphasizes how the domain considers it as imperative to integrate the rehabilitation treatment with the physical routines and the social relations of the rehabilitees in order to be successful. Nicholls and Gibson [2010] call for a move towards a holistic approach for rehabilitation practice. They stress how successful physiotherapy requires the therapists to develop a more holistic view than the current focus on the injured biophysical body and include the everyday physical and social situation of the rehabilitees.

Another example [Mastos et al, 2007] describes how having specific, achievable goals that are close to an individual's everyday environment will increase the motivation of the individual to engage in the therapy. They identify four components of a goal-oriented physical therapy process, one of which is the setting of goals that are meaningful for the individuals—goals that are tuned to the activities of daily living (ADL) such as walking to the store, picking up a towel, wearing socks, etc. The rehabilitees and the therapists have

to periodically monitor the achievement of these goals in order to train and support the rehabilitees to achieve them.

In addition to this leaning towards a holistic approach, the domain is moving towards a localized approach, where the professional physiotherapists fine-tune their prescriptions based on the individual rehabilitee's situation at hand. Research in the past [e.g. Campbell et al, 2001; McClain, 2005; Petursdottir et al, 2010] recommends that the physical therapists closely engage with the specific, everyday needs of their rehabilitees, fine-tuning their prescriptions collaboratively.

2.2 THE CONCEPT OF SELF-MONITORING

Meanwhile, the medical and nursing domains have invested much effort in conceptualizing the role of self-monitoring in shaping compliance with prescribed medicinal treatment. Mainly originating from social psychology⁴, self-monitoring has been defined and understood in a variety of ways in the medical domains. However, the common understanding is that self-monitoring involves actions of observing, collecting, recording, and measuring a range of data, in order to gauge and assess how one is complying with treatment and the progress made due to compliance.

Korotitsch and Nelson-Gray [1999] define self-monitoring as a process of collecting data by a patient within naturalistic (everyday non-clinical) settings, and making assessment based on these data. There are two actions or responses that a person has to perform that together constitute self-monitoring. The first response is to notice or observe when the target behavior—such as an action, thought, or emotion—occurs. The second response is to keep a record of such occurrence over a period of time and of any information that is relevant. Both these actions are oriented towards self-monitoring of an individual's performance towards achieving goals that he/she has to achieve in order to live healthy or manage particular health conditions.

Wilde and Garvin [2007] propose a more suitable definition for this thesis. The authors model the concept of self-monitoring based on an exhaustive literature survey of patient compliance with prescribed treatment for chronic health conditions (including physical rehabilitation). Hence, it makes sense to draw upon their work in order to understand the underlying influence of self-monitoring on compliance. Furthermore, as I will discuss in chapter 3, I take the help of Wilde and Garvin's model to draw inferences on how self-

⁴ Case in point is the seminal work by Snyder [1974] who presents a self-monitoring scale that can help people to gauge the extent to which they monitor and adapt their expressions in social interaction.

monitoring is the underlying concept which guides the works of designing and developing pervasive technology to support compliance.

Wilde & Garvin define self-monitoring as: “*Self-monitoring is the awareness of symptoms or bodily sensations that is enhanced through periodic measurements, recordings and observations to provide information for improved self-management*” [p 343, 2007].

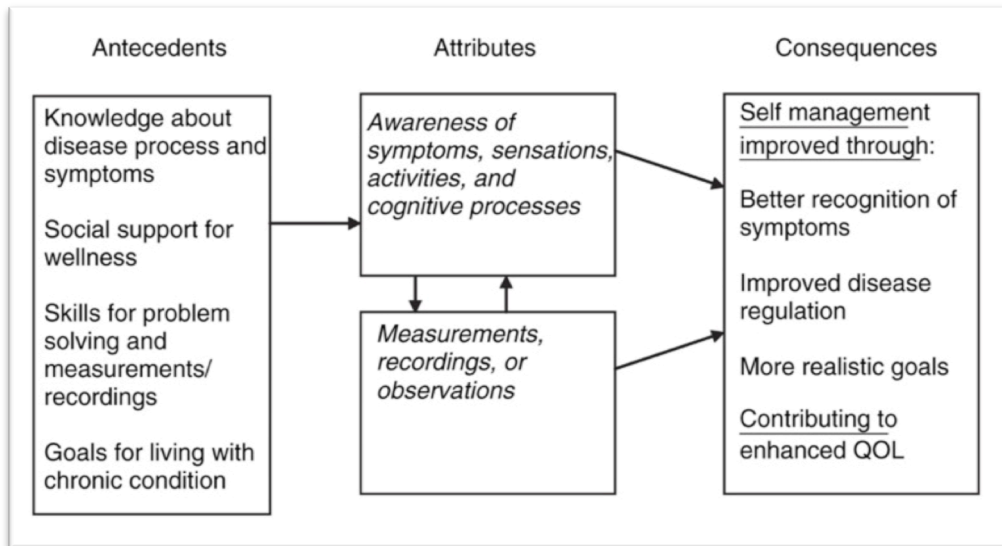


Figure 2.1: Model of the concept of self-monitoring [Wilde & Garvin, 2007]

They present a model of the concept (see Figure 2.1). There are two attributes of the concept: awareness and measurement. These attributes support each other in a synergistic manner. Active observation and measuring helps develop an awareness of the symptoms and body conditions, while at the same time, the awareness of when and what to observe and measure is required to carry out the measurements. The conditions that are necessary for the self-monitoring are a knowledge about disease and related symptoms; social support for being healthy; skills to observe, measure and take action; and goals for living with diseases. Self-monitoring leads to a better self-management of the chronic diseases and symptoms and an enhanced quality of life in general.

In this sense, Wilde and Garvin model self-monitoring as central to the different actions involved in complying with a treatment process at home. Self-monitoring directly influences the actions of self-awareness, goal setting, and the sharing of the symptoms with peers and caregivers.

2.3 SUMMARY

In summary, the domain of physical rehabilitation is dealing with non-compliance by recommending a *holistic* and *localized* approach. This approach calls for a focus on

integration of the treatment procedures with the individual rehabilitee's physical and social environment at home and on close collaboration between the therapists and the rehabilitees for fine-tuning the treatment.

Furthermore, the *ability to self-monitor* the way one complies with a treatment to assess the progress being made is considered as a core factor influencing compliance, as shown by the amount of medical and nursing research invested in establishing the concept of self-monitoring.

In this thesis I draw on these two approaches—the move towards holistic and localized therapy practice, and the focus on the concept of self-monitoring—as the key 'take-away' points from a literature study about the domain of physical rehabilitation, and the broader medical and nursing domains. In particular, I take that for supporting the domain of physical rehabilitation address rehabilitee non-compliance it makes sense for a designer to align with supporting these two approaches through the design of digital technology. Later on in this thesis, in chapter 13, I will discuss how the thesis points to new opportunities for designing digital technology to support both the approaches.

3 RELATED WORK: Addressing non-compliance through digital technology

In this chapter I discuss how the concept of self-monitoring underlies in the related work of designing and developing pervasive technology to support rehabilitees comply with a range of therapeutic and medicinal treatment. I discuss how these related works are focused on integrating pervasive self-monitoring technology within the ‘context’ of complying with prescribed treatments. Such focus on integrating with context is a direct reference to the aim of realizing the ubiquitous and pervasive computing vision of ‘integrating digital technology with the fabric of everyday life’ [Weiser, 1999].

I then present the emerging concern within this field about how this context within which compliance happens is complex and situated; field-based works highlight how there is a need to consider the situated and ‘lived’ aspects of complying with the treatment at home from the perspective of a patient / rehabilitee. I consider this critique as a call for exploring a theoretical concept that orients the designers and developers to embrace the ways through which the rehabilitees comply with their treatment in the design of digital technological tools.

3.1 RELATED WORK: integration of pervasive self-monitoring technology with the context of compliance

Digital technology is being increasingly explored to support rehabilitees to comply with the prescribed therapy. The works predominantly explore the quality of playfulness and the immersive environment of the gaming world as a possible motivation for people to engage with their physiotherapy exercises [Alankus et al, 2010; Geurts et al, 2011]. The Nintendo Wii and the Microsoft Kinect platforms enable the designers to integrate play and related ludic experiential qualities with the tough everyday challenges of performing physical exercises at home for rehabilitation. Hence, experiments with ‘WiiHabilitation’ are gaining ground in this domain [Tanner, 2008]. At the same time, virtual-reality technologies are being developed to make exercising more interesting and to give immediate feedback in a rich and immersive environment [e.g. Holden, 2005]. Grönwall and Kramp [2011] present Link-lights, a modular and tangible rehabilitation technology that can be used to perform exercises of vestibular rehabilitation. Here again, they employ aspects of randomness and play in order to motivate the rehabilitees to comply with their exercises at home.

Combining the tough physical exercises with gaming is one of the possible ways to support rehabilitee compliance. As Balaam et al [2011] point, there needs to be more work to explore other forms of digital technology to consider the complexities of complying with therapy beyond the clinic. With their recommendation, I go beyond the works focusing on supporting compliance with physiotherapy, to consider the works focusing on supporting compliance with medicinal treatments for chronic diseases [Pavel et al, 2010; Lee & Dey, 2010; 2011; Chen et al, 2011; etc.] and general physical fitness exercises⁵ [Consolvo et al, 2006; 2009; Maitland et al, 2006].

3.1.1 The common conceptual thread: self-monitoring

The above-mentioned works mostly draw from different well-established theoretical concepts about compliance from various domains such as social psychology, medicine and nursing as theoretical foundation informing their design approaches. These concepts are self-awareness [Pavel et al, 2010; Lee & Dey, 2010; 2011], goal setting [Consolvo et

⁵ Though these works seem not to be addressing non-compliance with any specific treatment, it would augur well for this thesis to learn from them about the approaches they take for motivating people to engage in physical activities for a long and consistent period of time. After all, the core aspect of complying with a physical rehabilitation treatment is to perform physical exercises consistently over a long period of time.

al, 2006], and impression management [Consolvo et al, 2009, Maitland et al, 2006]. In the succeeding paragraphs, I briefly describe the example works focusing on each of the concept. Following which, by employing Wilde and Garvin's model of self-monitoring [2007], I highlight how the common thread of supporting self-monitoring ties these works.

3.1.1.1 Self-awareness

Encouraging the patients to comply with the treatment is one of the central ideals driving the technological initiatives. These works explore the design of pervasive sensor networks and mobile technology to record physiological and other contextual data and provide this information as objective measures for patients to increase their awareness about their health conditions.

Pavel et al [2010] describe a multi-agent system to collect physiological and contextual data from patients and their devices, transfer them to a database, filter the raw data, and present them to the patients in the form of life stories on their electronic devices—TV, mobile phones, PDAs, etc. Patients can recall their life through these stories and record any thoughts into the systems. The authors argue that by collecting and presenting the patients health data in the form of stories will help them to reflect and become more aware of their actions and relate to their health conditions in an objective manner.

Lee and Dey [2010] present concept designs of three intelligent sensing systems, which track the everyday activities of senior citizens, such as medication intake, making a coffee, and dialing a telephone number. The system presents these data in terms of how well the tasks were performed. With this technology the authors aim at enabling senior citizens to monitor their cognitive task performance in managing their everyday activities, in order to increase the self-awareness of the citizens on aspects of changes in cognitive abilities as they age. The authors [Lee & Dey, 2011] further present a deployment study of the medication tracking and phone usage tracking systems. Here they argue for a design of system that gives an objective means of recording data to support a more accurate self-awareness about the changes in the functional abilities of senior citizens.

UbiFit [Consolvo et al, 2009] is another example that collects people's physical activity, and presents these activity data on their mobile devices for self-reflection leading to more active behavior. Shakra [Maitland et al, 2006] is a prototype that similarly senses and presents data about physical activity levels for increased awareness.

3.1.1.2 *Goal Setting*

Houston is a prominent example that draws on goal setting [Consolvo et al, 2006]. It employs pervasive sensor technology combined with mobile devices allowing people to set individual goals for the physical activity levels they want to achieve. Further they can monitor and track the ways of achieving these goals, get positive rewards when the goals are achieved, and receive in-depth feedback on the progress of achieving the goal based on a historical analysis of the collected data.

3.1.1.3 *Impression management*

Consolvo et al [2009] bring the well-established theoretical concept of social impression management⁶ together with goal setting to inform the design of UbiFit system. The UbiFit system not only enables an individual to set, monitor and manage their goals for physical activity, it also employs the individual's social presence to motivate an increased level of physical activity. It uses an animated image of a garden as the wallpaper of a person's mobile phone to represent increased physical activity. This aids the people to show their physical activity status to the friends, without the feeling of sharing an intimate, personal data. In a similar vein, Shakra [Maitland et al, 2006] provides means for the people to share their physical activity levels with their peers, who are part of the same physical activity group. By sharing each other's activity levels, they can encourage each other to be more physically active.

Essentially, the above-mentioned examples focus on the design of 'pervasive self-monitoring technology'. The technology is designed with an aim to provide means for the patients to count, measure, record, and in general, quantify how they comply with their prescribed treatments or perform fitness regimes at home. In this sense, the above-mentioned works, either explicitly or implicitly, consider the ability to self-monitor (either manually by the patient, or by employing automatic sensor technology) as a common, central concept for addressing non-compliance.

Looking at the above-arranged related work through Wilde and Garvin's model of self-monitoring, I figure how self-monitoring—measuring, recording, and gathering data—

⁶ Social impression management is rooted in the work 'Presentation of Self in Everyday Life' by Goffman [1990]. Goffman demonstrates how an individual performs for a social audience, constantly gauging the response this audience provides in terms of verbal and body language, and other cues. The individual or performer acts in such a way as to make his verbal and nonverbal self-expressive actions fit those of the people around him/her. This management of one's impression requires a repertoire of social skills such as an ability to constantly monitor and be aware of how people are responding to one's action, a desire to be approved by the set of people in a given situation and readiness to employ this range of impression management skills.

enables the patients or rehabilitees become more self-aware, set achievable goals, and manage their social impressions.

By manually or automatically collecting the data regularly, keeping track of the activities over time, and reflecting on these historical data, a rehabilitee may enhance his/her level of self-awareness about how he/she is making progress. Data collected by consistently recording when and how a rehabilitee achieves the goals helps in setting achievable goals and keeping track of the performance. The rehabilitee may further share aspects about one's treatment process with friends and peers by sharing part of the recorded data, which in turn may enable the peers to give motivational feedback to the rehabilitee.

In this sense, the above-mentioned works justifiably take the concept of self-monitoring as their theoretical ground to address the issue of lack of compliance amidst patients. The domains of medicine and nursing have already established, based on evidence-based science, the concept of self-monitoring as central to the successful compliance with treatment at home. Applying this well-established concept in designing and developing technological tools seems straightforward.

3.1.2 Focus on integrating with the context of compliance

At the same time, the above-mentioned works stem out of the field of ubiquitous and pervasive computing. Integrating technology with the fabric of everyday life has been on the agenda of this field since the 1990s. Weiser's [1999] seminal article on the future of computing set up the agenda for a series of ongoing explorations looking for the technological means to realize a vision of computing being seamlessly integrated with everyday life.

Hence, these works explicitly focus on integrating the pervasive self-monitoring technology as part of the contexts where the individuals comply with treatments or fitness regimes.

Pavel et al [2010] seek to situate the self-monitoring technology as part of the subjective and lived everyday life by presenting the self-monitored data in the form of life stories that the people can relate with their everyday life and reflect on. Klasnja et al [2011] call for the design and evaluation of pervasive self-monitoring technology that can be used as means to understand and uncover the subtler and richer issues involved in using and 'possibly living' with the technology over time. Another recent work-in-progress [Chen et al, 2011] explores the possibility of designing a 'context-aware self-monitoring system' that can collect data and provide proactive, contextual feedback for people so that they can increase their self-awareness at appropriate time and location.

In this way, these recent works seek ways to design pervasive self-monitoring technology so that it is integrated with the contexts where the patients or rehabilitees comply with their prescribed treatment, beyond a clinic.

3.2 COMPLIANCE: situated as part of the everyday life at home

An increasing number of field-based works [Maitland & Chalmers, 2010; Axelrod et al, 2009; 2011], however, find that the context where compliance happens is not a stable container, but something that shapes the way the rehabilitees comply with their therapies. These works highlight how compliance at home is situated in a particular social and material context that is different from the clinic. The studies point to *how the rehabilitees comply with the prescribed treatment through integrating the treatment as part of their ongoing activities of daily living, people and social relations that they live with, and the things with which they surround themselves at home.*

Maitland and Chalmers [2010] reveal how some of the people rehabilitating from a cardiac arrest made sense of the sensor-based measured data of their heart rates based on how they *felt* their day was. The progress made in the rehabilitation was self-monitored based on how the rehabilitees felt about their own bodies, and how they could manage simple everyday activities such as walking to the store and climbing stairs, rather than being based on objective sensor-based measurements. The authors propose that the design of self-monitoring technology has to be reoriented to support varying degrees of engagement with the data. Further they propose that data should be recorded only when the rehabilitee initiates the monitoring, as an integral part of giving more control of the monitoring to the rehabilitees.

Axelrod et al [2009] use ethnographically inspired methods to highlight the heterogeneity of the rehabilitee's homes within which the designed rehabilitation technology would be placed. In particular, they argue that any design of rehabilitation technology must consider the way the rehabilitees live with existing technology, the memorabilia and other things they surround themselves with, the way they spend their time in their favorite places within the homes, and the different social interactions they engage with. The authors call for exploration of ways to address the challenges posed by the heterogeneity of everyday life for the design of rehabilitation technology that is *fully integrated* in the life of the rehabilitees at home.

3.3 SUMMARY: Towards embracing the rehabilitees' ways of compliance at home

In summary, the related works consider self-monitoring as an enabling theoretical concept that guides the design and development of pervasive technological tools that support the rehabilitees to comply with their treatment. The aim is to design such pervasive self-monitoring technology to be integrated with the particular context where compliance happens beyond the boundaries of a clinic.

However, as the field studies highlight, compliance is shaped by the context in different ways. The authors of these works urge the designers of digital technological tools for physical rehabilitation to take into consideration the way the rehabilitees engage with the particularities of a setting—ongoing activities of living (ADLs), people and social relations, and things—in order to comply with their treatment.

I read this urge as a call for exploring a question of how to embrace the ways in which the rehabilitees comply with the prescribed treatment through engaging with the particularities of the setting. Along with drawing upon the already well-established theoretical concept of self-monitoring, I read the field studies as opening a space for exploring a theoretical concept that gives an *a priori orientation* for the designer to embrace how rehabilitees comply with treatment in the design of pervasive self-monitoring technology.

4 EMBODIED INTERACTION

In this chapter, I turn to the phenomenological understanding about context [particularly as presented by Dourish, 2001; 2004] in the quest for a theoretical concept to embrace the way the rehabilitees engage with the clinics and the homes as distinct and yet rich contexts for complying with their treatment.

In the following sections, I briefly outline key phenomenological and ethnomethodological approaches in HCI [Winograd & Flores, 1986; Svanaes, 2000, 2001; Robertson, 1997; Suchman, 1987; 2007], discussing how the framework of embodied interaction draws upon these prior works, and hence offers a broader framework for this thesis. In particular, I present how a phenomenological re-thinking of ‘context’ takes into consideration the situated and emergent aspects of *how a context for a particular activity comes to being*. Following this, I describe how there is a challenge to get a ‘handle’ of the emergent context for design. In order to get a grip on how a particular context emerges, I turn to Dreyfus’s [1991] detailing of everyday human coping as a way of being-in-the-world, making emerge particular contexts. I propose ecology-of-resource as a device to frame an emergent context to design technology that can be engaged with and appropriated.

4.1 PHENOMENOLOGICAL AND ETHNOMETHODOLOGICAL APPROACHES IN HCI

As mentioned in the previous chapter, integrating technology with the fabric of everyday life has been on the agenda of ubiquitous and pervasive computing (Ubicomp) fields since the 1990s. However, computing has already become part of everyday life, though not as envisioned [Bell & Dourish, 2007]. The difficulty in realizing the vision of seamlessness lies in the fact that human interaction with things in everyday life is messy, networked, dynamic, and emergent [Bell & Dourish, 2007; Dourish & Bell, 2011]. The Ubicomp research works address this fact and aim for the vision of locating computing within this world, however, when it comes to realizing the vision, they seem to reduce this world to one person interacting with a single instance of a monolithic system. This approach of reduction and then building up the system as a set of designs for particular interaction reveals the underlying Cartesian philosophical frameworks of the ubiquitous computing research [Dourish, 2004].

In search for an alternative and more fruitful theoretical foundation for human-computer interaction as part of everyday life, different authors have drawn upon the phenomenological [for e.g., Winograd & Flores, 1986; Svanaes, 2000; 2001; Robertson, 1997; Dourish, 2001; Fallman, 2004] and ethnomethodological perspective [Suchman 1987, 2007; Robertson, 1997].

Winograd and Flores [1986] are one of the first authors to point out the fruitfulness of Heideggerian phenomenology in the field of HCI. They particularly draw upon Heidegger's analysis of human's tool use and the concepts of 'present-at-hand', 'ready-to-hand', and 'breakdown'. A tool presents itself as 'present-at-hand' in an environment for a user, who picks it up and uses it. The tool becomes 'ready-to-hand' when it withdraws to the background of the user's attention. When there is 'breakdown' in this workflow, the tool becomes the focus of attention, moving from the background to the foreground. They discuss how these phenomenological concepts can be fruitfully employed in the design of technological systems for collaborative work, by making the temporal aspects of work visible or 'present-at-hand' so that the workers are aware of the tools available in their environment that they could use to perform their tasks.

Svanaes [2000, 2001] drawing on Merleau Ponty points out how a human body acting with a particular intention, with the physical environment decides what is the foreground or background of its attention. He discusses how a human body acts with the physical environment around it, and perceives this environment through these actions. Svanaes explains the role of the physical human body in meaning making, and proposes a

framework for an interactive system that has a physical interface and hence is available within the physical horizon of a human user.

This focus on the physical human body and its relation to its environment make it a straightforward choice of framework for designing for physical rehabilitation, a process where physical bodies are healed and restored. This explicit focus on the physical aspects of human experience was much needed in the HCI discourse of the time; nevertheless, does not leave room for considering the relation between everyday human experience and the social settings within which the experience happens. Though physical rehabilitation is a process of healing of the physical body, as explained in Chapter 3, yet it is shaped by both the social and the material contexts within which the process unfolds.

Meanwhile, ethnomethodological approaches study and analyze how meaningful human action is embedded in the particular social settings within which it happens. Robertson [1997] combines Merleau Ponty and ethnomethodology to structure a field study of design organization involved in collaborative design work. He proposes a taxonomy of ‘embodied actions’ that the designers perform while engaging in the design process. He categorizes these actions as a) individual actions in relation to physical objects, to other bodies, and to the physical workspace and b) group activities that are constituted by the individual embodied actions. By bringing together phenomenological focus on the physical, and the ethnomethodological focus on the social, this taxonomy offers a broader understanding of how human actions generate meaning within particular physical and social settings. With this taxonomy Robertson formalizes the everyday practices of the design workplace. He argues that this will ease the transition between observing a human practice and designing a system to support these practices.

This formalized modeling of an ongoing activity as a set of actions, however, leaves out the aspects of performance, contingency, and improvisation that form the core of meaningful human actions. A seminal work to theorize these aspects is published by Suchman [1987, 2007]. Suchman d, based on her observations about how humans interact with a copy machine, criticizes the then prevailing conceptualization of human action as a set of sequential tasks that are predetermined by a coded ‘plan’. She demonstrates how human actions are always performed in response to the particularities of a setting. Within this setting, a human being employs a range of resources. Plans and other such historic or cultural ordering devices are some of the many resources that are available for carrying out an action that makes sense within that particular social setting. Hence meaningful actions cannot be prescribed, as they emerge out of the way the human beings act in relation to the setting around them, i.e. meaningful human action is *situated*.

Further, Suchman explains how the setting (for e.g. the designer workplace in Robertson's study) and the embodied human actions that are performed within this setting shape each other; they are mutually constituted. Hence, in practice, the taxonomy of actions is constantly emerging as the particularities of a setting change over time.

In summary, the above-mentioned approaches explicitly focus on one or the other aspects—physical or social embodiment—of human interaction with the world. While individually they have much to offer to this thesis, a framework that synthesizes these strands of phenomenology and ethnomethodology into a theoretical framework that addresses a designer's sensibility would be more fruitful.

Meanwhile, over the same period of time, research initiatives in physical / tangible computing and social computing have emerged with the respective aims of taking into account the human body and the social settings in which human interaction happens while designing digital technology for everyday life. Dourish [2001] analyses these recent works establishing their common foundation in phenomenology and ethnomethodology and proposes a framework for understanding human action in everyday settings: Embodied Interaction. Embodied interaction is the nature of human interaction with the world through which people make sense of their actions. The embodied interaction perspective stresses that action and meaning arises in *participation* with a particular setting in response to the particularities of that setting, and hence cannot be predetermined or prescribed in an unrestricting way by designers. The aims of embodied interaction are, firstly, to understand how action and meaning are related to the situation in which a person is acting and, secondly, to help in designing digital artifacts and systems to 'harness' the embodied and situated nature of human action. In this direction Dourish provides broad design principles, while stating that the designing of digital systems that take advantage of human embodiment is an open research area that is yet to be explored.

I find this perspective of embodied interaction as covering a broader understanding of embodiment by drawing upon ethnomethodology and phenomenology. In particular, it highlights the situated and emergent nature of the context for human action and meaning making. It is this focus on the relation between human actions and their setting that makes embodied interaction a more promising avenue to take in this thesis.

4.2 EMBODIED INTERACTION

Dourish discusses embodiment as the way we exist in the world and experience the world. Discussing the different accounts of Husserl, Heidegger, Schutz, and Merleau-Ponty, he paints the phenomenological picture about embodiment. He also draws from Suchman and other sociological frameworks along with phenomenology. He mentions how the tangible and social computing fields rely on and take advantage of the relation between action and meaning emerging out of the background of everyday, mundane activities. He highlights three common aspects about embodiment.

- Embodiment is not merely having a physical body, but being part of everyday, mundane experiences. Embodiment is a foundational, participative property rather than a given, physical property of the world.
- We are situated in the world. The world is the setting for our activities. Our ongoing activities are shaped by this world.
- Our embodied actions are of participative nature. We make sense of the world through our embodied action. . It is through our everyday actions that we turn objects from being present-at-hand to ready-to-hand and back.

Dourish builds on this summary to state that,

“Embodiment is the property of our engagement with the world that allows us to make it meaningful.” [2001, p. 126]

Embodiment then is the nature of our being. It is the nature of how we always act in the world *in concert with* other people and things, availing them as resources in order to achieve some purpose.

4.2.1 Context: an emergent relation between actions and setting

Based on the understanding of embodiment as being in the social and the material world, Dourish rethinks how the field of Ubicomp considers ‘context’, and its vision of integrating technology within this ‘context’. In particular, taking the embodied interaction perspective on context means moving away from the idea that context is a fixed, stable container with distinct physical properties.

The embodied interaction perspective on context also means considering a context as something that *comes to being* and constantly evolves due to the interplay between the particular ongoing actions and the setting within which these actions happen. Our everyday actions, such as getting ready and reaching office, working at the office, meeting friends over dinner, relaxing at home, are all constantly shaped by the particularities of a setting within which we perform the actions. These particularities

consist of different people, things, and norms that we encounter and engage with. These particularities become the background on which we make sense of our actions.

Further, drawing on Suchman [1987] one can see how a particular context emerges due to the enaction of the inter-relation between actions and setting. As described above, Suchman argues for a consideration of how human action is shaped by the social and material particularities of a setting within which it unfolds, and in turn how these actions shape these particularities over time. Furthermore, the situatedness of human action implies action as a relation that is enacted over time. Being situated does not mean a fixed embeddedness in a stable container of people and things, but an ongoing configuration and reconfiguration of things and people as resources for meaningful action. It is this constant inter-shaping of actions and their setting that *produces* a particular context that makes our actions meaningful for us. Hence, context is always *for* performing a set of particular actions in relation to the particular setting.

4.2.2 Integration with the context: incorporation through appropriation

This understanding of context as an emergent relation foregrounds how people have to engage with the social and material resources in order to incorporate them as part of their everyday activities. This view of context highlights how the designers and developers of technology cannot predetermine how technology becomes integrated in this emergent context. It is a matter of people engaging with the technology and making it a part of their ongoing activity *through* their actions.

Hence, integrating technology with everyday life means people have to act either, through the technology, or with the technology, incorporating them as part of their ongoing activity. Dourish terms this act of incorporation as *appropriation of technology*. Appropriation is a relationship with technology and everyday activities that is enacted over time. Through appropriation, we relate technology to the particular context for our ongoing activity.

4.2.3 Designing for embodied interaction

Dourish mentions that this understanding of embodied interaction is not only an analytical framework to analyze how people interact with the existing technologies, but also a generative framework that helps in designing novel interactive technologies.

He emphasizes that focusing on how we appropriate technology is the key to designing for embodied interaction, i.e., a focus on designing for integration of technology with everyday life. He calls for the designers to design technology to open up opportunities for

the people to engage with technology in varied ways and incorporate them as part of their ongoing activities and their settings. *In other words, the designer's stance must be to design technology that open up opportunities for people to appropriate it.*

4.3 THE EMERGENCE OF A CONTEXT THROUGH 'EVERYDAY COPING'

However, taking the embodied interaction perspective in a particular design situation is still a challenge that the designers face [Fernaes et al, 2008; Hornecker & Buur, 2006]. The challenge is to formalize or frame a context that is constantly emerging [Chalmers, 2004].

Dourish abstains from any formalization of the relation between embodied actions and their settings. He argues that as embodied interaction is inherently situated and continuously emerging, any prescriptive and formal guideline does not guarantee the success of a design. Hence, though he mentions designing for appropriation is the way to go forward, he does not offer concrete handles for the designers to design for appropriation. Meanwhile, Robertson [1997] argues that getting a handle on what constitutes the social and physical settings for particular embodied actions (the actions of compliance in the case of this thesis) is crucial for the designers of digital technology to support these actions. However, by formalizing the embodied actions and their relations in the form of a taxonomy, Robertson misses out on the emergent aspects.

Hence, there seems to be a tension between the need to formalize for design and the need to be open for considering the situated and emergent aspects of human interaction. I read this as a methodological tension arising with a move from understanding 'how the world is' to a position from where a designer can propose 'how the world could be'.

In order to gain an in-depth knowledge about how a particular context emerges, I turn towards Dreyfus's nuanced detailing about everyday human coping. Dreyfus, interpreting Heidegger, provides a detailed description of the phenomenon that underlies the emergence of a context: a phenomenon of purposefully acting by engaging with the particularities of a setting, through which a particular context that gives meaning to those actions emerges.

At the core of Dreyfus's interpretation of Heidegger is 'Being-in-the-world': the understanding that 'Dasein' (or human being) is involved in the already present world around it, and it is by this involvement that 'Dasein' uncovers the meaning of its existence and what the world means to it. He describes this involvement with the world as 'everyday coping'; an involvement which is non-perceptual-cognitive in its stance, but

is oriented towards a “*concern which manipulates things and puts them to use.*” [Dreyfus, 1991; p. 62,].

Below, I briefly summarize this account of how embodied action ‘makes emerge’ a particular context.

4.3.1.1 Modes of being of equipment: availableness, unavailableness and occurentness

During everyday coping, a person does not encounter just entities, but uses these entities at hand to get something done; the entities become the ‘equipment’. An equipment is always used for something, and it refers to other equipment within an ‘equipment whole’. Dreyfus describes four ways of being of entities, which we encounter in our involvement with the world.

- When a person is involved in everyday coping through an equipment, the equipment is always ‘available’ as a resource, Dreyfus’s term for ready-to-hand.
- When the equipment breaks down, and the person fixes it, or replaces it, and move on doing what he/she was doing, the equipment momentarily becomes ‘unavailable’.
- When the person de-contextualizes an equipment, he/she may become aware of its context free properties, which then can be re-contextualized in scientific theories. Here the equipment is encountered in a state of ‘occurentness’, Dreyfus’s term for ‘present-at-hand’.
- When the person does not re-contextualize, but just stare at the equipment, this gives rise to the traditional distinctness of a self-contained subject looking at an object, which displays characteristics of ‘pure occurentness’.

From these understandings, one can realize how human beings interact with the equipment by using them in different states: available, unavailable, occurent, and back.

Additionally, a person uses an equipment always in reference to other equipment, creating an ‘equipmental whole’. For instance, using a hammer makes sense only by referring to the nails, to the wall, to the painting that is to be hung, etc. The equipmental whole makes itself available for this person due to the ‘referential whole’. The referential whole captures the inter-relation between the various equipment within the particular equipmental whole. While using an equipment makes sense in reference to other equipment, a person’s use of equipment makes sense because the person’s activity has a point, a directedness, or a purpose. This purpose is not a mental representation of a goal to be achieved, but rather an interconnected directedness towards which the use of equipment points to. Dreyfus terms this human purposiveness as ‘involvement whole’. In

terms of hierarchy the involvement whole realizes the other two wholes, thereby making up the world we live in. For instance, a workshop with its inter-related equipment becomes a part of a person's setting only when he/she picks up the hammer and uses it *in order to* hang the painting.

An important thing to note here is that, an equipment in its referential whole has a 'public character'. It displays generality and obeys norms. Equipment becomes equipment for anybody who uses it, and there is a 'normal' way to use it. The normal way is based on the background of that particular life-world the Dasein is involved in, consisting of the particular social practices and norms other Daseins in the world understand.

4.3.1.2 Horizon of significance and the field of possibilities

The structure of the world that a person is involved in, gives him/her some hints for making sense of the world. This structure is termed as 'significance' – the background upon which we make sense and our activities have a purpose. This background provides us the basis on which we 'understand'. There are two types of understanding: basic, and primordial. Basic understanding is more close to how an animal perceives the opportunities for meaningful action in its current world and relies on the orientation and posture of the physical body. Primordial understanding involves this basic stance along with an implicit 'know-how' of pressing into possibilities that are within the horizon. We are implicitly aware of the equipmental whole, its inter-relationship with our own purposive involvement whole. Both these strands of understanding are embodied way of coping, rather than 'knowledge' involving mental processes and cognition.

This background understanding essentially consists of the equipment whole along with its referential whole, and a set of common social 'norms' that the particular Dasein shares with other people in that particular world or setting. This background provides us a 'field of possibilities' for meaningful action within the world we are involved in, and this is held together in a 'horizon of significance'. Beyond this horizon our skills, equipment, and norms do not make sense to us. Figure 4.1 illustrates a snapshot of the spatial-temporal phenomenon of how a human being is involved with the setting, and how a particular context within which this involvement makes sense emerges through this involvement.

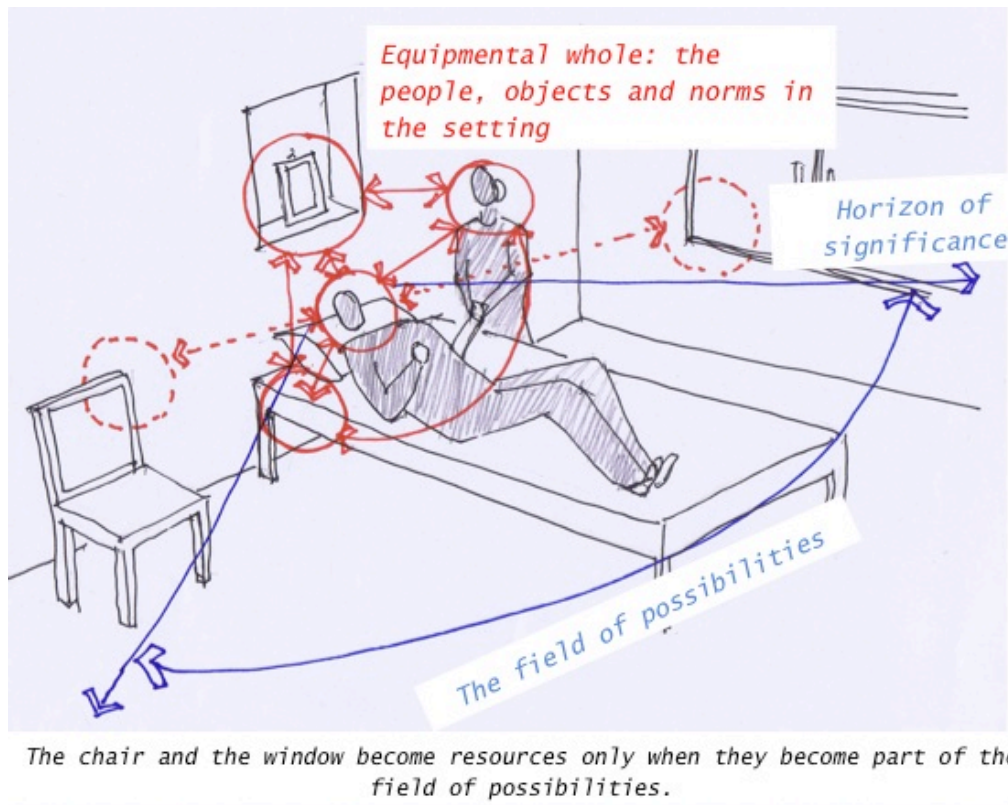


Figure 4.1: A Snapshot of Everyday Coping of a Human Being Involved with the World. The bed, the photo-frame, and the spouse become resources, because they are within the horizon where engaging with them as resources to comply with the therapy makes sense.

In summary, Dreyfus calls the attention of researchers and philosophers to ‘everyday coping’ as the primordial way of being and interacting with the world. To understand how a person makes sense of his/her actions within particular setting, one needs to take into account the involvement whole as the particular setting the person is involved with. This involvement comes about as and when the person engages with the equipment within the equipemental whole. The equipemental whole refers to interconnected set of equipment that becomes available for a human being within a situation. The equipment here is a generic term referring to the particularities of a setting: the things, people and social norms that the person engages within that setting. The involvement whole refers to overall directedness or purpose of the human being involved with the setting: complying with the rehabilitation treatment. The referential whole relates the equipemental whole to a person’s purpose by providing the background for understanding the possibilities for meaningful action within the setting.

The person presses into the possibilities that are offered within a horizon of significance based on, firstly, the basic understanding of the relation of his/her body to the current physical space and secondly, the primordial understanding of how the referential whole connects equipemental whole with the person’s purposive involvement whole. As the

person presses into the possibilities within this horizon, he/she engages with equipment as being *available as a resource* for performing meaningful action, moving from encountering them as mere occurrent objects to observe. In other words, the equipment or the particularities of a setting *becomes resources through the person's engagement with it*.

4.3.2 Ecology-of-resources

To frame in design how a context emerges, I propose that the field of possibilities, held together by the horizon of significance, be 'framed' as an *ecology-of-resources* (see Figure 4.2). My aim to frame the field of possibilities as ecology-of-resources is to capture, in one phrase, a snapshot of the underlying spatial-temporal phenomenon of how a person engages with the particularities of a setting in order to perform purposeful actions, and through this engagement make emerge a particular context where performing these actions make sense.

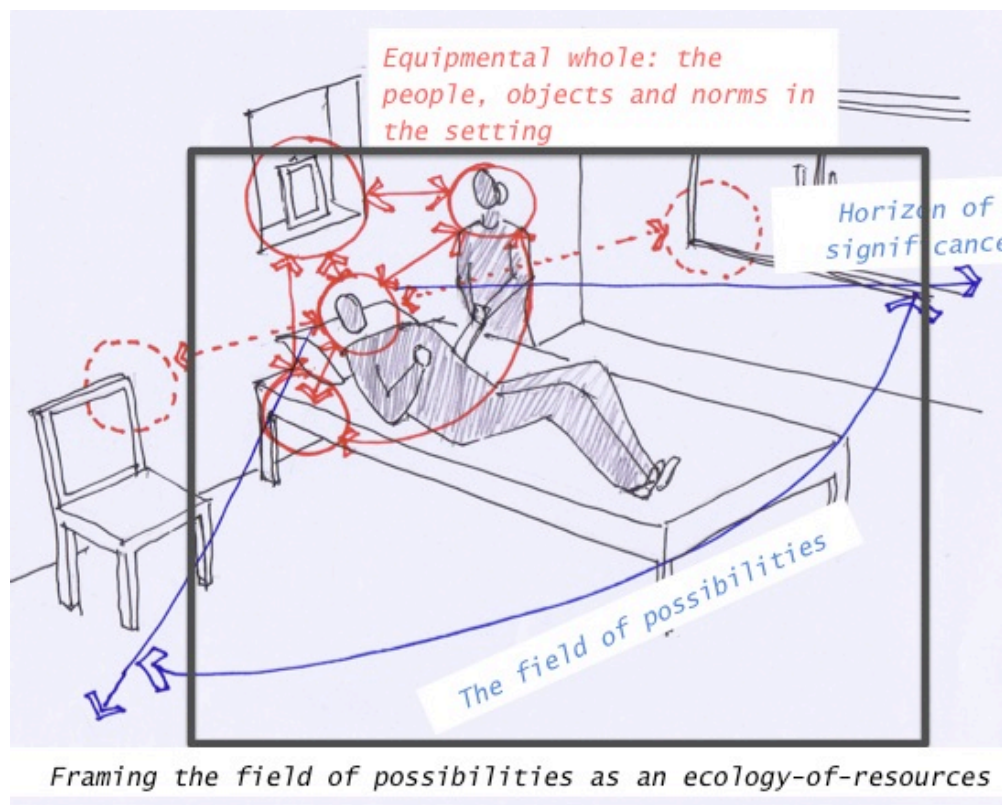


Figure 4.2: Ecology-of-resources

I define an ecology-of-resources as:

A frame to see the phenomenon through which a person engages with the particularities of a setting, turning them as available resources so as to perform purposeful actions; in other words, a frame to see the phenomenon of an emergence of a particular context.

By the term *ecology* I point to the relation between the three wholes—the involvement whole, referential whole, and the equipmental whole—within the region of the horizon of significance, that provides the background within which a person’s actions make sense. That is, by ecology, I point at how the things, people, and social norms and relations of a setting are related to each other, together making up the particularities of the setting, engaging with which people act. By the term *resources* I point to how a person engages with the particularities of a setting, moving them from a state of occurrentness to the state of available resources for the purpose of embodied meaning making.

At this juncture of the thesis, I take the ecology-of-resources as a framing device through which I can frame and embrace the way rehabilitees engage with the particularities of a setting in order to comply with their therapy.

4.4 SUMMARY

In this chapter, I presented the perspective of embodied interaction. The phenomenological and ethnomethodological perspectives position embodiment as being situated and participating in the world, which is made up of people, things, and cultural and social norms, i.e., the setting. Embodied interaction is the way we engage with the setting in an ongoing activity, turning the social and material particularities from being mere objects to available resources for meaning making and communicating. Looking at a context from this perspective means considering the context as being emergent through this engagement with the particularities of a setting.

Understanding a context, however, as being constantly emerging makes it challenging to get a grip on it in order to design technology that can become part of such a context. Dourish proposes broad principles that inform a designer’s stance to design for appropriation, but these principles do not offer more concrete handles for the designers to design for appropriation. I saw this challenge as a methodological problem and proposed ecology-of-resources as a framing device to frame the emergent context. I based this proposal on a more nuanced understanding about how a context emerges as presented by Dreyfus.

The stage is now set for taking this understanding—the embodied interaction perspective—to see how the rehabilitees comply with the prescribed treatment.

5 EMBODIED-SELF-MONITORING: the theoretical concept

In this chapter, I take the embodied interaction perspective to propose the theoretical concept of embodied-self-monitoring to embrace how the rehabilitees comply with the physical rehabilitation treatment as part of their everyday life.

In the following sections, I take the embodied interaction perspective to foreground how a particular *context for compliance* emerges through the rehabilitee's engagement with the particularities of a setting in order to comply with the prescribed treatment. I then discuss how this foregrounding highlights how *self-monitoring is an embodied action* that is performed by the rehabilitees in order to comply with a treatment. With this, I present the theoretical concept of *embodied-self-monitoring*.

5.1 A CONTEXT FOR COMPLIANCE

Following the phenomenological understanding of context as presented in the previous chapter, the particularities of a setting that a rehabilitee engages with *become* a very distinct context where complying with a physical rehabilitation therapy makes sense for the rehabilitee. A particular context for compliance comes into being through the enactment of the inter-relation between actions of compliance and the setting (see Figure 5.1).

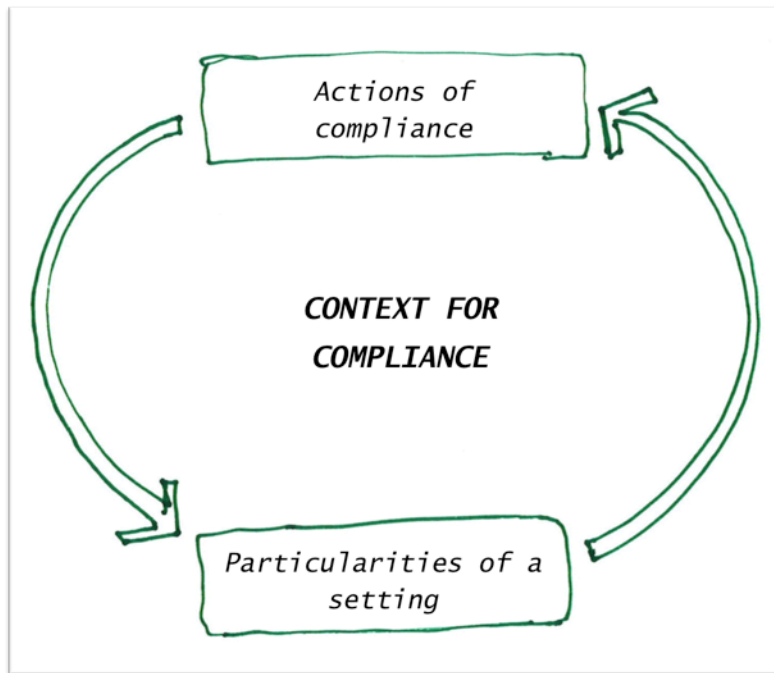


Figure 5.1: Emergent context for compliance: Inter-relation between actions of complying and the particularities of a setting

Hence, a *context for compliance* can be defined as:

An emerging relation between the particular actions that the rehabilitees perform in order to comply with their treatment and the particular setting within which these actions are performed.

As discussed in Chapter 3, complying with a rehabilitation treatment involves different actions that are performed over time and across different settings, be it the clinic or home. The embodied interaction perspective highlights how the clinic or the home are not mere containers for these actions, they constantly shape the rehabilitation process by offering a range of *socio-material particularities* that the rehabilitees can engage with and respond to. The home and the clinic are the ‘settings’ that contain different objects, people, social relations, and the particularities. The rehabilitees engage with the particularities of each setting, taking advantage that they offer to adopt and appropriate

the prescribed treatment so that complying with the treatment makes sense. Even as the particularities shape how a rehabilitee performs and makes sense of his/her rehabilitation treatment, the particularities are in turn, shaped by the rehabilitees' actions. To take advantage of the particularities of a setting, the rehabilitees have to engage with them, reconfiguring, and repurposing them as resources for action. It is through this interplay between the actions of engagement with particularities and the setting that a particular context for compliance emerges.

5.2 EMBODIED-SELF-MONITORING: Theoretical Concept

The embodied interaction perspective foregrounds how the particular actions that the rehabilitees perform in order to comply with the treatment—such as, measuring, recording, observing, reflecting, sharing, etc.—are shaped by the particularities of a setting within which these actions are performed, and in turn these actions shape the setting. In this sense, I see the rehabilitee's engagement with the prescribed exercise instructions and tools as *embodied actions* through which he/she takes advantage of the opportunities for adoption and appropriation of the prescribed treatment in context. As a consequence of taking such a perspective, I see self-monitoring as *ongoing, embodied action* that the rehabilitees perform through engaging with the particularities of a setting in order to comply with their treatment.

Looking back through the embodied interaction perspective at the concept definition of self-monitoring as put forward by Wilde and Garvin, I see self-monitoring as being embodied in the world. In order to sensitize and orient the design towards how self-monitoring is embodied in the particular context for compliance, I propose the theoretical concept of *embodied-self-monitoring*. I define embodied-self-monitoring as:

Measuring, recording, observing, and performing other such self-monitoring actions through engaging with the particularities of a setting for complying with a prescribed treatment.

I claim that through embodied-self-monitoring a designer can foreground the interrelation between performing the actions of self-monitoring and the particularities of a setting. I claim that through the theoretical concept, a designer can foreground how a particular setting becomes a particular context for compliance.

To explain, I refer to an example from the design explorations presented later in the thesis. Prabhakar, one of the rehabilitees who was a part of the design explorations, engages with his spouse Laxmi, as a resource to monitor how he performs his back-strengthening exercises. His physiotherapist at the hospital taught him these exercises

after he suffered a stroke. At home he does this exercise always on the bed in the living room, twice a day. As his movements are restricted to his home, visiting the hospital to take guidance from the physiotherapist is extremely difficult for him. His wife has to book a taxi, take the help of taxi driver to lift Prabhakar onto the taxi, wait in a long queue at the hospital, and repeat the process to come back home. Hence the couple visits the hospital once in two months, and performs the exercises at home as much as they can.

This example shows how Prabhakar's performance of the exercises is shaped by the socio-material particularities at his home. These particularities are constituted by his physiotherapist's instructions about the exercises, or what he and his wife Laxmi remember of these instructions, the restriction of his movements, the bed in the living room, his wife Laxmi, the particular form of exercise, all shaping how Prabhakar performs his exercises.

At the same time, as Prabhakar engages with these particularities, he actively modifies them. He engages with the bed as a resource to support his back, Laxmi as a resource to monitor how he performs the exercises and for encouragement. This engagement means that the bed has to be cleaned and made up regularly by Laxmi as it also acts as a couch in the living room for any visitors. Furthermore, Laxmi has to dedicate her time to monitor and guide Prabhakar twice a day.

By looking at Prabhakar's performance of exercises as being embodied, I foreground how it is shaped by the particularities of the setting, and in turn, how his actions shape these particularities. This foregrounding opens the space for *embracing* this inter-relation in order to design a pervasive self-monitoring technology that Prabhakar can engage with and make it as a part of this inter-relationship.

5.3 SUMMARY

In this chapter I took the embodied interaction perspective on how a rehabilitee complies with the prescribed therapy to highlight the emergence of a particular context for compliance. This further foregrounded how self-monitoring is an embodied action performed by the rehabilitees through engaging with the particularities offered by a setting in order to comply with their therapy. With this foregrounding I proposed the theoretical concept of embodied-self-monitoring. *I proposed that the theoretical concept of embodied-self-monitoring offers an a priori orientation for a designer to embrace the ways in which the rehabilitees comply with their treatment in the design of pervasive self-monitoring technology.*

6 DESIGNING FOR EMBODIED- SELF-MONITORING

Following the introduction of the theoretical concept of embodied-self-monitoring, in this chapter, I discuss how *designing for embodied-self-monitoring* means *embracing* the way a particular context for compliance emerges. Following this, I propose *ecology-of-resources* as a framing device for the designers to frame a particular context for compliance in order to design for embodied-self-monitoring.

The question that presents itself now is how to move towards the design of digital technology that can embrace this emergence of a particular context for compliance? When presented with a similar question about embodied interaction, Dourish focuses on how people appropriate and incorporate technological tools as part of their everyday activities, and urges the designers to design technology to support such ongoing actions of appropriation.

In line with the embodied interaction perspective, I propose that designing for embodied-self-monitoring be considered as:

Designing pervasive self-monitoring technology for offering opportunities for the rehabilitees to engage with the technology, and through this engagement, make the technology become a part of how they comply with their therapy. (See Figure 6.1)

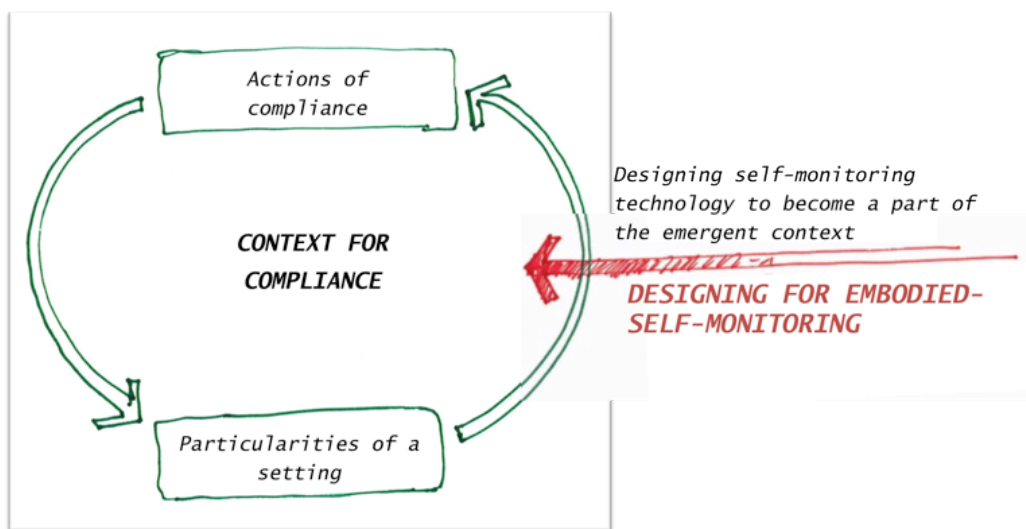


Figure 6.1: Designing for embodied-self-monitoring

This definition highlights how designing for embodied-self-monitoring means a foregrounding of the embodied nature of self-monitoring in the design of digital technology for self-monitoring. My focus here is on facilitating rehabilitee engagement with the designed technology as one of the resources that works in concert with the already engaged particularities of the setting in order to shape the rehabilitee's ways of compliance.

6.1 EMBRACING THE EMERGENCE OF A CONTEXT: a design stance

In this sense, designing for embodied-self-monitoring indicates taking a design stance of *embracing* how a particular context for compliance emerges.

By embracing I mean not just acknowledging that the context for compliance is emergent, but to *take advantage of* this emergence in the design of pervasive self-monitoring technology. I position that embracing—acknowledging and taking advantage of—the way a rehabilitee engages with the particularities of a setting as resources in order to comply with their therapy is a fruitful *design stance* to take in order to design pervasive self-monitoring technology. During the course of the thesis, I will highlight the fruitfulness of taking this design stance towards designing for embodied-self-monitoring.

6.1.1 Ecology-of-resources: A device for framing the context for compliance

In order to embrace how a context emerges the designer has to *frame* the context. By framing I mean explicitly looking for and fixing the rehabilitee's engagement with the particularities of a setting.

As mentioned in Chapter 4, while embodied interaction gives a fruitful handle to understand the emergent nature of context for compliance, it stops short of giving handles to designers for framing this context in order to design technology that can be incorporated as a part of the emergent context. To figure out an answer to the framing question, I drew draw upon Dreyfus and introduced a framing device: *ecology-of-resources*.

As the context for compliance is constantly emerging, framing it as ecology-of-resources means not merely looking at it from a distance, but 'seeing'. Following Schön [1983], I position seeing as an active engagement by the designer with the particular context and forming a stance of embracing the enacted inter-relation between ongoing actions and their setting in order to design digital technology. As mentioned above, forming such a stance lies at the core of designing for embodied-self-monitoring.

The framing can be illustrated by taking the example of Prabhakar, introduced before in Chapter 5. Looking at Prabhakar's exercise activity through the frame of ecology-of-resources (see Figure 6.2), the inter-relatedness between the particular things, norms, and people he engages with, within the setting of his living room, is foregrounded. The things (such as, the bed in the living room, TV, display case, etc.), the norms (such as exercise instructions prescribed by the therapist, the physical restrictions imposed by the stroke on Prabhakar, etc.), and people (Laxmi mainly, but also visitors, as the exercising happens

in the living room) constitute the ‘equipmental whole’ for Prabhakar. This equipmental whole comes to being (as occurrent or present-at-hand) only when Prabhakar enters his ‘involvement whole’, that is, when he takes on the purpose of exercising so that he can strengthen his body effected by the stroke.

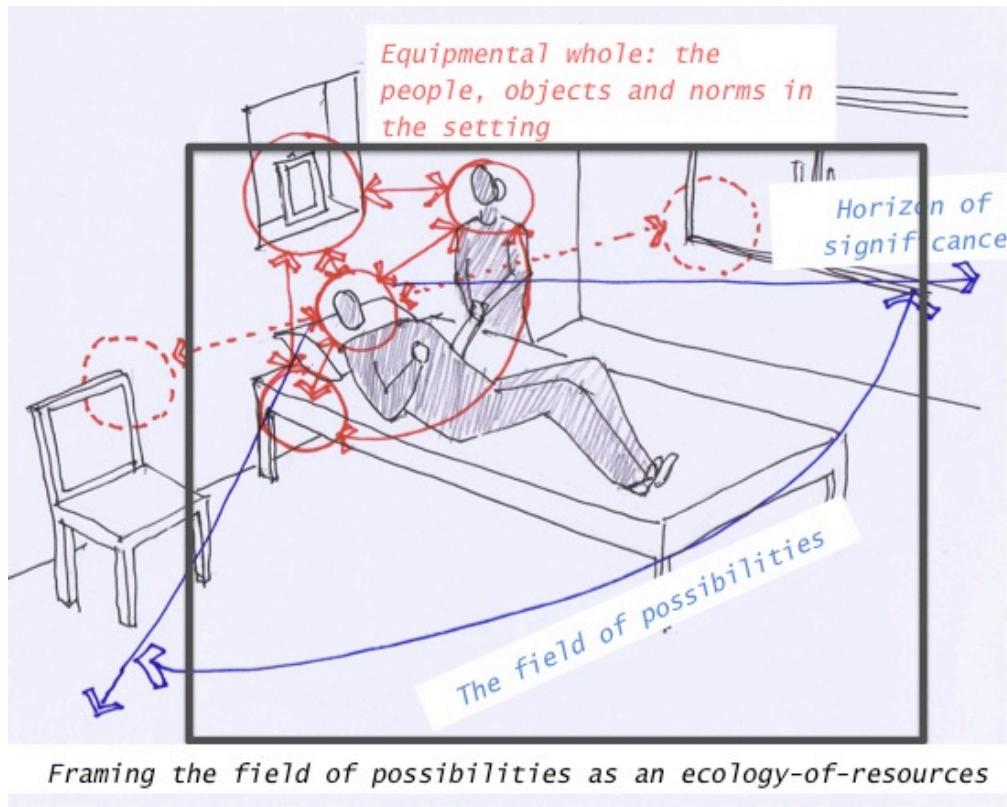


Figure 6.2: Framing Prabhakar’s context for compliance as an ecology-of-resource

Due to his experience of engaging with this equipmental whole for two years, he engages with the bed, Laxmi and their collective memory of exercise instructions, moving all of them as available resources (ready-to-hand) within the equipmental whole, leaving the rest as mere occurrent objects. This experience of exercising for two years at the same spot is what constitutes his background or primordial understanding of how he can engage with these particular things, norms, and people as available resources in order to achieve his purpose. It marks off a horizon of significance that makes these things and people as significant for Prabhakar to engage with and move them from occurrent objects to available resources. His basic and primordial understanding (embodied experiences of exercising for two years) makes him engage with the bed as a resource to support him while he performs the exercise, and as a resource to subtly remind him of and ‘mark’ his exercise routine everyday. He engages with Laxmi as both a motivating and monitoring resource, and with their memory of the exercise instructions as a resource to perform the exercise in the ‘right’ manner.

I propose that such a framing of Prabhakar's context for compliance as an ecology-of-resource opens up a designer to get a grip on the context to embrace how Prabhakar already engages with the particularities of the living room in order to make sense of complying with his prescribed treatment.

I imagine how by taking this design stance of embracing such framed ecology-of-resources, I can move towards exploring what could be the possible opportunities that a digital technology designed to support embodied-self-monitoring opens up for Prabhakar to shape his ways of complying with his treatment. In other words, I propose that by framing and embracing the emergent context for compliance, a designer can move from understanding 'what is' to 'what could be'.

6.2 SUMMARY

In this chapter, I moved from understanding how a context for compliance emerges through the embodied actions of a rehabilitee to forming a design stance of embracing the emergent context. I proposed that ecology-of-resources offers a fruitful framing device to frame the context for compliance to embrace the context in the design for embodied-self-monitoring.

The thesis now has to explicate the prospects offered by the theoretical concept of embodied-self-monitoring for the researchers and the designers while exploring the design of digital technology to support the way the rehabilitees comply with their therapy. Because of the concept's a priori orientation towards the particularities of a rehabilitee's everyday situation, exploring these prospects by engaging in a process of designing digital technology in these particular situations seems to be a promising approach.

7 METHODOLOGY

In this chapter, I present the methodology of the thesis: concept-driven interaction design research. Exploring the prospects offered by embodied-self-monitoring calls for such a concept-driven, and yet in-situ approach.

In the following sections, I describe how following the methodology means theorizing by exploring future scenarios about interaction with digital technology, and how this theorizing is driven by the activity of sketching. I then present how making explicit the process of theorizing through sketching demonstrates the prospects of a theoretical concept, leading to a ‘compositional whole’. Through this compositional whole, the exploratory research process contributes to the larger discourse on theorizing about human interaction with computation. However, as the design explorations of this thesis are situated in the real situations of rehabilitation, the compositional whole also offers pointers towards specific design solutions addressing the individual design situations.

7.1 RESEARCH-THROUGH-DESIGN IN HCI AND INTERACTION DESIGN

Design is increasingly being appreciated as an independent way of inquiry and research. As many authors have argued [Cross, 2007; Nelson & Stolterman, 2003], design is a unique way of inquiry, with its own rigor and relevance that are different from that of other scientific disciplines. These accounts rely on Schön's [1983] notion of design as being an explorative process driven by a designer's reflective conversation with the materials of the situation.

In line with this growing appreciation of design as an inquiry, the field of HCI is increasingly focusing on the role of design in research, and what it means to do a research-through-design [Wolf et al, 2006; Zimmerman et al, 2007, 2010; Fallman, 2008; Stolterman & Wiberg, 2010]. Zimmerman et al [2007], in particular, highlight how a 'research-through-design' process is a fruitful research approach to explore and articulate a design-space of possible solutions that address a real-world 'wicked' problem. The core aspect of this methodology is to explore a range of possible alternative solutions by engaging with a real-world problem. Defining the problem-space and the solution-space go hand in hand in such a designerly inquiry. They position 'research-through-design' as a complimentary, yet distinct from the other HCI methodologies with a leaning towards natural science.

As has been discussed in Chapter 3, considering the ways the rehabilitees comply with the therapy by engaging with a range of particularities is a complex issue warranting more exploratory research. Supporting rehabilitee compliance can be considered as one such wicked problem. The designers engaged in this quest have to figure out the specific solutions that support the rehabilitees to comply with their treatment, and at the same time understand the nuances of how rehabilitees comply with a physical rehabilitation program in everyday life [as discussed by Balaam et al, 2011]. Hence, taking a research-through-design approach in exploring the digital technological solutions seems a promising avenue.

The thesis, however, explores the prospects offered by the theoretical concept of embodied-self-monitoring for a design of digital technology supporting the rehabilitees to comply with the treatment. The main focus here is to contribute to the theorizing about the possible ways through which a rehabilitee may engage and interact with digital self-monitoring technology in order to comply with their prescribed treatment.

To realize this aim, I look towards concept-driven interaction design research [Stolterman & Wiberg 2010], a research-through-design approach that is *explicitly* and *a*

priori aimed towards theorizing about human interaction with computation. In the following section, I give a brief overview of this approach and its key characteristics.

7.2 THEORIZING THROUGH DESIGN

Stolterman and Wiberg position the concept-driven research-through-design as a complimentary, yet distinct from the approaches that are driven by the aim of designing and developing specific solutions addressing specific problems: a situation-driven research-through-design approach (see Figure 7.1). While the latter approach is oriented towards improving the ‘use’ situation, concept-driven approach is oriented towards improving the theoretical understanding about human interaction with digital technology.

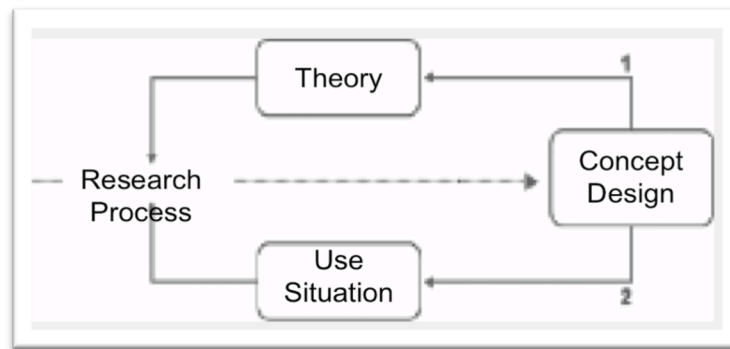


Figure 7.1: Two complementary cycles of interaction design research. Cycle 1 is concept-driven research; Cycle 2 is situation-driven research [Stolterman and Wiberg, 2010]

Stolterman and Wiberg state theory as an ordered and abstracted knowledge about the fundamental aspects of a particular discipline, in the instance of HCI, human interaction with computation. They define ‘theory of interaction’ as

“Contains knowledge that in an ordered and structured way tells us something about generic qualities and characteristics of interaction in a way that explains a range of instances of interactions” [page 100, 2010].

They draw from Weick’s [1989, 1999] conception of theory building as disciplined imagination, where the theorist conducts ‘imaginary’ experiments not necessarily to verify the theory, but to expand the range of situations where the theoretical understanding holds good.

As the discipline of interaction design is emerging with new ways of interaction and pushing the boundaries of knowledge, the focus is on the *process of theorizing* rather than on a more traditional focus of verifying the theory in controlled experimental conditions. Stolterman and Wiberg [2010] propose that formulating a theoretical concept and

creating an artifact that manifests the theoretical concept in particular design situation is an act of theorizing about interaction. In the following sections, I describe the key characteristics of a concept-driven interaction design research: the formulation of theoretical concept, the designing of artifact exploring the futuristic scenarios about possible interaction that the theoretical concept opens up, and the resulting ‘compositional whole’.

7.2.1 Theoretical concept

A theoretical concept is a construction that is informed from both the theory about interaction and the theoretical understanding about the design situation. This construction of the theoretical concept relates to the traditional way of researching, where literature analysis plays the major role in understanding the relevant theories. Formulating the theoretical concept is a starting step towards developing a core theoretical construct about a particular aspect of human interaction with digital technology. Through years of explorations from the researchers of the domain, this core construct can become part of the foundational knowledge in the field of HCI and interaction design research.

The theoretical concept of embodied-self-monitoring, as detailed in Chapter 5, draws from the theory about embodied interaction and from the way self-monitoring is conceptualized in the medical and nursing domains.

7.2.2 Exploring the possible scenarios through sketching

Formulating a well-informed theoretical concept is just one step towards theorizing. The creative act of design comes into play by crafting artifacts that manifest the concept in a form that is experiential and interactive.

In this thesis, I make available the aspects of the theoretical concept of embodied-self-monitoring for experience and exploration in different design situations through a process of forming design visions in the form of design ideals and sketching early forms of the design visions making them available for experience in-situ.

7.2.2.1 *Formulating the design ideals to manage the theory-situation dialectic*

Following a concept-driven design approach means exploring new possible scenarios about how rehabilitees may interact with digital self-monitoring technology (that is, in Nelson and Stolterman’s [2003] terms, exploring ‘that-which-is-not-yet-existing’ and ‘that-which-is-desired-to-be). The central intent of the explorations presented in this thesis is not to solve the problems of a particular situation, but to explore the prospects that the embodied interaction perspective offers for the design of such solutions.

However, the explorations are informed by the existing understanding of both, the broader aspects of how rehabilitee engagement with rehabilitation is embodied, and the specific ways in which the individual rehabilitees comply with their treatment. The two blue arrows between ‘theory’ and ‘situation’ in Figure 7.2 indicate the dialectic relation that the explorations engage with. This engagement between the abstractness of a theory and the specificity of a design situation is facilitated through the formulation of a ‘design ideal’ [Bagalkot et al, 2011].

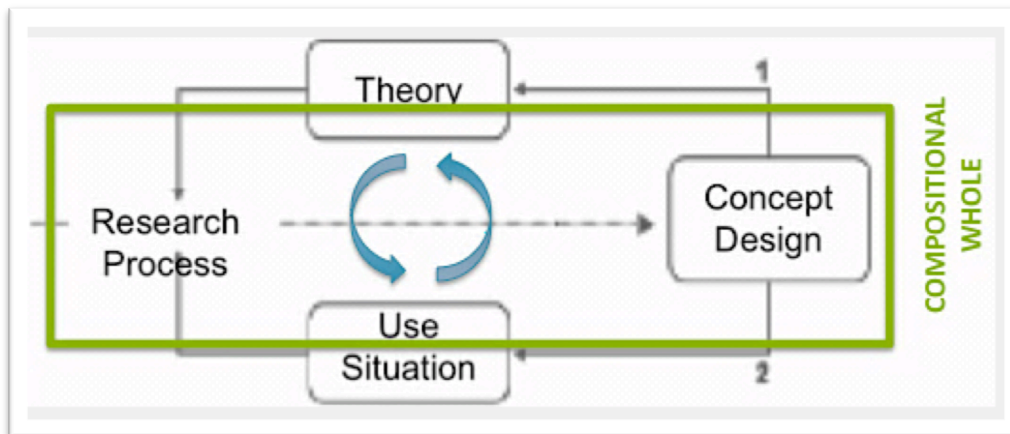


Figure 7.2: Theory-Situation Dialectic and the resulting compositional whole [Stolterman and Wiberg, 2010, my annotations]

It is here that the thesis differs from a concept-driven approach. While a concept-driven research-through-design can be performed within the setting of a lab, the thesis explores the prospects offered by embodied-self-monitoring in the actual settings where the rehabilitees perform the embodied actions of self-monitoring. Engaging with the actual settings of rehabilitation means the design process has to be responsible in some way towards addressing the demands of the particular design situation, while at the same time focus on the main aim of contributing to theorizing. In this sense, the thesis evolved through a constant conversation between the theoretical concept and the particular design situations. In order to negotiate this dialectic conversation, we⁷ formulate the design ideals through which we envisioned the possible scenarios of interacting and engaging with pervasive self-monitoring technology as one of the resources to shape the particular ways through which the rehabilitee at hand complies with the therapy.

In articulating the design ideal, we take from what Löwgren and Stolterman [2007] call as an interaction design practitioner’s ‘vision’: something that emerges when a designer encounters a design situation. The quality of the vision depends on the designer’s

⁷ From here on, the text shifts to ‘we’ to include other designers, researchers and the participating therapists and rehabilitees in the explorations.

experience and repertoire, and drives the design process towards articulating specific preferred states. Similarly, the design ideal is the initial vision that emerges when the interaction design researcher encounters a particular design situation. The quality of the ideal depends on the theoretical understanding of the researcher combined by reflection on previous experiences. While the design practitioner can be esoteric about how the vision emerges in a particular project, the researcher has a responsibility to make explicit, and put on display, the process of how the design ideal emerges from the interaction between theory and situation.

7.2.2.2 *Sketching*

These early visions of what is possible and desirable are manifested in the form of different artifacts, using various methods of sketching as explained in the following method section, in close collaboration with the rehabilitees, their family members, and the professional physiotherapists they engaged with. These artifacts are not ‘prototypes’ that satisfy and solve a well-specified problem of a specific situation. Rather, they may be considered as ‘sketches’ through which we co-evolved the understanding of the theoretical concept, and the design visions of what could be possible scenarios of interaction and point towards the desirable solutions for the specific design situation.

7.2.3 Compositional whole

The theoretical concept and the designed artifacts, together form a ‘compositional whole’. The compositional whole contributes to theorizing about interaction by pointing to the possible scenarios of new ways of interacting with digital technology. While the theoretical concept captures the core essence of the scenarios, the designed artifacts demonstrate the possible scenarios by making the aspects of the concepts available for experience. Nelson and Stolterman [2003] highlight this designed whole as a result of a series of design judgments made to shape the design process towards particular directions. The compositional whole highlights how the theoretical concept, the design situation, the designed artifact, the design judgments taken are all emergent qualities of a designed whole. In order to contribute to interaction design research I have to articulate these constituents in relation to the whole, rather than in isolation of each other.

As this thesis takes an in-situ concept-driven approach, the compositional whole includes the theoretical concept of embodied-self-monitoring that orients the designer towards embracing the particular emergent context through the framing device of ecology-of-resources. Such framing opens a space for formulating design visions in the form of design ideals. Sketching early versions of these visions leads to experiencing and enacting a range of the possible scenarios of new ways of interacting and engaging with pervasive

self-monitoring technology as one of the resource to shape the rehabiltee’s ways of compliance (see Figure 7.3).

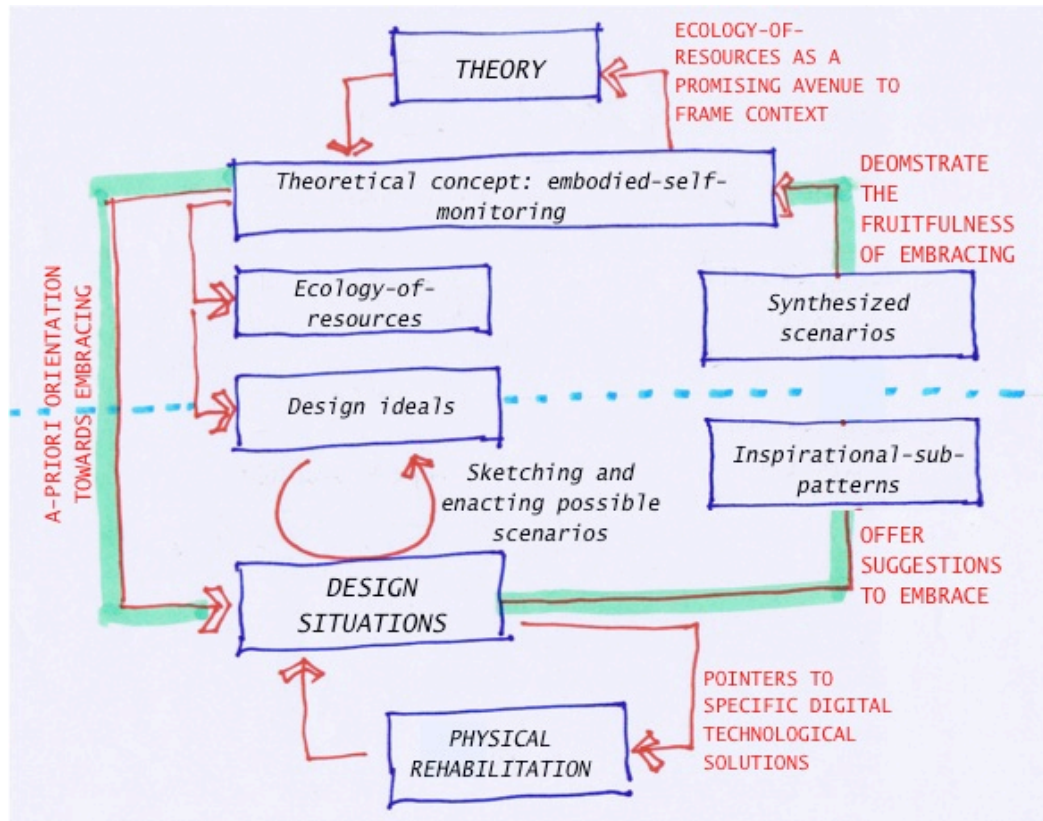


Figure 7.3: The compositional whole of the thesis

By articulating how this compositional whole emerged, I demonstrate the prospects offered by the theoretical concept of embodied-self-monitoring towards embracing the emergent context for compliance in the design of pervasive self-monitoring technology. In particular, the possible scenarios that were sketched, envisioned, experienced and enacted demonstrate these prospects. I will deliberate on how the compositional whole contributes in Chapter 13.

7.2.4 Transferring the design knowledge

7.2.4.1 Situatedness of design knowledge

As Nelson and Stolterman [2003] highlight, design knowledge—the knowledge generated from a designerly inquiry—is situated in the particular settings within which the design process unfolded. However, to be considered as research, works of design practice have to reflect on the work and communicate ‘re-usable’ results from this reflection [Cross, 2007]. Fallman and Stolterman [2010] describe how works presenting single design explorations struggle to generalize their reflections across other design situations. Any attempts to generalize the knowledge about design visions and ultimate

particulars that hold good for particular design situations across other design situations and settings is fraught with major problems. I align with an increasing number of design researchers [Fallman & Stolterman, 2010; Gaver & Martin, 2000; Löwgren, 2007] who argue for a *transferability* of designerly knowledge rather than generalizability across user populations.

Transferability focuses on how to package the learning from subjective experiences of the designers so as to make it available for a broader community of designers exploring the same space of possible scenarios about interacting with digital technology. The other designers have to translate these learning in their design situations rather than apply it as an established theory.

7.2.4.2 *Inspirational patterns as ‘transferable’ formats*

I look towards ‘inspirational patterns’ as fruitful formats for transferring design knowledge experienced in this thesis. Löwgren [2007] describes how knowledge within the interaction design discipline is created in an ongoing debate and discourse between the members of the research and design community engaged with specific application domains. He proposes ‘inspirational patterns’ (I-patterns) as a format to structure this discourse and orient it towards generating inspirational and transferable design knowledge. He envisions how designers can synthesize different design examples in the form of inspirational patterns, and publish them as their propositions to shape the ongoing discourse towards particular directions. He presents nine ‘inspirational patterns for embodied interaction’ that are synthesized from different early design examples that are aimed to support embodied interaction.

Löwgren positions the I-patterns as different from the already established design patterns prevalent in mainstream HCI. The inspirational patterns are not derived from ‘proven and successful’ designs, but are abstract synthesis of knowledge generated in designing different artifacts—even early speculative design sketches—that explore a common theoretical frame in different design situations.

In this thesis, I present my experiences of engaging in the design explorations as examples that indicate at sub-patterns of the three inspirational patterns. While the inspirational patterns are beyond the particularities of a domain of use, the sub-patterns presented here are specific to the domain of designing for physical rehabilitation. The three inspirational-sub-patterns presented in this thesis act as suggestions for other design practitioners based on my experience of engaging in the designing of digital technology for embodied-self-monitoring.

7.3 SUMMARY

In this chapter, I outlined the methodological approach taken in this thesis. Following a concept-driven approach, the thesis engages in two sets of explorations—MagicMirror set in Denmark and ReHandles in India—to explore the prospects offered by supporting the embodied actions of complying with rehabilitation therapy. These explorations emerge through an engagement with the actual setting of rehabilitation—the clinics and homes of rehabilitees—driven by the acts of sketching and experiencing early versions of design visions. This process led to an in-situ enactment by the rehabilitees of a range of scenarios about the possible ways through which they can engage with digital self-monitoring technology as a resource to shape the way they comply with rehabilitation therapy. In Chapter 11, I synthesize the scenarios to highlight how supporting embodied-self-monitoring offers seven of the possible opportunities for the rehabilitees to shape their ways of compliance. In Chapter 12, I synthesize my experiences of engaging in the design explorations in the form of three inspirational-sub-patterns.

8 SETTING UP THE EXPLORATIONS

In this chapter, I present the national policies about the role of IT in healthcare of Denmark and India, which constitute the broader settings of the MagicMirror and ReHandle explorations, respectively. These broader settings influenced how we gained access and recruited the rehabilitees and the therapists in the explorations, and the kind of enabling technology envisioned—an aspect that I will discuss in the discussion section. I then present the methods we used to engage the rehabilitees and the therapists in the co-exploration process, and kind of data we gathered for synthesis and reflection.

8.1 BROADER SETTINGS OF THE EXPLORATIONS

While the MagicMirror exploration is situated in the therapy for senior citizens after hip-replacement surgery in Copenhagen, ReHandle is situated in the physical rehabilitation of senior citizens in and around Mumbai, India. The broader social and political aspects of IT in health care (in particular, care of the elderly) in Denmark and India shaped the recruitment, the process and the envisioned technological outcomes of the two explorations.

8.1.1 MagicMirror

Denmark has a strong tradition of publicly financed healthcare. Similar to other Scandinavian countries, healthcare is administered regionally while elder care is run locally through the municipalities. However, this infrastructure is facing pressure due to various factors, including a growing population of older people. By the year 2050, nearly sixty per cent of its population is expected to be sixty-five or older [OECD 2009]. This image of a precarious future has helped spur a number of governmental initiatives with a strong emphasis on new healthcare technology, which falls under the ‘national welfare technology initiative’ [Digitaliseringsstyrelsen, 2012]. One of the focuses of this initiative is to explore technological solutions to support the care of senior citizens at home, leading to a range of tele-care and tele-rehabilitation initiatives.

This push from the state policies is manifested in different funding schemes for designing and developing welfare technologies. For example, EBST by the *Danish Enterprise and Construction Authority* funded the pilot project (MagicMirror version 2.0) that led to the design of ReDiary. The professional caregivers—doctors, physiotherapists, people from the nursing community, etc.—are encouraged to experiment with early forms of novel digital technology in pilot projects so that they can access the larger pot of money to develop the technology into products that can potentially reduce the cost on the Danish society.

8.1.1.1 Methods of access and recruitment

In the case of both the MagicMirror explorations, versions 1.0 and 2.0, it was the physiotherapists who came to our research group with a broad proposal of exploring novel digital technology that can help them encourage rehabilitee compliance. This initiative from the side of physiotherapists can be traced back partly to the push from the state, and partly to the therapists’ own prior engagement with novel technology—such as Nintendo Wii, etc.—for influencing rehabilitee compliance.

For the MagicMirror version 1.0 exploration, we had an initial discussion with the physiotherapists from the nearby Tårnby rehabilitation center, who then recruited Anita⁸ a 70-year-old rehabilitee who they thought was enthusiastic to explore the possibilities of novel digital technology. As this was a very early exploration, the expectations of the physiotherapists and Anita about what they will gain from the exploration were low. The physiotherapists were expecting a more concrete vision of how a novel technology would fit in their everyday routines. Anita was happy to volunteer her expertise of a senior citizen dealing with different ways of complying with the physical rehabilitation therapy.

The MagicMirror version 2.0 was actually set up by the physiotherapists from the Gentofte municipality of Copenhagen, who had a small fund for conducting a pilot project from the *Danish Enterprise and Construction Authority*. The physiotherapists came to our group at the university to explore the design of a new technology in the pilot project, on the basis of which they could apply for a larger fund to develop and perform clinical tests with the designed technology. It was again the physiotherapists who recruited Anna, a 74-year-old rehabilitee undergoing therapy after a hip-replacement surgery. Anna was asked to be a participant in the exploration, as the physiotherapists knew that she was an enthusiastic person, and had made good progress in her rehabilitation process due to this enthusiasm.

8.1.2 ReHandle

India has a national healthcare system that is administered locally by the regional governments. This is an income-dependent, subsidized, payment scheme, including waived costs for the poor and needy. However, it lacks proper funding, trained staff, and is of poor quality. These aspects are especially detrimental to elder care [Evans et al., 2011].

By 2050, over thirty per cent of India's population will be sixty-five or older [OECD, 2009]. Similar to the developed countries, this growth is creating serious welfare challenges. The existing healthcare infrastructure for seniors, or rather the lack of it, represents a changing attitude towards elder care in India [Jamuna, 2000; Ingle GK, 2008; Evans, et al., 2011]. This is the especially true for the younger generations who place increasing importance on careers and independence, and less on traditional family based senior care [Jamuna, 2000]. At the same time, the seniors are dealing with inaccessible healthcare system due to their physical and social immobility,

⁸ A fictional name. All the names of the rehabilitees and the therapists are fictional.

misconceptions and mistrust of western medicine, and the lack of a financial support structure [Kumar, 2003]. These aspects of the growing disintegration of traditional systems of family based care, and difficulty in accessing healthcare facilities due to physical immobility particularly defines the design situation of ReExercise.

Meanwhile, combined with the global technological push, there is also a growing interest at the policy level in ‘Patient 2.0’ types of healthcare. The ‘National Programme for the Health Care of the Elderly’ [NPHCE 2011] provides a more action-oriented framework for promoting the concept of ‘active and healthy aging’ among the senior population. Such policy level initiatives make way for concepts of ‘self-care’ and ‘community-based care’ to be considered as some of the potential solutions that can help make good healthcare accessible in India beyond the boundaries of a clinic [Bhuyan K, 2004]. While there has been an increasing number of technological initiatives supporting self-care in the ‘developed’ world as a way to deal with the rising cost of institutional healthcare [e.g.: Consolvo et al, 2009; Lee & Dey, 2010; 2011], the potentials of such initiatives are yet under-explored in the context of developing countries [Bhuyan K, 2004]. Hence the design of tools for self-monitoring of physical rehabilitation exercises is considered a crucial element of supporting the elderly rehabilitees access proper care.

The ReHandles explorations are situated as part of this broader scenario, where self-care of physical rehabilitation is often the only means of being able to carry on with the activities of daily living. Case in point is Gita (ReSwing and ReWall) who has to travel 4 hours from her village to access a private professional physiotherapy care in Pune, which is expensive too. Even in the urban settings—ReBreathe and ReExercise are with rehabilitees living in suburban Mumbai—compiling with the prescribed exercises clashes with aspects such as prevailing modes of exercises, and expectations of care from male adult children. In this sense, the role of professional physiotherapists was very minimal in the ReHandle explorations, as compared to Denmark.

8.1.2.1 Methods of access and recruitment

ReSwing and ReWall

During July 2009, I ‘tele-supervised’ a short design research project by Riyaj, a master student from Industrial Design Centre, IIT-Bombay. The brief for him was to contact one or two senior citizens in rural India who were undergoing physical rehabilitation therapy and figure out how they manage their exercises, and what are their attitudes towards digital technology. Riyaj came across Gita, a 74-year-old rehabilitee in his parents’ village, Lonand. As part of his project, he produced brief videos of how Gita exercises and one particular video caught our imagination. The video showed how Gita

performed her knee exercises by moving back and forth on the swing in the garden of her home.

On my visit to India, I visited Gita and her husband Kumar, along with Riyaj and asked them if they could be part of the exploration. I mentioned that the project is for academic purpose, and their identity will be anonymous through the standard form used for recruitment of participants. Both Gita and Kumar trusted us, and were very forthcoming in sharing their life stories and also enthusiastic throughout the exploration. Though we did not promise them to leave back the sketches we designed with them, in the end we left the ReSwing sketch (the trophy that congratulated the couple for successful rehabilitation of five years) as our regards to their collaboration.

ReExercise and ReBreath

I came across a newspaper article [Lobo, 2010] that mentioned how HelpAge, an NGO working for senior welfare, had started a physiotherapy center in Govandi, a suburb of Mumbai, in collaboration with the local senior citizens' club. Through the NGO, I got in touch with Madhav, a 69-year-old secretary of the club. We visited the physiotherapy center, and presented the aims of the project to Madhav and other senior citizens, through which we got the seniors on board for the project.

Madhav, along with sharing stories about his daily life as senior citizen, also introduced us to some of the seniors living in the neighborhood, who were getting home based care for various medical reasons. Only Prabhakar, apart from Madhav, was undergoing a physical rehabilitation therapy. So we invited Prabhakar and his wife Laxmi to be part of ReExercise exploration and Madhav to be part of the ReBreath exploration. While Prabhakar and Laxmi were not expecting much from the exploration, Madhav wanted us to give him a letter of appreciation for the senior citizen club that he can frame and keep as a memento. Madhav was also inclined towards a solution that can resolve the feeling of neglect from the sons felt by the senior citizens, which played a crucial role in shaping the ReExercise exploration.

8.1.3 Co-design methods

In all the explorations we started out by engaging with the therapists and the rehabilitees in identifying how the rehabilitees engage with the particularities of a setting in order to comply with their therapy. We observed and discussed through informal interviews focusing on how particular contexts for compliance emerge through this engagement. Based on these inputs, we formulated a *design ideal* per case helping us articulate design

visions of how the rehabilitees could engage with digital technology as one of the available resources when performing the actions of embodied-self-monitoring.

8.1.3.1 Sketching and experiencing the possibilities through enacting

We then sketched [Buxton, 2007] early versions of the visions captured by the design ideals in different forms, including software/hardware, video, photomontages, etc., that are available for people to experience the possibilities. We used Arduino and Flash, in combination with Wizard-of-Oz techniques, to make interactive sketches that are available for experience. The sketches were intended as early suggestions of possible solutions to help inspire further exploration and co-exploration with the rehabilitees, their spouses, and therapists.

We took these interactive sketches to the homes of the rehabilitees, asking them to engage in a series of in-situ enactments [Brandt & Grunnet, 2000] of how our sketches could become part of their ongoing rehabilitation processes. Also, the sketches were presented to and constantly critiqued by the professional therapists involved in the particular rehabilitation processes in question during the entire process of design exploration.

8.1.3.2 Gathering data for synthesis and reflection

During the explorations we were focused, firstly, on how an individual rehabilitee engaged with the particularities of his/her setting in order to make emerge a particular context where complying with the prescribed therapy made sense to him/her. We focused on what kind of objects, activities and social relations the individual rehabilitee engages with while exercising at home and at clinic (in the case of MagicMirror). Secondly, during the enactment with the sketches, our focus was on video recording how the rehabilitee engages with the sketches in combination with other objects, activities and social relations for performing the exercises. We also focused on recording what the rehabilitees imagined, and demonstrated through the enactment, about the possible scenarios of how supporting embodied-self-monitoring opens opportunities for them to engage with the digital technology as one of the resources to shape their ways of compliance.

I then synthesized these scenarios across the explorations to highlight how supporting embodied-self-monitoring offers seven kinds of opportunities for the rehabilitees to shape their ways of compliance. This synthesis is a reflexive walk through of our explorations where I explicitly put our design process on display. I did this by going over the videos of the design explorations, recording our observations we made during the co-design sessions, the design ideals we formulated together, and the feedback that the rehabilitees

and the therapists provided before, during, and after the process of sketching. I focused on one rehabilitee per design situation as an opportunity for exploring unique possibilities leading to a range of examples of the prospects offered by supporting embodied-self-monitoring. I sought uniqueness in each design situation to drive this exploration, leading to a range of possible scenarios. In this sense, the two series of the explorations presented in this thesis, in their totality, make up the ‘sample size’ for the synthesis into seven kinds of possible opportunities offered by supporting embodied-self-monitoring, as presented in Chapter 11.

8.2 SUMMARY

In this chapter, I presented the methods that I employed to recruit and engage with the rehabilitees, their spouses and physiotherapists in the MagicMirror and ReHandle explorations: In-situ sketching and enacting in close collaboration with the participants, and making this process and the design judgments taken throughout the process explicit. These methods are a natural outcome of taking a concept-driven approach to research-through-design.

9 MAGICMIRROR

In this chapter, I describe how the MagicMirror exploration unfolded. Due to the onus of explication of the emergence of the compositional whole, I present the design judgments throughout the exploration in minute detail. The main focus of this explication is to demonstrate how by taking a stance of embracing the embodied ways of compliance, informed by embodied-self-monitoring, we could envision, experience, and enact a range of possible scenarios about new ways of interacting with pervasive self-monitoring technology. I urge the reader to bear with this explication.

This exploration is set in the physical rehabilitation world of rehabilitees living in and around Copenhagen. First, I describe the early exploration, MagicMirror version 1.0, describing the starting inspirations of MagicMirror: prior work and an inspirational video. I then describe how we explored early speculations in collaboration with therapists from Tårnby rehabilitation center and Anita, a rehabilitee undergoing therapy for strengthening her back.

In the next section, I describe the MagicMirror version 2.0 exploration, describing the design situation, followed by the description of how we framed Anna's context for compliance as an ecology-of-resources. I follow this with the description of the design ideal of 'Magic-Mirror-Spiral' that we formulated. I depict the process of in-situ sketching through which we explored the possibilities offered by the sketch, moving the process towards the design of ReDiary: a sketch for a portable and personal device carrying self-monitored data.

9.1 MAGICMIRROR: version 1.0

9.1.1 Prior work

Recent works in Scandinavia have looked at physical rehabilitation as a process of constant negotiation between the rehabilitees, their therapists, and other caregivers. Björgvinsson and Hillgren [2004] and Hillgren and Linde, [2006] explored the recording of instructions by the therapists in the form of video as a language that the rehabilitees can understand. At the same time, two works [Sokoler et al, 2006; 2007], grounded in the phenomenological embodied interaction perspective, explored the design of digital technology to support rehabilitees to record their activities outside clinic to share them with their therapists. One work [Sokoler et al, 2007] explored how digital technology could support the rehabilitees to audio and video record their problems in order to share them with their therapists at the clinic, and support both the rehabilitees and the therapists to video record the therapists' prescriptions at the clinic. This work explicitly focused on exploring how to design such a digital technology for recording and collaborating to help the therapists and the rehabilitees manage the change in the social setting of a clinic brought forward by using such technology. Another focused on the design of means for the rehabilitees to attach digitally recorded information to their paper patient records, and carry them to the clinic for the periodic meeting with the therapists.

The two MagicMirror explorations further explore the ideas of video and other forms for recording the rehabilitee's performing exercises and supporting a movement of information about one's own rehabilitation across clinic and home. Carrying forward the phenomenological perspective underlying the above prior work, the MagicMirror explorations focus on the broader social and physical setting of the rehabilitee participants.

9.1.2 Inspirational instance

Louise Milner, a master student, did a video documentary project peeping into the homes of some rehabilitees undergoing physical rehabilitation. The documentaries were a series of small snippets of videos showing a glimpse of how the rehabilitees managed their exercises as part of everyday living. One particular video snippet showed an 84-year-old lady Martha exercising at home (see Figure 9.1), doing push-ups on a soft mattress!

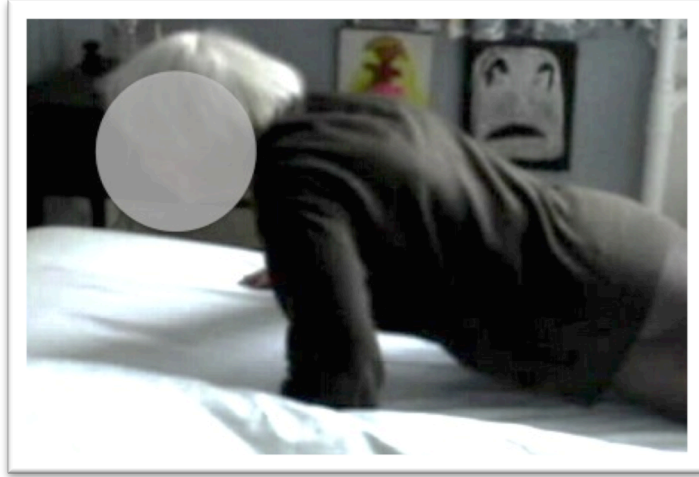


Figure 9.1: 84-year-old lady exercising at home

Looking at the documentary from the embodied interaction perspective made us to focus on the way Martha engaged with the bed and the soft mattress as a resource to perform her exercises, and how her therapist may not have any clue about this way of performing the prescribed therapy. We speculated on two possibilities:

- How would the meeting with her therapist change, if Martha had some means of recording and sharing her home exercises to her therapist?
- If and how would she change the way she exercises, if her therapist recorded the right way to exercise and gave Martha the recording to take home?

9.1.3 Early exploration⁹

Building on the previous explorations of using video recording in rehabilitation settings, we engaged in a small design exploration with two physiotherapists to find out how the above two speculations may work out. The physiotherapists from the Tårnby rehabilitation center suggested Anita, a 70-year-old lady, undergoing rehabilitation for bad back, as a rehabilitee participant for the exploration.

9.1.3.1 Scenario

We began with forming a basic scenario based on the above speculations. We wanted to explore the possibilities of body tracking and video recording the exercises the rehabilitee performs under the supervision of the therapist at the rehab clinic. The rehabilitee takes home this recorded video and uses it as a ‘reference’ exercise to monitor self while exercising at home, as it plays out on the TV. Simultaneously, the MagicMirror tracks

⁹ This exploration has been published in the form of Bagalkot, Nazzi & Sokoler [2010] and Bagalkot & Sokoler [2010].

the body movements, records, and overlays it on the instructional video, thus giving the rehabilitee a self-referential video for exercising. This recorded video is then taken back to the clinic where the rehabilitee and therapist discuss the progress in detail.

Consider this scenario (see Figure 9.2):

Ole is a 70-year-old man living alone. He has developed knee pain due to a cycling accident and is undergoing a rehab process at the rehab center. He meets his therapist and they record the video of Ole doing the exercises at the rehab center. This video is carried onto Ole's cell phone to his home, where he plays the video on his television, while exercising. The MagicMirror tracks his movements and overlays this feed with that of the recorded version, thus giving Ole a direct reference to exercise correctly. On his next visit to the rehab center, the therapist looks up the recorded home videos of Ole's exercises and both of them discuss his progress and next steps.

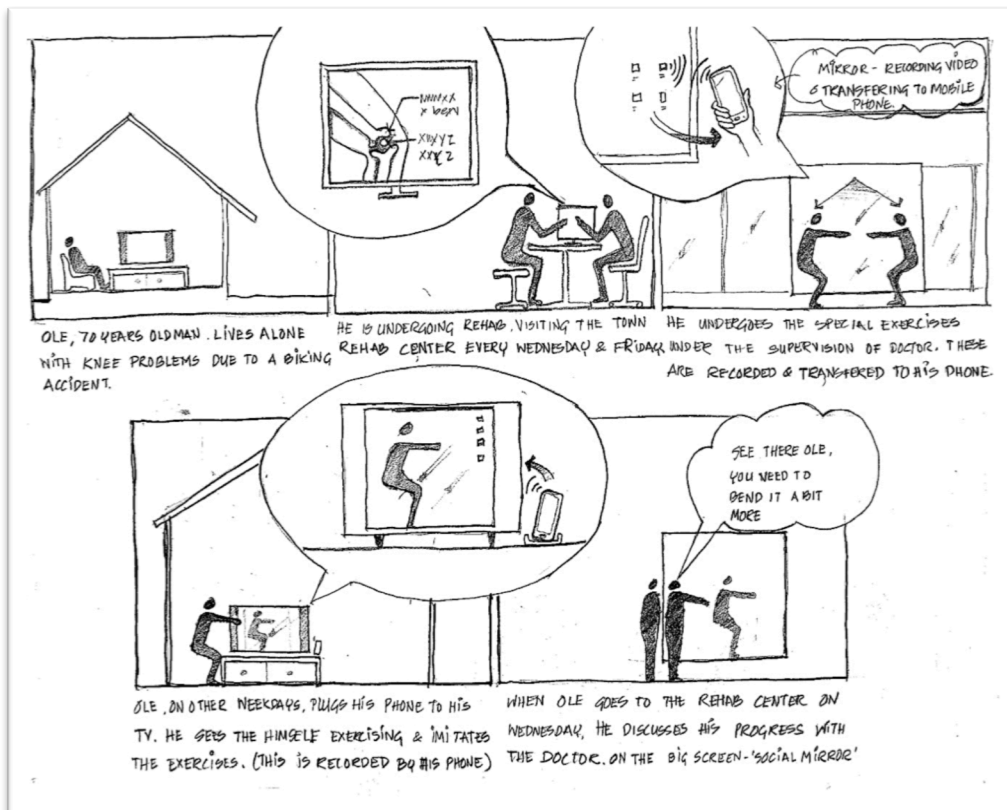


Figure 9.2: Scenario for MagicMirror version 1.0

9.1.3.2 Sketching and co-exploring

We imagined a technology that would track the motions of the rehabilitee, may be through an Infrared enabled webcam, which would then be processed by an image processing software for tracking and overlay. This process would happen in real time, with the processing done by the software as the video is being captured. In the initial

sketch of MagicMirror, we simulated the tracking and overlapping by using a combination of Adobe Premier and Flash. The exercises were captured by the Adobe Premier suite through the webcam of a MacBook Pro, which were then taken to Adobe Flash and the body joints were tracked frame by frame (Figure 9.3).

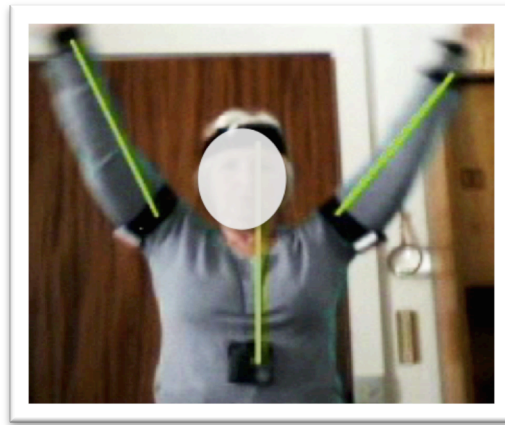


Figure 9.3: The body joints tracked for the particular exercise

We enacted a three-stage cycle with the rehabilitee and the therapists: recording of the reference video at the rehab center, exercising at home using this reference video, and finally, the meeting back at the rehab center with the therapist and rehabilitee discussing over the home video (Figure 9.4). We set up a webcam connected to a laptop and video recorded the exercise session of the therapists with Anita at the rehab center. This video was projected on a screen, imitating a mirror. We took these recorded videos to the studio, where we tracked Anita's movements frame by frame in Adobe Flash. This video was taken to Anita's home after couple of days and played on as the reference video for Anita to watch and exercise. The new exercises were again recorded through Adobe Premier and played alongside the reference video during the exercise at home. This home video was taken back to the design studio, to be tracked and laid over the reference video. Finally, we took the overlaid video to the rehab center again so that Anita could show her therapists how she exercises at her home and discuss her progress.



Figure 9.4: A three-stage co-designing of MagicMirror – at rehab center, at home and back at rehab center

9.1.3.3 *Early speculations*

This MagicMirror version 1.0 exploration pointed to three possibilities:

1. If and how video recording and body tracking may open opportunities for Anita to engage in self-monitoring by engaging with the digital technology as a resource for getting an immediate visual feedback about the position and movement of body as she exercises.
2. Anita mentioned that the simultaneous viewing of the instructional video along with her current video gave her an idea of the progress she has made. The exploration pointed to how looking at the current video, overlapped with the original video gives an immediate feedback about how much Anita can move her arms as compared to the range she managed to move on her first day of rehabilitation therapy.
3. If and how video recording her own exercises, looking at the videos over time may open opportunities for Anita to engage with the technology as a resource for becoming her own ideal or role model of rehabilitation progress.

Further, since the beginning of the exploration the therapists were wary of making this into a ‘tele-monitoring’ project, and they wanted Anita to maintain her period visits and consultation with the therapists at the rehab center. The early exploration pointed to how the back and forth movement of video data could reinforce this concern for face-to-face meetings. This led us to speculate if the recording and carrying of videos back and forth the rehab center and the home by the rehabilitees may be engaged as resources for enhancing the quality of the periodic meetings between the rehabilitees and the therapists.

9.2 REDIARY: MagicMirror version 2.0¹⁰

From these early experiences and speculative ideas, we engaged in the second version of MagicMirror exploration, which led to the design of ReDiary.

9.2.1 Design situation

A group of physiotherapists from the Gentofte community healthcare center contacted Tomas to explore a possibility of working on a pilot project that will lead to an application for funding a rehabilitation product development project. Their motivation was to explore the role of digital technology to reduce costs of rehabilitation. After initial

¹⁰ Published in Bagalkot and Sokoler [2011a, 2011b]

discussions with the therapists, we decided to focus our explorations on the situation of rehabilitation after a hip-replacement surgery.

Currently the rehabilitees undergo a program of bi-weekly therapy sessions involving a series of physical exercises for a period of six weeks. The therapists strongly recommend the rehabilitees to exercise at home in-between the sessions at the rehabilitation center. The therapists monitor the progress of the rehabilitees based on their expert readings of pain in motion, stiffness, imbalance, and range of motion achieved, as the rehabilitees exercise with them in the rehabilitation center.

In the initial discussion, the therapists identified three ‘key’ things the therapists want to monitor during the exercise process: the vertical body position, balance of weight on either feet, and knowledge about hip muscle activity. Further, we agreed not to aim at replacing the current periodic face-to-face meetings between the therapists and the rehabilitees, but to increase the quality of these meetings.

For this exploration, the therapists asked Anna, a 65-year-old lady undergoing the therapy after hip-replacement surgery, to be part of this exploration. Anna visits the clinic twice a week to exercise with the guidance of the therapists, and also tries to do these exercises at home in-between the visits.

9.2.2 Design ideal: Magic-Mirror-Spiral

9.2.2.1 *Framing an ecology-of-resource*

From this early discussion and interviews with the therapists, we formed a broad ecology-of-resource to consider how the rehabilitation process moves across the clinic and home. We figured that at the clinic Anna may engage with her therapist Rasmus, the exercise tools such as steppers, chairs, etc. At home, she may engage with the furniture of her living room either to rearrange it for making space for exercising or to use them to give support.

Based on this broad understanding of Anna’s ecology-of-resources, and from the earlier experiences of MagicMirror version 1.0, we formulated the design ideal of *Magic-Mirror-Spiral*. The spiral starts off at the rehab center by video recording the exercises the rehabilitee performs under the supervision of his/her therapist. The rehabilitee takes home this video and uses it as the ‘reference’ exercise to monitor self while exercising at home. During this period the system tracks the body movements and overlays it on the instructional video, thus giving the rehabilitee a self-referential video for exercising. The rehabilitee then takes back this home video to the center to discuss the progress in detail with the therapist (see Figure 9.5).

We formed a scenario to capture this early vision:

Anna is a 65-year lady who has had a hip-replacement surgery. On the suggestion of her surgeon, she visits the local physiotherapy center. The physiotherapists suggest to her an exercise program and they record the video of Anna doing the exercises at the rehab center. Anna carries this video to her home on her mobile phone, where she plays the video on her television, while exercising. The MagicMirror tracks her movements and body positions and overlays this feed with that of the recorded version, thus giving Anna a direct reference to exercise correctly. On her next visit to the rehab center, the therapist looks up the recorded home videos of Anna's exercises and both of them discuss her progress and next steps. As Anna goes about in this spiral of exercising at the rehab center and at home over six weeks, she becomes more aware of her progress, and at the same time articulate her home exercise experiences to her therapist.

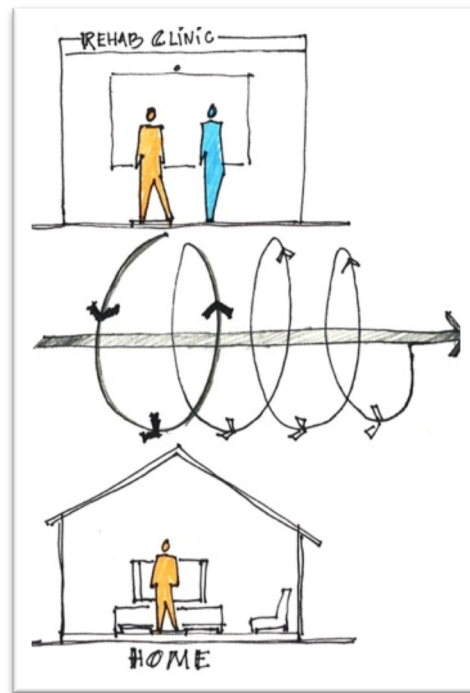


Figure 9.5: The Magic-Mirror-Spiral

9.2.3 Sketching and co-exploring

We sketched a 'balance board' with pressure sensors measuring the weight balance, a belt with an accelerometer for vertical position, a wearable EMG sensor called as 'e-patch'¹¹, and a digital counter for counting the number of repetition of the exercise. These sensors along with a webcam were attached to a laptop. The webcam video recorded the exercises, which were displayed on the big screens with the sensor

¹¹http://www.madebydelta.com/delta/Business_units/ME/Body_sensors/ePatch.page

information overlaid on the video in real time. The sketch gave real-time visual feedback of the balance on each foot, the vertical body position with reference to the horizontal, the number of exercises, and a graphical display of muscle activity. With this sketch of MagicMirror as the central artifact we explored what could be the possibilities of enhancing the design vision.

We did this by going through a staged enactment of the Magic-Mirror-Spiral: recording the exercises at rehab clinic, taking these videos back to the home, recording the exercises at home, and bringing the home exercises to discuss them at the rehab clinic.

9.2.3.1 Recording the exercises at rehab clinic

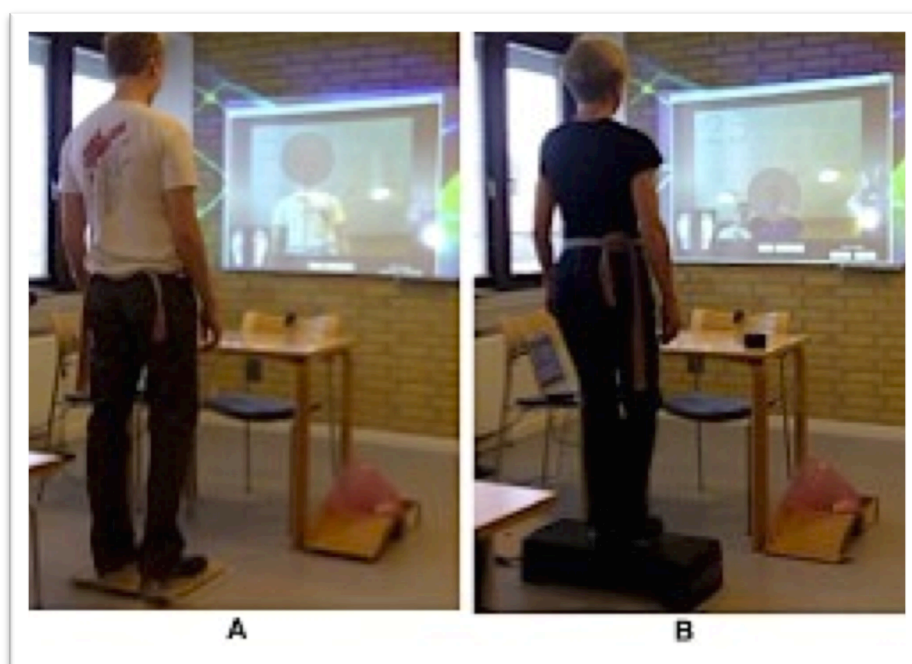


Figure 9.6: A) Rasmus trying the sketch and B) Anna trying the stepping exercise with the sketch at the rehabilitation clinic

We first took the early sketch to the rehab clinic and demonstrated how it works to the therapists. Based on the features of the sketch, they discussed and finalized an exercise scheme including stepping exercises, sit-to-stands, and balancing on each leg alternatively. Rasmus, Anna's therapist, introduced the sketch to Anna by demonstrating the exercise scheme and how the sketch provides feedback, explaining what each line means (see Figure 9.6 A). Anna then performed these exercises with Rasmus helping her out (see Figure 9.6 B).

The therapists taking charge gave us early indications of the role the therapists play in physiotherapeutic care; they go beyond mere prescribing the exercise schemes, and their success depends on a more holistic understanding of each rehabilitee and how they fine-

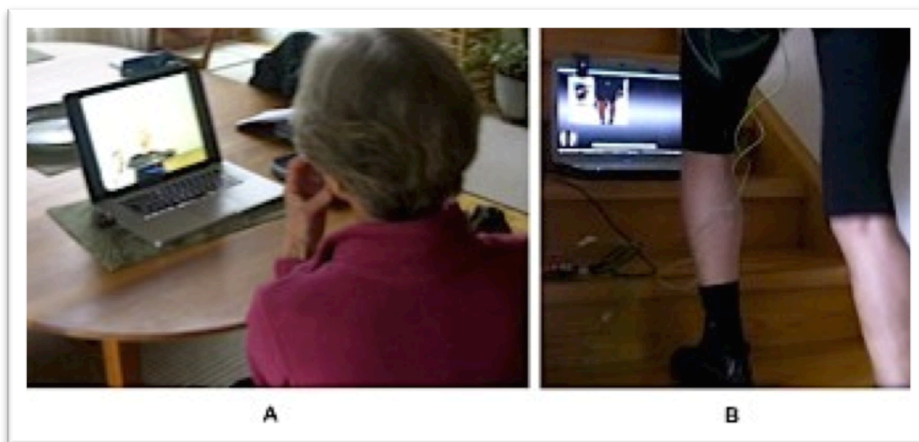
tune their prescription to each person. This contextualization by the therapists means that they are dependent on the rehabilitees' engagement in the process for successful care.

9.2.3.2 *Exercising at home*

Following week, we took these recorded exercises to Anna's home, a nice house with a living room and garden accessible by a small flight of stairs. Based on the scenario, we had planned to connect the MagicMirror to Anna's TV, so that she can look at what she did at the rehab center as a reference to exercise at home. There was a mismatch of connecting cables, and as one of us was figuring out how to go about it, the rest sat with Anna showing her the exercise videos. We discussed her thoughts on what engaging in the Magic-Mirror-Spiral means to her (see Figure 9.7 A).

Anna mentioned that the video recording of the exercises and getting them back to the rehabilitation center acts as an external motivation to exercise at home.

"It is like a whip! You know, they (the rehabilitation center) send this van to pick me up to the rehabilitation center. I am tired and lazy to go sometimes, but as soon I see the van, I have to go. I guess this (video recording) will be something similar."



*Figure 9.7: A) Anna looking at her exercise videos from the rehabilitation clinic.
B) recording her stepping exercises at her home*

Before we asked Anna to try exercising with the MagicMirror sketch at her home, we explained how her exercise videos from the rehab center would be reference videos. And along with the overlapped of the live video of her exercising would give her live feedback while exercising at home. But Anna did not agree,

"It will confuse me. Looking at what I did and what I am doing now... it is difficult!"

On prodding further she said,

“I would like to see what I did at the rehab center separately, maybe when I am relaxing in the afternoon.”

We then asked Anna to try out the sketch, with the live-recorded videos to be played on the laptop, instead of her TV. When Anna had to do the stepping exercises, she did not use the stepper given to her by the rehab center, instead used the flight of stairs (Figure 9.7 B). The use of laptop made this shift from exercising in her living room to the stairs easier, thereby prompting us to change our scenario to take into consideration how Anna engages with the stairs, rather than the stepper as a resource for performing her stepping exercises.

Furthermore, Anna was of the opinion that video recording her home exercises gives her a set of videos that she can share with her family to tell them her story of rehabilitation.

9.2.3.3 Back at the rehab clinic

We took the home videos back to the studio, where we made a series of eight cards each representing the eight videos of the exercises from the rehab clinic and home. Each card had the title of the exercise along with select key-frames of the video. We envisioned that these cards could be one of the ways that Anna brings her video data to the rehabilitation center.

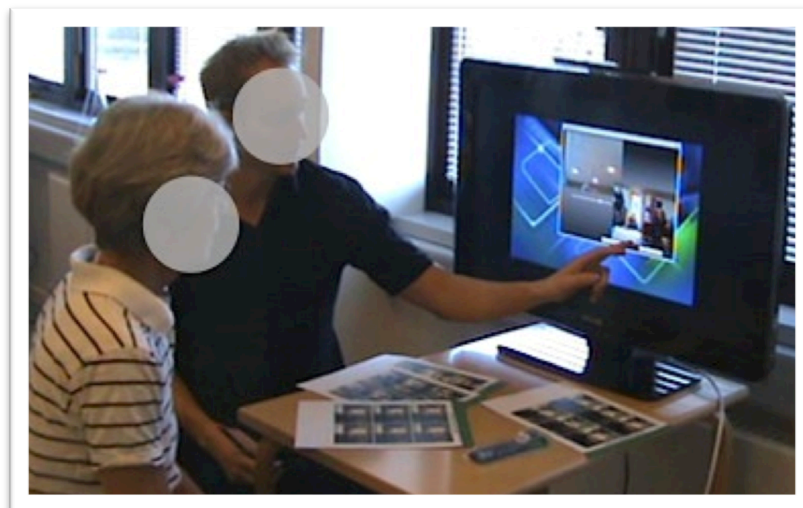


Figure 9.8: Anna and Rasmus staging the meeting back at the rehabilitation clinic, discussing her home videos

We took these cards to the rehab center the following week and asked the therapists to envision a scenario enacting the discussion with Anna based on the video cards. We then set up a discussion table with a TV screen connected to the laptop (Figure 9.8). Each card was connected to the video, and a team-member would pull up the video on the TV

monitor when a particular card was picked up for discussion, employing the Wizard-of-Oz method.

Rasmus explained the ‘script’ of the enactment to Anna and asked her to pick up one of the cards of the home exercise and point to any problem she faced during exercising. Now, Anna was in advanced stages of her rehabilitation program and as such she did not face any problems while doing the exercises. Rasmus then had to ask Anna to go through all the cards and videos to continue the discussion. Furthermore, we had not involved Anna in the preparation of the cards, which on hindsight, was the obvious thing to do, as it was her self-monitored data. Preparing the cards would give her an opportunity to sit back and reflect on her exercises and be prepared to her meeting with Rasmus.

After the long discussion and looking at all her videos, Rasmus was tired. The therapists experienced a glimpse of what it would be if all the rehabilitees came to the meeting with such rich data of videos. Rasmus, reflecting the views of other therapists, said,

“I don’t think I need videos. I know if there is any problem when the rehabilitee has difficulty to do some movement. And then the e-patch data can give us more (physiological muscle data) if I realize there is a problem.”

At the end of the meeting, the therapists wanted to get away from videos and just use the e-patch connected to a mobile device that the rehabilitees can bring back and forth.



Figure 9.9: Anna demonstrating her troubles when engaging in everyday activities at home

At the same time, before the discussions with the therapists, Anna gave us a demonstration of how frustrating it is to manage even simple everyday tasks, picking up a towel from the floor for instance, when she is dealing with a new hip joint (see Figure

9.9). She had brought with her the pincher to pick up the towel and other things to help articulate her everyday difficulties. She was of the opinion that able to video record these instances and sharing with her therapists and family will help her to talk about her everyday situations.

9.2.4 Reframing Anna's context: expanding the ecology-of-resources

As the sketching process evolved, we had to expand on our initial framing of Anna's context for compliance as a Magic-Mirror-Spiral.

Anna faced difficulties to exercise at home in the beginning of her therapy. The post surgery pain, combined with dealing with a new hip joint, made performing simple activities, such as picking up a towel from the floor, or wearing socks very difficult for her (Figure 9.9). She had to force herself to go to the clinic so that at the least she can exercise twice a week. The clinic has a pick-up service arranged to pick the rehabilitees from their homes, bring them to the clinic and back according to their weekly schedule. For Anna this pick-up service acted as not just the means to get to the clinic, but an external motivation to get out of her home and deal with her new situation. Looking at this from the lens of ecology-of-resources, we understood that Anna engages in her rehabilitation practice by engaging with the pick-up service and turn it as resource to motivate her to go to the clinic and exercise. During the exploration, Anna mentioned that the act of video recording of her home exercises would act as a motivator, similar to the van sent by the rehab clinic to pick her up for her weekly sessions. This points to the possibility that just by requiring to show up at the rehab center with some video 'proof' of exercising may mean as an external motivation for engaging the rehabilitation process.

Furthermore, during the enactment of recording the exercises at home, Anna preferred to look at the rehab exercise videos separately from recording the exercises at home. She wanted to use the viewing of the videos as a period of reflection to get an overview of her exercises, and pointed to the possibility that during this period she can prepare for her meeting with the therapists at the clinic. Here, Anna engaged with the videos not just as the resources giving feedback on the right way to exercise, but also as a resource to reflect and prepare for the meeting, i.e., as a resource to engage with her therapist.

Meanwhile, one of the exercises that Anna had to perform was a stepping exercise, she had to step up and step down using a stepper at the clinic (Figure 9.7B). Her therapists gave her a stepper to perform this exercise at home. However, Anna does not use this stepper as she feels it does not match the aesthetics of her home, and instead chose to do the exercise on the stairs in her living room. She had to move from her dining room

where she did the other exercises to the living room to do the stepping exercise. Here, Anna does not relate to the stepper as an available resource at her home, but avails the stairs as a resource to exercise.

In summary, we broadened Anna's context for compliance as an ecology consisting of the exercise instructions from her therapists and the training equipment at the clinic, the pick-up service to go from home to clinic and back, the things at home such as stairs, chairs, etc., and her experience of dealing with a new joint in her body.

9.2.5 Design sketch

Based on this reframing of the ecology, we formed a paper, and a working desktop sketch of ReDiary.

ReDiary is envisioned as a portable and personal device to the rehabilitees. It becomes a personal device moving back and forth the rehab clinic and the home providing opportunities to record exercises in the form of video, audio instructions, and muscle activity data from wearable sensors (Figure 9.10). It is visualized as a touch pad device (with the dimensions similar to Apple or Android tablet) with a webcam and Internet connectivity.

The therapists can record the first exercise session of the rehabilitees at the clinic through the web-camera on the diary. The rehabilitees wear e-patch on their hips and also wear shoes with pressure sensors that detect the pressure balance on each leg. The sensor data is displayed as a visual overlay on the live-exercise video. This recorded exercise becomes the reference exercise for the rehabilitees. Back at home, they can plug the diary to their television and exercise, which is again recorded in the form of video snippets. Again, the set of body sensors measure the muscle activities while the rehabilitees are exercising at home. This sensor data is presented in-sync with the videos. Further, the rehabilitees can make notes in the form of audio and pictures, thereby preparing for their next meeting with the therapists. We envisioned how the rehabilitees can take the diary back to the rehab center and engage with the sensor data, the videos and the notes, as resources to discuss with their therapists their problems, progress, and further steps.

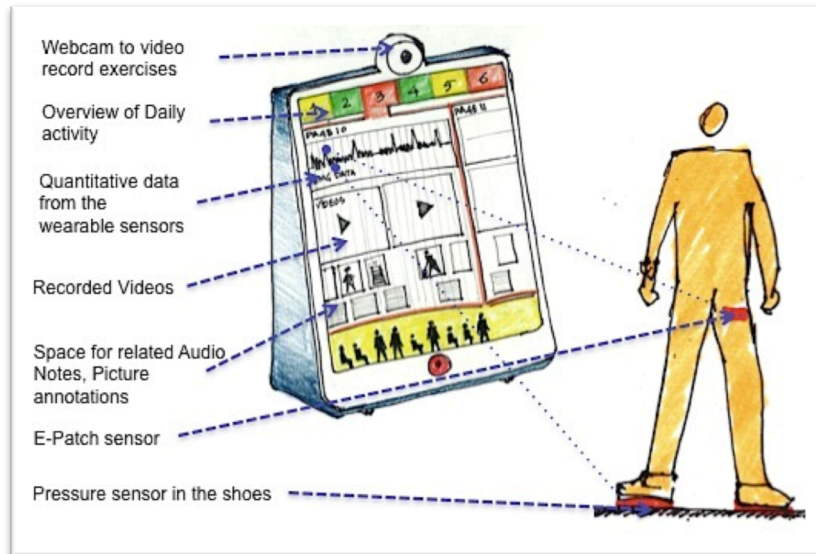


Figure 9.10: ReDiary paper sketch

9.3 SUMMARY

In summary, by exploring the design of digital technology through taking an embodied interaction perspective on Anna's context for compliance, we arrived at the design sketch of ReDiary. During this process, we employed ecology-of-resources as a framing device to frame and reframe Anna's context of a rehabilitee, and take advantage of what was framed.

We entered the MagicMirror exploration with an initial frame of how Anna moved across her home and clinic in order to comply with her treatment. This was reflected in the sketch for recording exercise videos across the home and clinic. However, this broad framing had to be tempered with how Anna employed the stairs rather than the stepper and the chair in the dining room. *Taking advantage of how Anna engages with the objects around her home as resources for exercising*, we evolved the sketch of the display to a portable form.

Meanwhile, the therapists were on board with the initial idea of videos as the central form of recorded data that they could engage with to collaborate with Anna. However, as the exploration evolved, we encountered the possibility of how watching the videos would mean an increased investment of therapists' effort and time, and they would rather look at the processed overview from the recorded sensor data. At the same time, Anna imagined how recording her exercises in the format of videos helped her not only to gauge her own progress, but also to employ them as materials to articulate how she performs her exercises at home. In this manner, we framed and reframed Anna's emerging context for compliance through the activity of sketching, collaboratively

deciding what object, people, and technology could become a resource in this ecology. This framing made way for us to take advantage of how Anna already engaged with the various resources to comply with her treatment. The ReDiary sketch came about through this process of framing, reframing, and piggybacking.

10 REHANDLES

In this chapter, I describe how the different explorations that we group under the heading ReHandles unfolded. While the early explorations are set in Denmark, the main explorations happened in and around Mumbai, India.

In the first section of the chapter, I describe a video study that became a starting inspirational instance, followed by three very early explorations: ReWrist, ReBrush, and ReNinety°. These early explorations helped us to speculate and envision directions to take in the subsequent explorations.

Over the next four sections, I describe the individual explorations set in India¹²: ReSwing, ReWall, ReBreath, and ReExercise, highlighting the design situation, the ecolog-of-resources, the early design visions, and the design sketch. For each of the explorations I present how the participants explored and experienced the possibilities offered by the sketches.

Again, the main focus of this chapter is to demonstrate how by taking a stance of embracing the embodied ways of compliance, informed by embodied-self-monitoring, we could envision, experience and enact a range of possible scenarios about new ways of interacting with pervasive self-monitoring technology.

¹² Published as Bagalkot, Sokoler & Shaikh [2012].

10.1 REHANDLES: version 1.0¹³

ReHandle is a word formed by inspiration from the Danish word ‘handle’, which means to act, and from the English meaning of ‘handling’ as engaging with things to achieve some purpose or responsibility. Through ReHandle we want to metaphorically highlight that the design visions and sketches presented here are oriented towards taking advantage of how the rehabilitees handle things and people around them to manage their rehabilitation in their everyday life.

10.1.1 Inspirational instance



Figure 10.1: 92-year-old rehabilitee exercising at home or conducting a musical?

One more video snippet from Louise’s collection of video documentary showed a 92-year-old man exercising at home (Figure 10.1). The video shows how he exercises at home while listening to a classical music on the radio, and as he warms up to the music, his hand and shoulder stretches turn to the hand motions of a music conductor.

This documentary made us speculate about a possibility of supporting the rehabilitees to merge their rehabilitation exercises with their other everyday activities, which are more pleasurable.

10.1.2 ReWrist

The setting of the ReWrist exploration was the Tårnby rehabilitation center. Currently the rehabilitees undergoing wrist rehabilitation visit the rehab center once or twice a

¹³ These explorations are published in the form of Bagalkot & Sokoler [2011c].

week, depending on the severity of the problem. They exercise under the supervision of their therapists using different props. The therapists suggest the rehabilitees to exercise at home giving out printed pamphlets describing the exercises. However, the rehabilitees invariably do the wrist motions as they go about their activities in their everyday life. For instance, opening a door by rotating a door handle involves what the therapists define as supination and pronation, the two-way rotations of a wrist.

With ReWrist, we explored if, and how, the everyday activities involving the wrist motions as specified by the therapists can be recorded as exercises, thereby exploring ways to merge the rehab exercises as part of other everyday activities of rehabilitees.

A scenario (Figure 10.2):

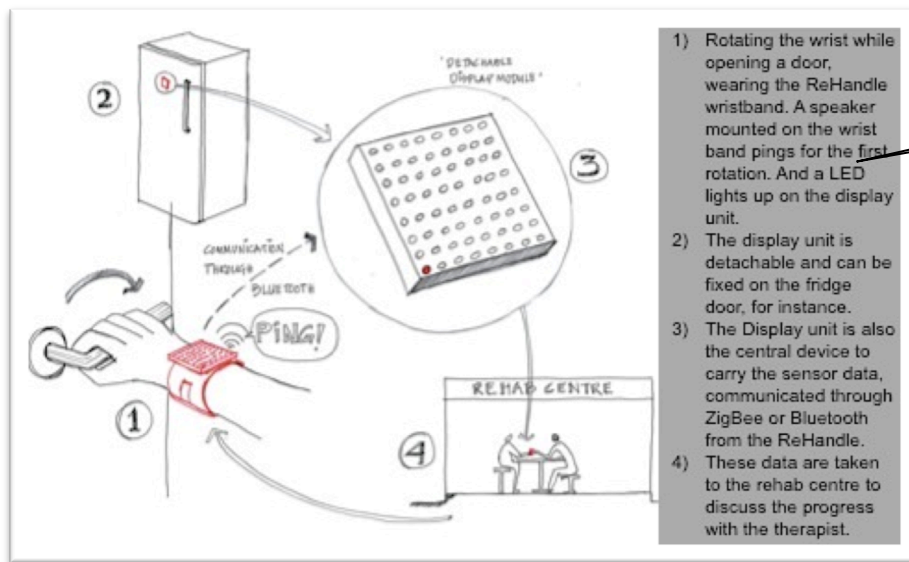


Figure 10.2: ReWrist paper sketch

Mette, 65 years old, just-retired secretary, visits the nearby rehab center twice every week for rehabilitating her wrist. Her therapist John gives her ReWrist to exercise at home, setting the wristband for 20 numbers of wrist rotations that she needs to perform per day. Next day at home, Mette is working in the kitchen wearing ReWrist. She leaves the kitchen to enter her bedroom, rotating the door handle. As her hand does the full rotation, the ReWrist gives out a small sound, and an LED lights up on the display module. Mette comes to know that this motion is good for her wrist, and she goes ahead to complete the day's share of rotations, using the door handle as a prop. After she finishes the 20 rotations, 20 LEDs are lit up on the display, giving her the idea that she has finished her quota of exercise for the day.

On another day, Mette removes the display unit and sticks it on her refrigerator and switches off the sound feedback. As she goes about doing her daily work, the wristband detects the rotations and lights up the display module remotely, giving Mette a direct feedback of how many rotations she did during the day. During her next visit to the rehab center, she and John discuss her progress from the data available from the display module.

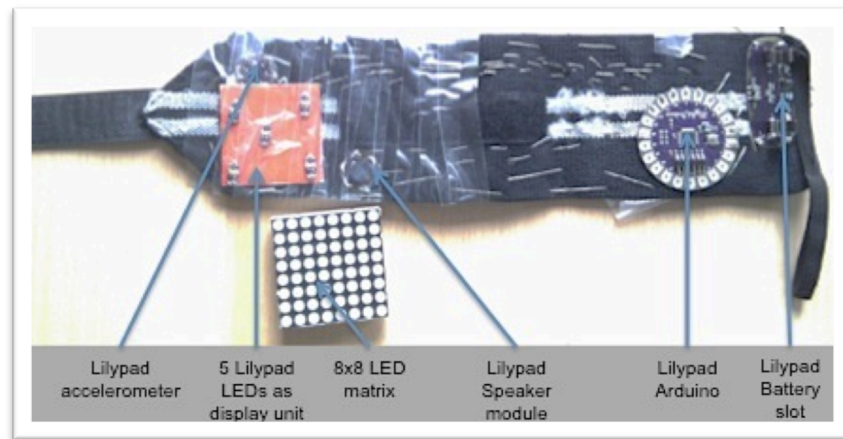


Figure 10.3: ReWrist electronic sketch

We used a Lilypad accelerometer fixed on a wristband to detect the wrist rotations connected to a Lilypad Arduino. Rotating the wrist lights up an LED and a small speaker lets out a sound (Figure 10.3). This sound is a feedback for the person to let him/her know that they just performed a rotation that is qualified as an exercise in their rehab program. ReWrist records the number of rotations per day, and the angle achieved during these rotations.

10.1.2.1 Co-exploring and experiencing ReWrist

We took the hardware sketch to engage a therapist and a rehabilitee in sharing their initial thoughts at the rehab center (Figure 10.4).

The therapist thought that the overall idea of recording the rotations was helpful, but stressed on the need to convert the accelerometer data into degrees for his understanding. Discussing the possibilities, the therapist wondered if we could have a set of detachable displays, one for each day that the rehabilitee is at home. The rehabilitee can bring back the different display units, which carry the information of her exercise and progress per day to the therapist to discuss the progress.

The rehabilitee expressed that she performs many activities at home involving wrist rotations: opening doors, taps, combing hair, brushing teeth, etc. Wearing the ReWrist

may help her in giving her a clear idea on the number of required rotations she managed to do everyday. She was enthusiastic of how she can use everyday things like a door handle, a ladle, or a hairbrush as props for her exercise at home.

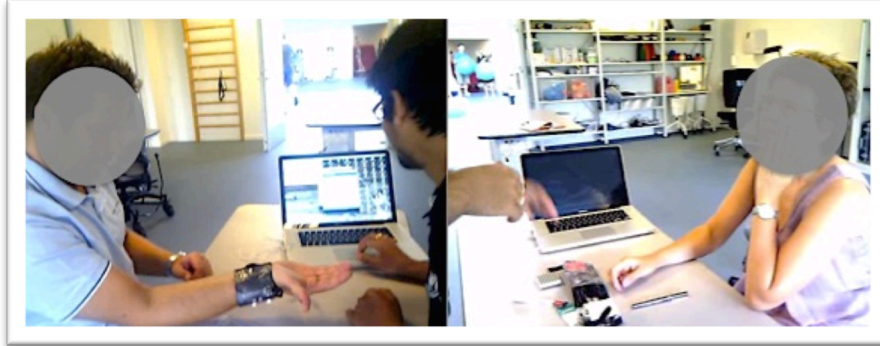


Figure 10.4: Therapist and a rehabitee trying out the ReWrist sketch at the rehabilitation center

10.1.2.2 Reflections

ReWrist aims at bringing the other everyday practices of rehabitees as part of rehab exercises. It does not give feedback of whether the rehabitees are doing the exercise correctly, but gives a feedback of how many times the rehabitees managed to perform the wrist exercises as they went about their everyday chores. The dedicated LED display, which displays only the information of the number of rotations the rehabitees managed, may indicate to the rehabitee a possibility to engage in wrist exercise while staying within their everyday activities. The enthusiasm of the rehabitee, who was part of the exploration, to exercise her wrists as she is combing her hair, or cooking, indicates how she could imagine the possibilities of moving from her everyday chores to exercising her wrists and back.

In summary, ReWrist points to the possibility of a self-monitoring technology that opens up an opportunity for the rehabitees to engage with it and turn it as a resource for getting immediate feedback of how much they exercised as they went about their everyday chores, and as a resource for being aware of a possibility of engaging with dedicated wrist exercises every time they open a door, for instance, and yet staying close to practices they are familiar with.

10.1.3 ReBrush and ReNinety°

In the MagicMirror exploration, Anna expressed specific concerns and thoughts that brought forward two design possibilities, which we captured in the two explorations: ReBrush, and ReNinety°.

10.1.3.1 ReBrush

As described in the previous chapter, the sketch was a balance-board-hack with a digital counter fixed on it counting the number of steps the rehabilitee manages using the board, which was displayed on the screen (Figure 9.7B in Chapter 9). After the performance, the rehabilitee mentioned that the counter reminded her of how she exercises while brushing her teeth. She exercises her weight balance by standing on one leg and counting to ten before shifting to the next leg, all this while she is brushing her teeth. While this exercising of weight balance is one of the important exercises prescribed by her therapists, the rehabilitee performs the exercise as an integral part of brushing, by taking advantage of the rhythm of brushing in order to *keep pace*.

ReBrush takes this forward by providing self-pacing opportunities with the purpose of supporting the rehabilitees' actions of integrating exercises with brushing teeth. In this light, we present the following scenario (Figure 10.5):

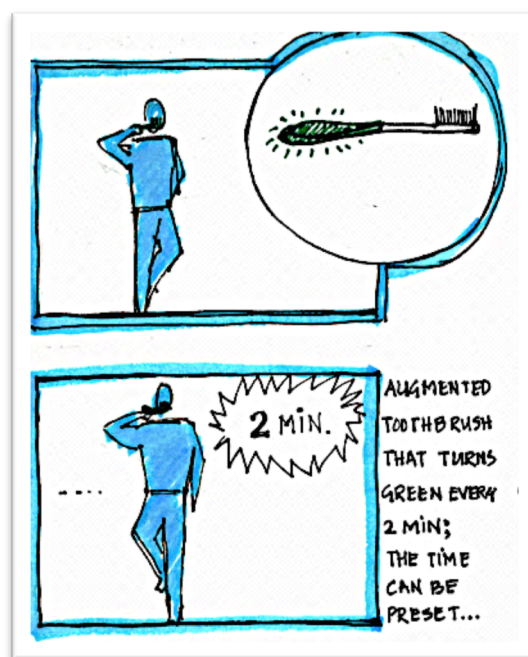


Figure 10.5: ReBrush scenario

Anne is a 65-year-old lady undergoing rehabilitation from hip replacement. Her therapists suggest her to perform the standing-on-one-leg exercise at home. For this purpose, she gets the ReBrush and sets the timer for 1 minute. The next day while she is brushing her teeth, she stands on her left leg; after a minute, the handle of the brush turns green. Anne then shifts her position for another minute. After a course of 2 weeks, Anne has pushed herself to manage to stand on one leg for 3 minutes at a stretch, by

... pacing the timer gradually. ReBrush communicates this data to a database giving Anne and her therapist the information of her progress.

Thereby, ReBrush points to the design possibility of opening opportunities for the rehabilitees to engage with self-monitoring technology and turn it as resources for self-pacing the way they take advantage of the rhythms of everyday activities to perform physical exercises.

10.1.3.2 ReNinety°

A concern that Anna raised is what we call the ‘fear of the ninety degree bend’. The therapists ask the rehabilitees to be careful while doing everyday activities at home and not to bend their hip joint beyond ninety degrees, as this will lead to dislocation of the replaced joint. However, this fear of possible dislocation of the new joint, combined with the presence of a new joint severely affects the rehabilitee’s confidence in performing everyday activities, for example, picking up a towel from the floor, or wiping wet feet (Figure 9.9, Chapter 9).

This led us to speculate if a simple set of sensors and actuators attached to the seam lines of their clothes can give the rehabilitees immediate feedback when they approach the 90° angle. A scenario of ReNinety° (Figure 10.6):

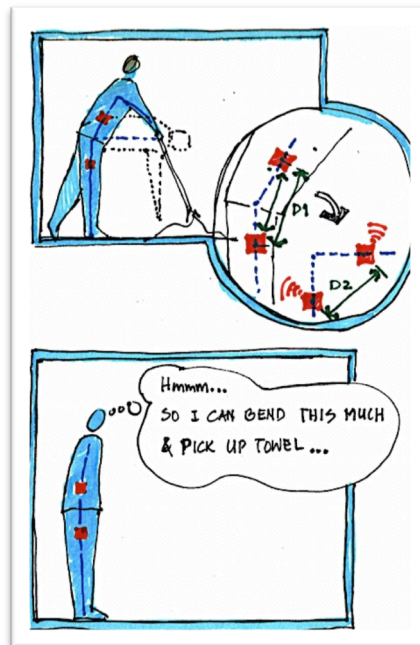


Figure 10.6: ReNinety° scenario

Karl is a 70-year-old undergoing rehabilitation from hip replacement. His therapist, while mentioning the ninety-degree rule, give him ReNinety°: a set of two patches

containing distance sensing sensors and vibrating actuators. The therapist asks Karl to attach each patch to the seam line of his shirt and pants that he wears at home. Back at home, Karl is not sure of how much he can bend to pick up the towel. He slowly bends and tries to pick the towel with the help of a picker. As he reaches about 100 degrees, the sensors detect that he has reached the threshold set by the therapist and sets off a small vibration in the patches. This alerts Karl and simultaneously tells him the extent to which he can bend.

Through this scenario, ReNinety° points to the design possibility of opening opportunities for the rehabilitees to engage with the self-monitoring technology and turn it as a resource for measuring their body positions, and engage with this feedback as a resource for reinstalling their confidence in their abilities to manage everyday physical activities.

10.1.4 Summary

The three early explorations pointed towards different possibilities of opening opportunities for the rehabilitees to engage with it:

- As a resource for getting immediate feedback of how much they exercised as they went about their everyday chores.
- As a resource for self-pacing the way they take advantage of the rhythms of everyday activities to perform physical exercises.
- As a resource for measuring their body positions, and engage with this feedback as a resource for reinstalling their confidence in their abilities to manage everyday physical activities.

10.2 ReSWING

In ReSwing, we aimed to explore the possibility of opening opportunities for the rehabilitees to engage with the digital technology as a resource for getting immediate feedback of how much they exercised as they went about performing their other everyday chores.

10.2.1 Design situation

Gita and Kumar live in Lonand, a village that is about 80 km from Pune, India. Gita is a 74-year-old lady who has had her knee joints replaced five years ago from a hospital in Pune, after which she underwent three months of physiotherapy to be mobile and reduce the pain. Her doctor prescribed her an exercise regime to continue at home so that she remains mobile and not experience much pain. Back at home she has integrated these exercises into her everyday routine. One standout example is the way she has integrated some of her knee exercises with the swing in her garden (Figure 10.7B). Everyday she swings back and forth by pressing her feet on the ground, thereby exercising her knees, while listening to a musical broadcast on her radio. Additionally, she stitches clothes for her friends and neighbors for a small fee during festivals and uses a foot-operated sewing machine. This again helps her to keep her knees in shape.



Figure 10.7: A) Gita in her living room with her trophies. B) Exercising on the swing in the garden.

Gita has successfully rehabilitated post her knee surgery: she is mobile, active, and performs her everyday activities that she used to perform before surgery, though in a different manner. However, she still has to exercise everyday. Leaving the exercise for duration of more than five days brings the pain back to her. This duration is not measured, and she has an awareness of her body and the replaced knees, which has been developed by living with them for the past five years. Further, her doctor in Pune asks

some of his patients from places near Lonand to visit the couple for advice on living with the replaced knees. For the couple, recollecting their experience of pain and pleasure over the past five years has become easier over time. This became evident for me during our interview when they talked about how they dealt with the rehabilitation process. They have managed to stay mobile by a practice of integrating the exercises with everyday routine, as they had no direct and constant access to the doctors (Pune is a three hour bus ride from Lonand) once they moved to their village.

We found Gita to be an active person. She is the leader of a *bhajan mandal*, a group of musicians who perform devotional songs. She goes around nearby towns and villages to perform, and has collected a fair amount of trophies congratulating her effort. These trophies are displayed centrally in her living room (see Figure 10.7A).

10.2.2 Ecology-of-resources

We took help of ecologies-of-resources to frame Gita's context for compliance. Gita has integrated her knee exercises with the pleasurable activity of the swing. She engages with the swing, and the pleasure of being on the swing, as resources to motivate her to perform her knee exercises. Another thing that we took inspiration from is the way she engaged with the trophies and awards in her living room turning them as resources to tell a story about her active life post rehabilitation.

Additionally, Gita mentioned how over the five years, she has developed an innate sense of the relation between her not doing her exercise and the increasing pain. She knows that if she is travelling it is hard for her to exercise, and the pain in her knees gradually increases if she does not exercise for a week. However, this period of a week is her measure through experience, and not an objective measurement of time. In other words, she engages with her past experience turning it as a resource to develop an awareness of the relation of exercise and pain, and further engages with this awareness as a resource to encourage her to keep exercising as and when she can.

10.2.2.1 Design ideal

We took advantage of this framing of Gita's context, and envisioned how Gita may engage with the digital technology as a resource for measuring, recording and making her swing activity a legitimate form of exercise. We also envisioned how Gita can engage with the digital technology as a resource to give a material form to her felt awareness, making it visible to her and other people visiting her home, so as to reinforce the encouraging role the awareness plays.

10.2.3 Design sketch

We formed an early version of these visions in the form of ReSwing sketch. This design sketch consists of two components: a mat with an accelerometer connected to an Arduino and Zigbee module (Figure 10.8), and a trophy with three LED lights connected to another Arduino and Zigbee module (Figure 10.8). The trophy is designed to fit the aesthetics of the other trophies that she has in her home, with the text congratulating her and her husband of being successful in her rehabilitation program.

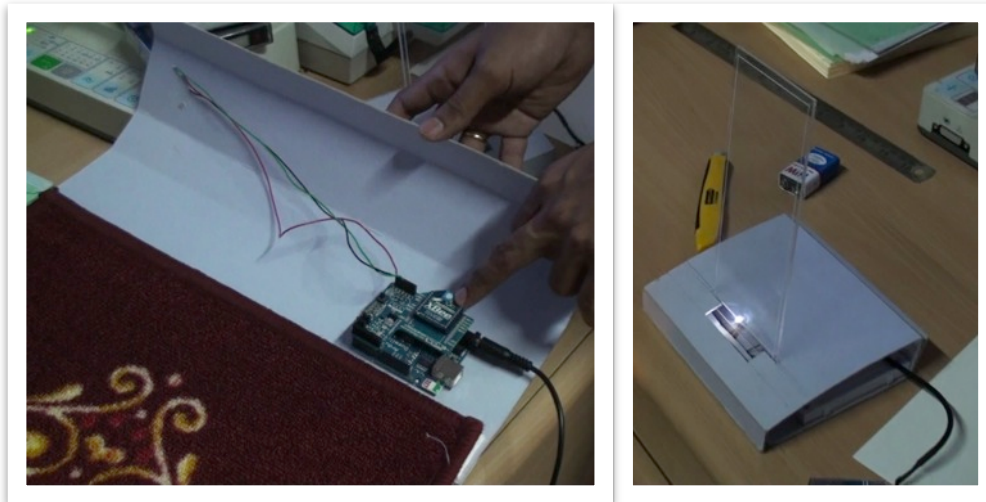


Figure 10.8: The Arduino, Zigbee unit on the mat sketch and the LEDs on the trophy sketch.

When Gita keeps the mat on the swing and does her exercise sitting on it, the central LED of the three LEDs lights up, and the other two flickers. The mat communicates the accelerometer readings to the LEDs in the trophy via Zigbee. When the mat is rolled and kept after using, the central LED remains lit and the two side ones switch off. The central LED then fades off gradually over time (24 hours) till Gita uses the mat again. The trophy lights up and fades off based on how much the mat was used, showing Gita the frequency of her exercise.

Gita can display the trophy in her living room, along with her other trophies, and may engage with it as a 'prop' in her recollection and retelling of her rehabilitation story to new and would-be patients sent to her by her doctor. Gita can use the mat on the swing or keep it on the foot-operated sewing machine. It will record both her activities and trigger the LEDs on the trophy (see Figure 10.9).



Figure 10.9: The ReSwing sketch on the swing and the trophy displayed on top of TV in the living room.

10.2.4 Experiencing an early version of the design sketch

We left the ReSwing sketch with the Gita for a week, asking her to engage with it whenever she exercises using her swing.

During our visit to her home after a week, the couple demonstrated how they engaged with the sketch. Gita was on the swing in the garden, pushing her knees back and forth. We asked Kumar, who was in the living room looking at the LEDs on the trophy, to see if they were flickering fast enough. Gita mentioned that this has been the routine for a week now, with her husband fixing the speed of her exercise based on the flickering of the LEDs on the trophy. However, we had not designed the sketch with this purpose! This surprising instance opened us to consider how closely Kumar was involved in the rehabilitation of his wife.

This insight became even more apparent later when Kumar engaged with the trophy as a resource to tell me stories about his role in Gita's rehabilitation. When Gita was in the kitchen to make us some tea and Kumar discussed the text on the trophy, which included his name along with his wife's congratulating them for their efforts. He said,

“Thank you for mentioning my name there. I have done a lot of work to get her on her feet... close friends and family knew about my efforts, but now you have given me something to make it permanent.”

He further recounted the details about his active role in the rehabilitation of his wife, telling stories about him staying in the hospital in Pune during Gita's surgery, encouraging Gita to keep exercising everyday, and modifying her exercises to suit their home environment.

Gita also demonstrated how she engaged with the mat to record her knee movements when she used the sewing machine, and mentioned how she showed the trophy to her visiting daughter explaining her how the trophy reflects her activity on the swing.

10.2.5 Summary

Through the process of framing and reframing Gita's context for compliance, we took advantage of how she engaged with her everyday routines, objects, and her spouse as resources for complying with her therapy.

Our initial ecology-of-resource framed how Gita engaged with the swing and the sewing machine to perform her knee exercises while enjoying the activity of swinging and stitching, respectively. *We took advantage of Gita's engagement with everyday activities* to sketch ReSwing in the form of a mat that Gita could place on the swing or on the pedal of the sewing machine, so as to engage with it as a resource to measure and record how she moves her knees as she performs these daily activities.

Discussing this initial framing with Gita, we expanded this ecology to include the way she engaged with the awards and memorabilia to tell her life stories about travelling and playing music. *We took advantage of her engagement with the objects around her* to envision the design of ReSwing to display the recorded knee data in the form of a trophy, so as to offer opportunities for Gita to engage with the rehabilitation trophy as a resource for enhancing her felt awareness of progress, and for sharing episodes from her successful rehabilitation to prospective rehabilitees who visit her and friends and family.

While exploring these opportunities through sketching, we accidentally came across how Gita engaged with Kumar as a resource to read the feedback on the trophy and communicate to her if she has to increase or decrease the speed of her knee motions on the swing.

10.3 ReWALL

10.3.1 Design situation

One of the other exercises that Gita performs is to press her back to the wall and bend her knees, repeating this for 10 times (Figure 10.10). She does this every morning as part of her routine, taking support of the wall of her living room at the same spot, right next to the window. When asked why the same spot everyday, Gita revealed that, apart from the morning sunlight washing over the wall, doing it at the same spot reminds her of the exercise whenever she moves nearby; that spot of the wall acts as a ‘marker’, subtly reminding her about her exercise. Further, we came to know that the number of repetitions is not as important as the degree of bending she does, as she is in advanced stage of rehabilitation and performs this exercise to stay mobile. However she has no means to measure the extent of her bending; her measure is more of a ‘feeling’ based on her body awareness, honed over repeating the exercise over the years.



Figure 10.10: Gita exercising at the same spot in her living room.

The couple keeps visiting their daughter and son, who are living with their families in Pune. These trips break the continuity of Gita’s exercise, as her everyday routine is disturbed. She admitted that even if she manages to exercise for a couple of days, it is inconsistent and sporadic. Another interesting aspect of Gita is that she is also a good craftsperson, creating beautiful things for decorating her home with cloth, beads, old coins, etc.

10.3.2 Ecology-of-resources

We framed Gita's context for complying with the bending exercises as below. Gita engages with the wall as a resource to support her in keeping her back straight while she performs the exercise, and as a resource to subtly remind her of the exercise routine everyday. She engages with the same spot of the wall due to the quality of the morning light as a resource for enhancing her aesthetic experience of exercising. She also engaged with the same spot of the wall as a resource to subtly remind her of her exercises.

When she visits her daughters' home in Pune, though she could engage with a wall of that house as a resource to exercise, she does not do it as part of a daily routine. We saw a break in her ecology-of-resource. Additionally, Gita does not engage with any particular resource to measure the depth that she reaches during the exercise. Elsewhere, Gita engages with different materials—cloths, beads, old coins, etc.— as resources to create artifacts decorating her living room. She then engaged with some of these artifacts as resources to tell us her life stories.

10.3.2.1 *Design ideal*

We piggybacked on this framing of Gita's context, and envisioned how Gita may engage with the digital self-monitoring technology as a resource for enhancing the 'marker-ness' of the wall, and at the same time get feedback about the range of depth she reaches daily during exercising. Additionally, we envisioned how Gita may engage with a self-monitoring technology as a resource for enhancing her aesthetic experience of exercising.

10.3.3 Design sketch

We sketched an early version of these visions using a decorative¹⁴ textile wall-piece and two Force Sensing Resistors (FSRs) projecting out of the wall-piece. These are connected to a Lilypad Arduino. An RGB LED is also connected to the Arduino. During her exercise, as Gita brushes across each sensor it registers her touch and lights up the LED in different colors—green for touching the top sensor and orange for touching the bottom sensor (Figure 10.11). The wall-piece can be hung based on her height and the depth target that she wants to achieve. While for the current sketch we used only two FSRs, adding a series of them at fixed intervals can give her more precise feedback.

¹⁴ Mother of one of the designer chose the pattern and the color of the textile.

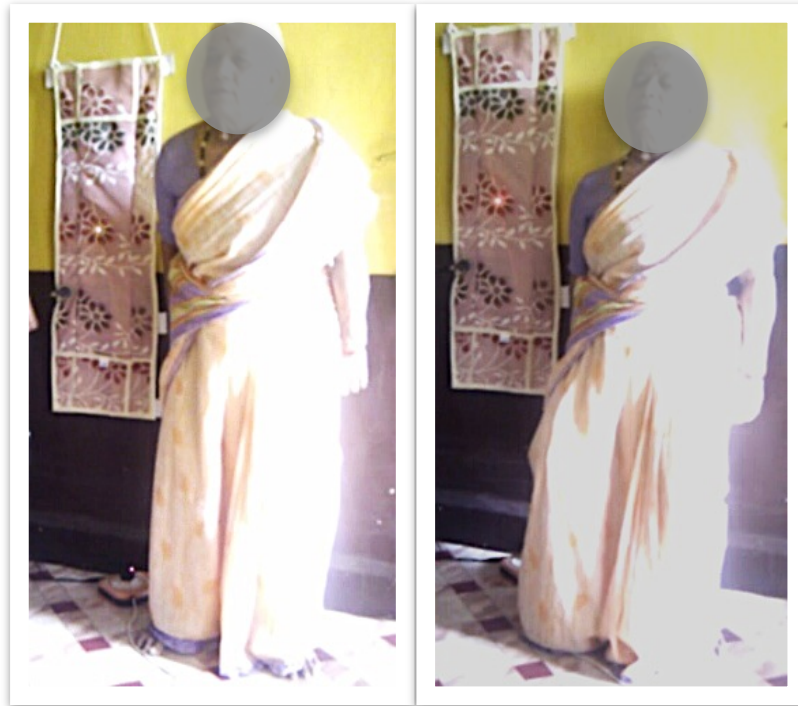


Figure 10.11: Experiencing the ReWall sketch

The ReWall sketch manifests an early version of the visions of the design ideal in a form of an interactive textile. The wall-piece can add a material layer to the wall, emphasizing the spot where Gita exercises. Further, the color of the LED can indicate the depth she reached during her last exercise. Gita can roll up the wall-piece and take it with her on her trips to Pune, using it at her daughter's or son's home for the exercise.

10.3.4 Experiencing an early version of the design sketch

We took this sketch to Gita's house, hung it next to wall spot with the help of a sticker and asked her to try the sketch out. Gita was not sure how to hold her hands as she bent down. The sketch required that she kept her arms straight, grazing the surface of the wall. As she bends her knees, her arms graze the two FSRs triggering the LED that indicates the depth she managed. However, Gita kept bending her arms to reach the FSRs before she bent her knees to the respective height. Kumar kept telling her to keep her arms straight, and once even intervened to make them straight. This instance again pointed us how he plays his role as a motivating and guiding presence in her rehabilitation.

Meanwhile, Gita liked the textile and the pattern. She was happy when we mentioned that the design pattern was the choice of one of the designer's mother. However, we could not leave the sketch with the couple, as it was powered by the laptop.

10.3.5 Summary

Our initial ecology-of-resource framed how Gita engaged with the wall spot as a reminder, and the morning light as a resource to enhance her experience of exercising. We further included how she engaged with the range of decorative pieces adorning the walls of her living room as resources to tell her life stories. *We took advantage of Gita's engagement with everyday objects* to sketch ReWall in the form of a decorative-textile piece that could be hung on her living room wall, next to where she exercises. Gita may engage with the textile as a subtle reminder that displays her daily range of exercises at the same spot.

10.4 ReBREATH

10.4.1 Design situation

Madhav, a 69-year-old man is an active member of the community and a secretary of the neighborhood senior citizens group, taking care of a physiotherapy center, an activity center, and a gym. Due to the nature of his activities he suffers from weak knees, and according to Ravi, his physiotherapist at the local physiotherapy center, he is couple of years away from a knee replacement. Ravi has prescribed him an exercise regime to push the surgery further. Madhav has to keep a soft pillow or a rolled towel under his knee while lying down, apply pressure on the towel and count till 10. He has to repeat this 10 times each, while lying down and while sitting everyday. However as he admitted in the interview, he does not consistently perform these exercises. When the pain is too much to bear, he hobbles to the physiotherapy center – a 5-minute walk from his home – and is forced to perform the exercises under the care of the physiotherapist, and swallow some painkillers. Furthermore, Madhav is supposed to visit the therapist once every week to discuss his progress, but he drops in sporadically as he is busy. And as the secretary of the senior citizen group that runs the therapy center, Ravi cannot help much to enforce the periodicity of his visits, but remind him of his weakening knees.

At the same time, as an ex-body builder, he is actively engaged in exercising at the nearby gym that he started. He goes to the gym everyday at 4 am, performs a series of upper body exercises, lifts weights, and is back home by 5 am. He and his wife, who is a yoga enthusiast, then do a series of yogic breathing exercises. Madhav is proud of his ‘fit’ body, recollecting only his gym exercises and the yogic breathing, whenever we asked about his exercise regime at home, and conveniently forgetting about the knee exercises.

10.4.2 Ecology-of-resources

Our first meeting was in the physiotherapy center, where with the help of Ravi, Madhav performed his knee exercises. After this interview, we framed his context for compliance as an ecology that constituted how Madhav engages with a soft towel to support his knees and with Ravi as a physiotherapist who guides him to perform the exercises. Through this framing, we envisioned a basic self-monitoring technology that consisted of a FSR fixed on the soft pillow he keeps under his knees. The FSR counts the number of times he presses his knees and sends this count to his mobile device as text messages (Figure 10.12).

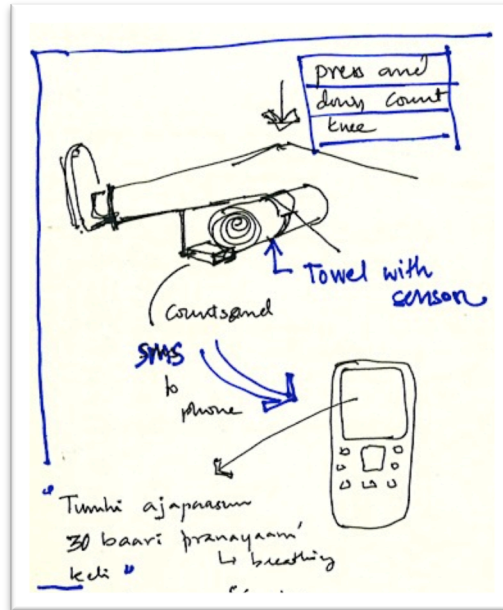


Figure 10.12: Early sketch for Madhav

However, in the subsequent interaction with Madhav and visits to his home, we came across how he hardly performs his knee exercises and considers the weight lifting and yogic breathing as the exercises, instead. We then had to reframe Madhav's context for compliance as an ecology-of-resource where he engages with the weight-lifting exercises as resources to remain fit, and with the yogic breathing exercises as resources for being mentally agile for managing all the social activities he is involved with. He engages with his knee exercises only when he feels the pain in his knees.

10.4.2.1 Design ideal

By reframing his context, we modified the initial vision. Now we envisioned a digital self-monitoring technology that Madhav can engage with as a resource to merge his favorable activities of yogic breathing and weight lifting with the knee exercises. We also envisioned a digital self-monitoring technology that Madhav may engage with as a resource to record the daily number of knee exercises he performs and employ this record as a resource to negotiate with Ravi.

10.4.3 Design sketch

The ReBreath is a support belt used while lifting weights in the gym that Madhav wears around his chest while doing his knee exercises (Figure 10.13). During the exercise, Madhav lies down with a rolled towel below his knees. When he applies pressure on the towel by pressing down the knees, he takes-in his breath, holding it as much as he can, and releasing it as he eases his knee back. The chest-belt detects the change in the chest

form and counts every expansion and retraction as one count. After 10 such counts, an LED is lit indicating that his exercise is done for the day. Further, the belt will send this information as a text message to his phone. We sketched this feature by employing a Wizard-of-Oz technique, manually sending the text message during demo and try-out with Madhav.

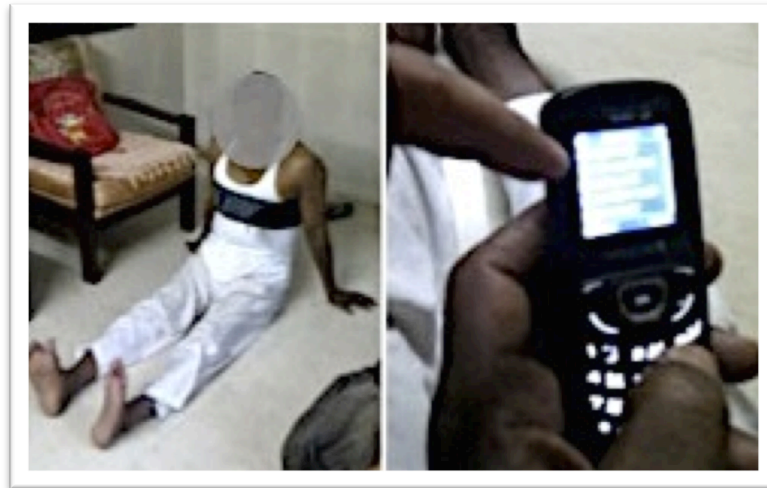


Figure 10.13: Madhav trying out the ReBreath gym belt and looking at the text message of his exercise counts

The ReBreath sketch captures early versions of the design ideal in the form of a wearable gym belt that counts the breathing and sends these counts as text messages to Madhav's phone. He can engage with the belt as a resource for turning his favorable activity of breathing exercises as a counting device to count his knee exercises. The sketch, by counting the breathing, opens an opportunity for Madhav to focus on his meditative breathing while exercising his knees, rather than focus on mentally counting the number of exercises. Further, he may engage with the text messages as daily record in his phone to show it to his therapist whenever he drops in the physiotherapy center. This may open an opportunity for his therapist to encourage Madhav to be more regular in his visits to the clinic.

10.4.4 Experiencing an early version of the design sketch

During the session of experiencing, Madhav wore the gym belt on his chest, and used his breathing to count his knee exercises. Being a fitness enthusiast, he did not stop there, but tried out different gym exercises where he can use breathing as a means of counting. He mentioned that controlled breathing is part of most of the exercises where he lifts weights, and he could use the ReBreath sketch to count even when he lifts weights. This display by Madhav pointed to us to how he may engage with the technology, merging his yogic breathing with the weight-lifting exercises, rather than with the knee exercises.

Seeing him trying out different gym exercises, we almost gave up hopes that he may engage with ReBreath as a resource to perform his knee exercises, but he did come back to them with an idea for self-pacing.

He mentioned that there must be a number display on the belt rather than LED, which shows the exact count for the exercise. He also wondered if the sketch could allow him to pace his exercises everyday, *“I do 10 exercises today, and it (the sketch) lights on after 10. Tomorrow I set the timer to 15, and after 15 counts the light switches on; this could be a much better way...I can then show my phone to the doctor whenever he complains that I do not exercise (smiles)...”* His exploration of the possibility of him pacing his knee exercises brought back some of our hope that he may, after all, engage with the self-monitoring technology as a resource for self-pacing his knee exercises and negotiating with this therapist about the counts.

10.4.5 Summary

We framed Madhav’s context for compliance as an ecology constituted by how he engaged with his therapist Ravi as a resource to negotiate the number and the frequency of his knee exercises. We took advantage of this framing to envision the first ReBreath sketch (Figure 10.12), which constituted of a simple pressure sensor that Madhav can engage with as a resource to monitor the counts of his exercise, and store these counts in the form of text messages on his phone.

However, during the exploration, we had to expand this initial framing to consider how Madhav engaged with his weight lifting and breathing exercises rather than his prescribed knee exercises. *We took advantage of Madhav’s engagement with these preferable activities* so as to envision a digital technology that can offer an opportunity for Madhav to perform his knee exercises along with his breathing and weight-lifting exercises.

10.5 ReEXERCISE

10.5.1 Design situation

Another couple that we engaged in the senior citizen neighborhood was the Patils. Prabhakar is a 78-year-old man who had a stroke two years earlier that has left him partially paralyzed. He can walk around the house with the help of a walking stick, but cannot go out due to a weak nervous system. He lives with his 74-year-old wife in a modest house with a living room, kitchen, and a single bedroom. The Patils described how, after the stroke, which occurred two years ago, Prabhakar is now dealing with a weak spine, and has to perform exercises everyday at home. He performs his physiotherapy exercises twice a day: after breakfast and before dinner. These exercises consist of lying down on the hard bed in the living room (Figure 10.14A) and lifting his torso by pushing his weight onto his elbows. When Prabhakar demonstrated these exercises, Laxmi told him to keep his elbows straight and also intervened to make them straight (Figure 10.14B). Later on, going through the video of these interviews, we saw how Laxmi tried to motivate Prabhakar to exercise. Laxmi is always present to help her husband perform the exercise correctly and kept encouraging him to exercise. During the interview, it was Laxmi who took the initiative to overview Prabhakar's exercises and asked him to demonstrate it.



Figure 10.14: A) Prabhakar exercising at home. B) Laxmi playing a motivating guide.

Before the Patils shared their exercise routine, Madhav brought forward a common matter of concern¹⁵ about the lack of care shown by the Indian sons towards their aging parents. I was struggling to repeat the question for the Patils with my limited skills of spoken Marathi. Madhav jumped in the conversation to ask Laxmi the question (in Marathi),

¹⁵ Right from our first visit to the Senior Citizens' Club, Madhav remained focused on the seniors' concern about sons' lack of care. He also mentioned how happy he was that his sons take care of him and his wife.

“Don’t you ever feel that your sons should be living with us? (Then he turned to me, speaking in English) that’s the main question you forgot to ask. (Laxmi started to cry while Madhav continued) I asked this because they will not say anything about what they feel in the absence of their own son. They will be happier if their son would stay with them. That is the main reason why they are upset. That’s why they divert their minds to TV and gods.”

Laxmi could not control herself and asked us if she can leave the room. Madhav then explained that the Patils have two sons and four daughters living in different suburban areas of Mumbai with their respective families. While one of the daughters lives nearby and calls and visits them regularly, the Patils feel let down by their sons. The sons do not call and only visit once a month or so.

The Patils have turned to more spiritual ways to fill this emotional gap. When we asked Laxmi about her routine, she said,

“I watch religious programs on the television, and I pray twice everyday. It gives me peace, sometimes when I am troubled and worried I just sit and pray.”

This was also evident in the videos we recorded. They had framed pictures and idols of gods (as Hindus they worship many) all around the house. These could be found on the walls in the living room and on the television. They also had a special corner in the kitchen where they prayed everyday.

10.5.2 Ecology-of-resources

Based on this moving interaction with the Patils, thanks to Madhav’s intervention¹⁶, we reframed Prabhakar’s context as an ecology-of-resources that highlighted how Prabhakar engaged with Laxmi as a resource to motivate and guide him to perform the exercises. Further, we included the way the couple engages with religious idols and spiritual activities as resources to deal with their displeasure about their sons’ lack of care. However, we did not consider this lack of care directly as part of this ecology. For one, we did not have the time to meet their sons and discuss these issues with them, and secondly we felt overwhelmed by this sadness, not knowing how to deal with it in pursuing the larger design goals of the thesis. Instead, we focused on the religious ways of their life, and the strength they give to each other.

¹⁶ Refer Lutz et al [2013, forthcoming] for a Science and Technology Studies inspired take on Madhav’s ‘serendipitous interruption’ and how it shaped the design process.

10.5.2.1 Design ideal

By reframing Prabhakar's context, we envisioned how Prabhakar may engage with a digital self-monitoring technology as a resource for closely involving Laxmi in his exercises, and as a resource for Laxmi to continue and enhance her involvement in her husband's exercises. We also envisioned how Prabhakar may engage with a digital technology as a resource for turning his performance of the exercises as a way of praying to god.

10.5.3 Design sketch

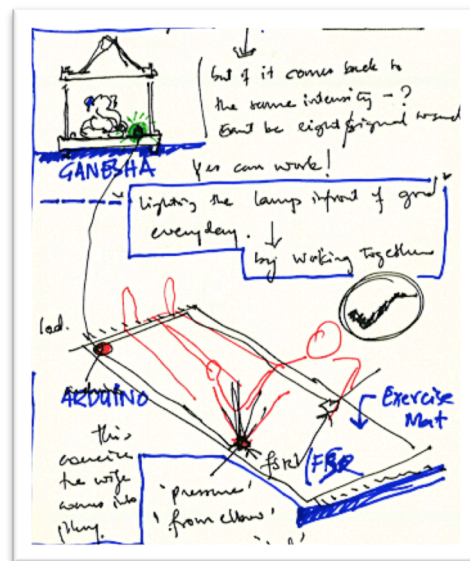


Figure 10.15: Paper ReExercise sketch showing the exercise mat and the LED connected to Ganesha idol

The ReExercise sketch constitutes an exercise mat with a FSR connected to a LilyPad Arduino. An LED is connected to the Arduino and is fixed on a small idol of Ganesha (Figure 10.15 shows a paper sketch and 9.16 the hardware sketch), the elephant god worshipped by the couple. During his exercise, Prabhakar lies on the exercise mat and positions his elbow on the FSR. The force he puts on the elbow when lifting his torso is registered, and the LED in front of Ganesha is lit. The brightness of the LED is based on the force he exerts on the FSR, the maximum being the force applied when his hand is perpendicular to ground, as prescribed by his doctor. The LED switches off gradually after 8 hours, and he has to switch it on again the next day by exercising.

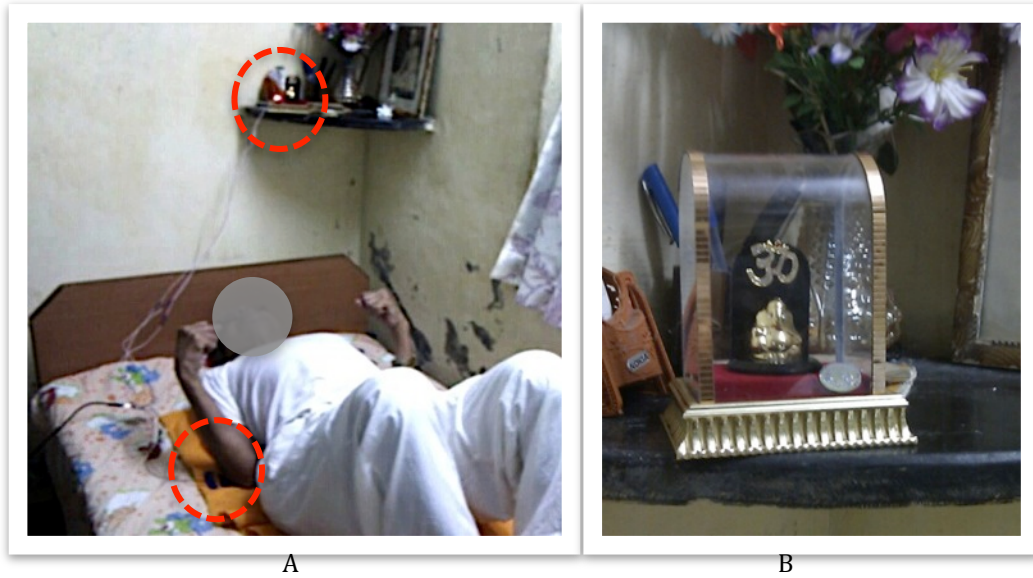


Figure 10.16: A) Prabhakar exercising with the ReExercise mat connected to the LED on Ganesha idol (B) The Ganesha idol in detail

The sketch manifests early versions of the visions held by the design ideal in a particular form. Firstly, Prabhakar may engage with the sketch along with Laxmi to get real-time feedback of how he is exercising, based on the degree of brightness of the LED. Further, Prabhakar may engage with the sketch as a resource to light up the LED lamp in front of Ganesha by performing his exercise everyday. This opens up an opportunity to enhance his exercise experience and take it to a more spiritual experience.

10.5.4 Experiencing an early version of the design sketch

We took this sketch to Patils' home, demonstrating to them how it works, and asked Prabhakar to experience and enact how he may engage with it. He laid down on the exercise mat, while Laxmi placed his elbows on the FSR. Prabhakar being a Hindu cannot show his feet towards the idol of Ganesha. Hence, when he started the exercises, the idol was behind his head. Laxmi had to read the feedback from the LED and communicated it to him,

“Keep this (his elbow) straight, it (LED) has to be brighter.”

After the exercise, we showed Prabhakar the video of the exercise he did, telling him the relation between the right posture of his elbow and the brightness of LED on Ganesha. He was happy when Laxmi pointed out,

“See you really lit it bright.”

This interaction between Laxmi and Prabhakar was close to what happened between Gita and Kumar. Here due to the religious arrangement and Prabhakar not being able

to see the feedback, Laxmi was closely involved in the monitoring process. Later on, as we sipped hot tea prepared by Laxmi, she gave us her feedback,

“This thing (FSR) has to be bigger. It will help to position the elbow in the exact position.”

Then she mentioned that she was happy that we kept the LED on Ganesha,

“It is good, we can keep this Ganesha here in the living room and keep lighting it up; we light the lamp in front of idols (that they keep in the prayer alcove in the kitchen) twice everyday.”

10.5.5 Summary

We took the insight about the spouse’s role as part of the initial framing during ReExercise so as to consider how Prabhakar engaged with Laxmi as a motivational resource. *We deliberately took advantage of the close social-relation between Laxmi and Prabhakar* to envision a digital technology that, by working with the way the couple exercises together, could support Prabhakar to engage with Laxmi to read and communicate the feedback and to encourage him to perform his exercises twice a day.

During the exploration, Madhav’s intervention brought up how the couple lives with a feeling of loss and neglect and engages with spirituality as a resource to motivate them to continue, not just to exercise, but also to live in general. With this feedback, we modified the initial framing to include how the couple engages with their spirituality to be motivated in life. *We took advantage of how the couple engages with the spiritual everyday activities* and envisioned a digital technology that the couple can engage with as a resource supporting to perform the boring exercises as part of performing the more engaging spiritual activities.

11 FINDINGS: Offering opportunities for shaping compliance through design

In this chapter, I move from the specifics of the individual design situations and present common findings across the situations in the form of seven assertive statements. Through these assertive statements, I demonstrate how supporting embodied-self-monitoring through design offers opportunities for the rehabilitees to shape the ways through which they comply with the prescribed treatment. These seven assertive statements are in no way a complete picture, but a beginning of an articulation of a larger space of possibilities; they are seven of the possible opportunities.

The explorations provided possible scenarios of how rehabilitees could engage with digital technology, which is designed for supporting embodied-self-monitoring, in order to shape their ways of compliance. Following a concept-driven IxD research approach gives me an opportunity to synthesize these possible scenarios in the form of assertive statements. Through these statements, I highlight what embracing the ways of compliance offers towards designing pervasive self-monitoring technology supporting rehabilitee compliance. By presenting the findings in the form of assertive statements, I make them open for contention and critique by researchers working in the domain, and hence invite them in a process of exploring and articulating the larger space of possibilities.

11.1 SEVEN OF THE POSSIBLE OPPORTUNITIES

The explorations brought forward different scenarios of how supporting embodied-self-monitoring opens opportunities for the rehabilitees to engage with the digital technology as a resource to shape their ways of compliance. I synthesize these scenarios to highlight how supporting embodied-self-monitoring offers seven of the possible opportunities, listed as follows:

1. Opportunities for a rehabilitee to become one's own reference for performing the exercises and monitoring the progress.
2. Opportunities for a rehabilitee to perform the actions of recollecting, reflecting, and articulating the performance of the exercises.
3. Opportunities for a rehabilitee to prepare for the periodic meeting with his/her therapists.
4. Opportunities for a rehabilitee to perform the actions of sharing with family and friends.
5. Opportunities for a rehabilitee to integrate exercises with the objects he/she lives with.
6. Opportunities for a rehabilitee to turn everyday activities as legitimate ways of exercising and integrate the exercises with other everyday activities.
7. Opportunities for a rehabilitee to integrate the exercises with social relations.

11.1.1.1 Supporting embodied-self-monitoring offers opportunities for a rehabilitee to become one's own reference for performing the exercises and monitoring the progress.

We found how using multimedia tools—such as video—for recording the performance of exercises offer the rehabilitees an opportunity to engage with the technology as a resource for indexing the progress they have made in rehabilitating the affected body part. When the rehabilitees access the database of the recorded videos, audio notes, etc., they can see how their own body has healed over time and the relation of this healing to the particular settings within which they perform their exercises.

During both the MagicMirror explorations, version 1.0 and 2.0, Anita and Anna imagined and experienced how by video recording their own exercises they could engage with their own body as an index for seeing how they have healed over time and across the different settings where they exercised. They employed these videos as 'reference videos' to help them guide and monitor how they perform these exercises at home. However, they engaged with the videos, recording, and watching them in different ways.

Anita was more receptive to the idea of simultaneously viewing on her TV the reference exercise, overlapped with the video of her current exercise, even as she is performing the

exercise in her living room. She also mentioned how by looking at this video of her own body, she could visualize the progress she made over time. The reference video showed her performing the exercise for the first time at the clinic. When the video of her current exercise was overlapped on this reference video, Anita got the immediate visual feedback of how much more she could stretch her hands above her head, as compared to the first day of her treatment. During the exploration, Anita also imagined how, if she could go through the daily videos of the exercises, she could see for herself how she has progressed over the days. In this way we found how self-monitoring her exercises by recording the videos, and watching the live-videos along with the reference video while exercising, offered an opportunity for Anita to see her own body as a reference or an index of getting better over the days.

Anna, however, was not so impressed by the simultaneous viewing of the current video, which was overlapped on the reference video, while she was exercising. During the exploration at her home, we found that Anna moves about her house when she performs her exercise. She performs the sit-stand exercise with the help of the dining chair, and the stepping exercise on the small flight of stairs that lead from the living room to the dining room. Hence, the video not only had to play on the TV, which was in the living room, but also had to be portable. Additionally, Anna felt that the overlapping would confuse her visually as to which is the reference exercise, and which is the current one. She mentioned how she would prefer to look at the reference exercise video before she begins her exercises, while relaxing in the living room. She also mentioned that she would look at the videos of the exercises she performed in the home, after she has performed them, in order to gauge for herself how she has made a progress.

In this way, we found how performing embodied-self-monitoring by recording and watching the videos of their exercises opened opportunities for Anita and Anna to engage with the technology as a resource to become their own reference idols for performing the exercises and gauging the progress they made.

11.1.1.2 Supporting embodied-self-monitoring offers opportunities for a rehabilitee to perform the actions of recollecting, reflecting and articulating the performance of exercises.

During the explorations we considered a rehabilitee's actions of recollecting, reflecting and articulating, not isolated mental tasks, but embodied actions performed in concert with the particularities of the setting. This consideration led us to explore how supporting these embodied actions of engaging with the recorded self-monitored data could open opportunities for the rehabilitees to turn it as a period where they can recollect past experiences, reflect on their progress, and articulate how they perform their exercises

over time. By articulating the self-monitoring data—looking at the video database, digging into historical trends, relating the history of exercises to the progress they made, or making notes and annotating the recorded data—the rehabilitees can gather materials to support their intuitive or ‘felt’ awareness of progress they are making in complying with the treatment.

Anita pointed out to how looking at the videos of past exercises can help her recollect specific episodes of her performance of exercises. In particular, she imagined how by looking at the videos, provided they are organized according to the dates, she could recollect and remember how she felt when she exercised during that particular day.

Meanwhile, it was Anna who pointed to us the possibility of how engaging with the recorded videos while lounging in her living room could provide her materials to reflect on her rehabilitation. She mentioned how she would like to look at the recorded videos from the rehabilitation clinic before she performs the exercises at home, making notes about what exactly she needs to do. She also mentioned how she would spend her evenings to look at the videos of the exercises she performed at home, comparing with the reference videos, and in general reflecting on how she is making a progress. Further, during the exploration, we did not involve Anna in making the materials for her to share with her therapist. Anna’s lack of participation during the staged participation at the clinic highlighted how engaging with the video and the sensor material—watching the videos, selecting particular parts of it, making audio notes, taking pictures of specific ways of exercising, etc.—is crucial for Anna to reflect and articulate the collected data about how she performed her exercises at home.

This insight led us to conceptualize the design of ReDiary as a personal journal that consists of videos of the rehabilitees themselves exercising everyday. We explored with Anna on how sitting with ReDiary in the afternoon, flipping through its ‘pages’, seeing the videos of the way her exercises have evolved over time can become a period of self-reflection. Further, she can annotate the videos and the synchronized sensor data with audio notes, insert pictures, and make small snippets of the videos for sharing with friends and family. In other words, Anna can articulate and work with the recorded data in order to make better sense of how she complies with her treatment.

On a different note, the ReWall sketch intends to add a decorative-textile layer to Gita’s living room wall, offering an opportunity for Gita to employ the self-monitoring technology to emphasize the fixed spot where she exercises everyday. By intending to become a fixed object that displays subtle, ambient information about the daily levels of exercises, the ReWall sketch pointed to how Gita can engage with the self-monitoring

technology as a ‘visual marker’ that can subtly trigger recollections about immediate history of exercises.

11.1.1.3 Supporting embodied-self-monitoring offers opportunities for a rehabilitee to prepare for the periodic meeting with their therapists.

Further, we found how supporting the rehabilitees perform the embodied actions of articulating the recorded self-monitored data opens opportunities for them to turn this period of articulation as a period where they gather and prepare materials for the periodic meeting with the therapists at the clinic. By going over the self-monitored data at home and articulating it—annotating the videos, making notes, taking additional pictures—the rehabilitees can gather a rich set of materials to put forward their concerns and collaboratively articulate with their therapists.

As mentioned before, we did not involve Anna in the preparation of the materials for the simulation of the periodic meeting between her and Rasmus, her therapist. This led to a situation where Anna could not talk and articulate to Rasmus how she performed the exercises at home with the help of the electronic sketch, and he had to encourage her by asking leading questions. This debacle pointed to us the importance of Anna’s engagement with the recorded material so that she can be prepared to share and articulate how she performed the exercises at home, what goals she can achieve and how to modify, or set new goals with her therapist. We envisioned that by engaging with ReDiary Anna could take to articulate the recorded data, marking them with her concerns, carry this articulated data to the clinic. During the meeting, she can employ the diary as a rich source of materials to bring forward her concerns, such as pain during specific exercises, or how she modified the exercises due to the arrangement of furniture at home, etc. In this sense, the MagicMirror exploration pointed to how supporting the rehabilitee perform the embodied actions of articulating the data can offer them an opportunity to develop a more sophisticated ‘language’ to discuss with their therapists, who have an already established expert language to talk about the rehabilitation process.

Meanwhile, Madhav’s therapist Ravi pointed to us about how Madhav does not comply with the knee exercise treatment, but comes in to the clinic whenever he feels the pain in his knees. While exploring the ReBreath sketch, which records the everyday count of Madhav’s exercise and stored them in a folder of text messages in his mobile phone, Madhav mentioned how he can show these messages to Ravi as a ‘proof’ of his compliance. Furthermore, Madhav speculated how he and Ravi can negotiate and agree on the daily number of the exercises that he has to perform. Ravi can feed this number in the phone, which can communicate this threshold number to the sketch, so that it

switches on an LED after he performs this fixed number of exercises per day. In this sense, though ReBreath dealt with basic self-monitored data—i.e. the count of exercises—that are presented in the form of simple text messages, Madhav could imagine how going through these messages could help him in negotiating his rehabilitation goals with Ravi.

11.1.1.4 Supporting embodied-self-monitoring offers opportunities for a rehabilitee to perform the actions of sharing with family and friends.

Informed by the embodied interaction perspective, we considered that sharing data about rehabilitation with friends and family as an embodied action that a rehabilitee performs. We found how supporting sharing as an embodied action through design offers opportunities for the rehabilitees to engage with the self-monitored data as specific objects through which the rehabilitees can convey stories about how they comply with their rehabilitation treatment with family and friends.

Anna wondered if she could take pictures about her exercises at home so as to share that with her friends when they visit her. ReDiary envisions how she can select the specific episodes by marking the specific videos and images and, due to its envisioned form-factor, pass it around to share with her friends. The sketch of ReDiary in this sense points to how Anna can engage with such a personal device and turn it as a resource to create a personal digital album consisting of images and videos that can be passed around.

During the ReSwing exploration, Gita employed the trophies and the decorative objects that she makes as objects to tell her life stories. This prompted us to speculate if she can similarly engage with the recorded self-monitored data to tell stories about her rehabilitation process to prospective rehabilitees visiting her for advice. ReSwing by displaying the self-monitored data in the form of a trophy opens an opportunity for Gita to engage with it and make it a fixed object in her living room, along with other trophies and awards. Gita may employ the rehabilitation trophy as a prop to share rehabilitation stories, similar to the way she shares her music stories, with her friends and family. Gita mentioned how, during the deployment week, she discussed the trophy to her visiting daughter showing how she exercises with the swing and how that is reflected in the trophy. Kumar, when he saw his name along with the name of his wife on the trophy, recollected his efforts in the rehabilitation of his wife and shared the episodes with us.

11.1.1.5 Supporting embodied-self-monitoring offers opportunities for a rehabilitee to integrate the exercises with the objects at home.

Presenting the self-monitored data in the form of physical artifacts pointed to how supporting embodied-self-monitoring could offer opportunities for the rehabilitees to engage with the recorded data as a resource to integrate the exercises with the things and objects they surround themselves with at home. This was particularly evident in the ReHandle explorations set in India. I have already mentioned above how ReSwing-trophy offered an opportunity for Gita to make the recorded self-monitored data part of the constellation of awards and memorabilia in her living room.

In a similar vein, ReWall, by subtly displaying Gita's daily exercise data at the same spot where she performs these exercises daily, can become a fixed part of her living room. Furthermore, because of its textile and wall-hanging form, it pointed to how Gita could engage with a digital technology as a resource to make it a part of similar such decorative pieces in her living room. In hindsight, it might have been more fruitful to involve Gita in making the textile wall-hanging and working with her more closely to fix the sensors in a manner that suits her aesthetic appeal. However, Gita indicated how even this first instance of ReWall sketch seems like a part of her living room, and speculated how she could use it while in Pune visiting her daughter.

ReExercise explores this possibility for integration with objects by fixing the LED based feedback in front of an idol of Ganesha. The LED changes its brightness based on the amount of pressure Prabhakar exerts on his elbow during his exercise. Having this feedback, which will be persistently lit for 8 hours after he exercises, as part of the idol presented Prabhakar and Laxmi an opportunity to convert the self-monitored data as a spiritual object part of their living room.

11.1.1.6 Supporting embodied-self-monitoring offers opportunities for a rehabilitee to turn everyday activities as legitimate ways of exercising and integrate the exercises with other everyday activities.

We found how by supporting the rehabilitees to integrate the self-monitored data with the different objects at home, further offered opportunities for them to integrate the exercises as part of other everyday activities that the rehabilitees perform.

ReWrist, ReBrush and ReNinety^o explored the early versions of this possibility. ReWrist, by tracking the number of times a rehabilitee rotates his/her wrists, points to how a rehabilitee can engage with such a wearable tracking technology as a resource for exercising the wrists even as he/she performs everyday activities such as opening a door, or cooking. Anna can attach the ReBrush to her toothbrush, and engage with this

combination as a resource to pace her exercises that she performs while brushing her teeth. ReNinety°, a wearable device, detects if a rehabilitee is approaching the prescribed 90° angle while bending his/her hip, it vibrates and gives a warning. Our speculation was that by using this device over time, the rehabilitee can train their bodies to know how much it can bend, and hence gain confidence over the physical abilities to perform everyday activities such as picking up a towel, feeding the cat, etc.

We carried these early speculations into the ReHandle explorations. Gita already had integrated her knee exercises with enjoying the ride on the swing in her garden. We took advantage of Gita's integrated way of exercising, and intended to open an opportunity for her to engage with the digital technology as a resource to keep a track of when she exercises, and make this data visible as part of her living room. The dexterous form of the ReSwing-mat offered opportunities for Gita to use it on the swing, or as she mentioned and demonstrated during the exploration, on the foot-operated sewing machine as resource through which she can track how she moves her knees during these activities.

ReBreathe, meanwhile, came about in a situation where Madhav preferred to perform his weight-lifting and yogic breathing exercises rather than the prescribed knee exercises. The sketch of ReBreathe, by intending to measure the number of times Madhav holds his breath, pointed to how he could engage with the yogic breathing exercises as a resource to count and keep track of his knee exercises. The form of ReBreathe as a weight-lifting support belt further pointed to how Madhav's engagement with digital technology opens up an opportunity for him to, firstly, keep count of his weight-lifting exercises along with the count of his knee exercises and secondly, as he demonstrated to perform his simple knee exercises while he is doing some of the stretching and warming-up exercises at the gym. In this sense, exploring how to support Madhav's embodied actions of self-monitoring opened opportunities for him to envision how he could engage with digital technology as a resource to integrate the 'boring and mundane' knee exercises with the more 'exciting and favorable' gym and breathing exercises.

ReExercise further explored this thread of supporting embodied-self-monitoring to offer opportunities for the rehabilitees to integrate the tedious prescribed exercises with other more exciting or engaging activities. Prabhakar and Laxmi's spiritual ways of living, which was manifested in the range of idols of gods adorning their living room and the prayer routines, were the more exciting or engaging activities that ReExercise focused on. By lighting the LED display in front of Ganesha, Prabhakar can engage with the digital technology as a resource to convert his exercises as a way of praying: Lighting a lamp in front of the idol twice a day.

11.1.1.7 Supporting embodied-self-monitoring offers opportunities for a rehabilitee to integrate the exercises with social relations.

Finally, we found how supporting embodied-self-monitoring offered opportunities for the rehabilitees to engage with digital technology as a resource to integrate and bring their close social relations as part of the exercises. We encountered this possibility accidentally during the ReSwing exploration, which was explored further in ReExercise.

Kumar was actively engaged in managing the physical rehabilitation process of his wife, Gita. This motivating role became apparent when we visited their house to see how they were living with the sketch of ReSwing. We did not design the frequency of the flickering LEDs to reflect the speed with which Gita swung back and forth on the swing. However, we noticed that when Gita exercised with the swing in her garden, Kumar was in the living room, ‘reading’ the frequency of the flickering LEDs on the trophy and telling her if she has to increase her speed or slow down. This happen-by-chance experience pointed out how Gita engaged with the ReSwing swing as a resource to involve Kumar in closely monitoring her exercises.

We further explored this insight during ReExercise. Prabhakar being a Hindu cannot show his feet towards the idol of Ganesh. Hence, whenever he exercises with the ReExercise sketch, the idol is always on the alcove behind his head, an arrangement that was formalized during the demonstration. This arrangement offered an opportunity for Prabhakar to continue Laxmi’s involvement to read the feedback from the LEDs and communicate it to him. At the same time, this arrangement opened opportunity for Laxmi to engage with the digital technology as a resource to gently encourage Prabhakar and remind him of the correct way to hold his hand while exercising.

11.2 SUMMARY

In summary, these findings highlight how self-monitoring is embodied in the ways of rehabilitee compliance through engaging with a range of particularities at hand. Embracing this embodiment of self-monitoring led us to explore some of the possible scenarios where the rehabilitees could engage with digital self-monitoring technology as one of the resources, working in concert with others in a setting, for shaping the way they comply with the prescribed treatment. I synthesized these possible scenarios to highlight how supporting the embodied actions of self-monitoring through design opens seven of the possible opportunities for the rehabilitees to shape their ways of compliance.

I position these seven opportunities as examples of the fruitfulness of the theoretical concept of embodied-self-monitoring in exploring new ways of supporting the rehabilitees to comply with their treatment through engaging with digital self-monitoring technology in concert with other resources as a part of a context.

12 INSPIRATIONAL-SUB-PATTERNS

In this chapter, I articulate the three ways in which we embraced the way the rehabilitees engaged with the particularities of a setting—with the everyday activities, objects, and social relations. I do this by synthesizing and packaging our experiences of engaging across the design explorations, in the form of three *inspirational-sub-patterns for embodied-self-monitoring*. These are:

1. Embodied-self-monitored data is tied to positions of everyday activities
2. Material objects become tokens of embodied-self-monitored data
3. Embodied-self-monitoring is tied to close social relations of the rehabilitees

I draw on two inspirational patterns for embodied interaction as proposed by Löwgren. I position the first two sub-patterns as sub-sets of these well-established I-patterns, but with a particular focus on the design for embodied-self-monitoring. The third sub-pattern highlights the social aspect of embodied-self-monitoring, and hence acts as a tangential critique of Löwgren's patterns, which do not explicitly consider the social aspects of embodied interaction. I propose these sub-patterns as offering concrete directions for the design practitioners towards embracing the situated and embodied ways of compliance in the design of digital technology for supporting embodied-self-monitoring.

I briefly outline my motivation for synthesizing the examples in the form of inspirational-sub-patterns, followed by a brief description of the method. I then present the three sub-patterns.

12.1 I-PATTERNS AS TRANSFERABLE FORMATS

In Chapter 7, I discussed how the designerly knowledge emerged through this thesis is situated as part of the particular design situations of the explorations. As a consequence of following a concept-driven methodology, I am responsible as a design researcher to shape this situated knowledge into a transferable format, so that it becomes more conducive for other design researchers and practitioners to translate the knowledge into generating new design examples while engaging in different design situations of designing for embodied-self-monitoring.

For this reason, I look towards Löwgren's 'inspirational patterns for embodied interaction' [Löwgren, 2007]. As discussed in Chapter 7, Löwgren proposes the I-patterns as a format to structure the ongoing designerly discourse (about embodied interaction in his case), and orient it towards generating inspirational and transferable design knowledge. He envisions how designers can synthesize different design examples in the form of inspirational patterns, and publish them as their propositions to shape the ongoing discourse towards particular directions.

In line with this, I present three inspirational-sub-patterns for embodied-self-monitoring, for pointing to how designers can embrace and take advantage of the rehabilitees' embodied acts of compliance in order to design for embodied-self-monitoring.

12.1.1 Method

Löwgren's patterns are synthesized by a group of designers, as collective knowledge suggestions. Further, the examples they discuss have evolved over years to define a well-established domain of designing for embodied interaction.

However, the sub-patterns that I present here emerged out of our experiences in engaging with sketching and exploring the prospects offered by supporting embodied-self-monitoring. I draw on a limited range of examples from related work [Balaam et al, 2011] as they have a clear, a priori intention of designing for supporting the situated aspects of how rehabilitees comply with their therapy.

I follow Löwgren's suggestion for synthesizing the sub-patterns presented here. They are described so that they are 'envisionable'. They are 'grounded' in well-illustrated and accessible examples. They are presented in statements that are 'refutable and criticizable' by other interaction design researchers.

12.2 INSPIRATIONAL-SUB-PATTERNS FOR EMBODIED-SELF-MONITORING

The three sub-patterns are described with the help of short statements that captures the essence of the pattern, which are derivatives of the original I-patterns. These statements remind the designers about the possibilities they offer for designing for embodied-self-monitoring. A short text further describes the sub-pattern, highlighting some of the particular design situations where this pattern may be of use. This is followed by relevant examples.

12.2.1 Embodied-self-monitored data is tied to positions of everyday activities

Löwgren proposes how *virtual information is tied to positions in the material world*. This I-pattern points to how designers can take advantage of an ongoing activity by fixing information related to the activity to particular positions within the context for the activity. This fixing of information opens up opportunities for performing various embodied actions such as learning, sharing, and collaborating.

Looking back at our experiences of taking advantage of how the rehabilitees engaged with everyday activities to perform their exercises through this I-pattern, I propose that *embodied-self-monitored data is tied to positions of everyday activities*. This sub-pattern highlights how fixing the recorded self-monitored data to particular positions of the everyday activities, opens up opportunities for the rehabilitees to engage with the data as resources for performing embodied acts of self-monitoring such as recollecting, sharing, integrating with favorable activities, and social relations.

For example, in ReWall we fixed the data to the textile wall-piece hung beside the place where Gita exercises everyday, which pointed to how Gita may engage with the technology as a resource to get ambient and subtle reminder about her exercises. Gita may engage with the technology as an aesthetic resource that triggers conversation about her rehabilitation when her friends visit.

In ReBreath we connected the measuring of Madhav's exercises to the activity of controlled yogic breathing, which pointed to how Madhav may engage with performing and monitoring his knee exercises while he performs the yogic breathing.

In ReExercise, we fixed the feedback, about the amount of pressure Prabhakar exerts during exercising, on the Ganesha idol that is kept on the corner alcove near the bed where he exercises. This pointed to how Prabhakar may engage with the technology as a resource for closely involving Laxmi as an encouraging partner.

12.2.2 Material objects become tokens of embodied-self-monitored data

One of the I-patterns highlight how ‘material objects are tokens of virtual information’. This I-pattern points to how designers can take advantage of everyday objects that people engage and live with by fixing information related to an activity to these objects. Fixing the information to the objects opens up opportunities for the people to engage with digital technology in ways similar to their ongoing engagement with the familiar material as resources to perform various embodied actions.

Looking back at our experiences of taking advantage of how the rehabilitees engaged with familiar objects as resources to perform their exercises through this I-pattern, I propose that *material objects become tokens of embodied-self-monitored data*. This sub-pattern highlights how fixing the recorded self-monitored data to the everyday objects that the rehabilitees engage with to perform their exercise, opens up opportunities for engaging with the data as resources for performing embodied acts of self-monitoring such as reflecting, articulating, sharing and integrating exercises with favorable activities.

For example, we took advantage of how Anna engaged with her exercises on the wooden flight of stairs, and envisioned the design of ReDiary to be portable. This pointed to how Anna may engage with the diary as a personal object to recollect, reflect, and articulate on her progress while sitting in an armchair in her living room.

We envisioned the trophy of ReSwing to display the text about successful periods of rehabilitation, and sometimes to display images too. Engaging with these data, Gita may turn the trophy as a resource to recollect specific episodes of her rehabilitation, and as a resource to trigger conversations with visitors.

Rehab reader [Balaam et al, 2011] is another example where the designers take advantage of the familiar object—a squeeze ball—in order to open opportunities for a rehabilitee to engage with the technology as a resource to link the exercises training better grasping to the activity of reading a book from a tablet PC. The design envisions how a rehabilitee can employ a squeeze ball as an input modality to interact with the tablet PC to move the text forward/backward, change font, etc.

12.2.3 Embodied-self-monitoring is tied to close social relations of the rehabilitees

This sub-pattern proposes that by taking advantage of the close social relations that the rehabilitees engage with opens opportunities for engaging with the digital technology as a resource, which works in concert with these relations, to shape their ways of compliance.

We encountered this sub-pattern accidentally in the case of ReSwing. But by consciously taking advantage of how Prabhakar engaged with Laxmi as an encouraging resource we envisioned ReExercise, which pointed to how Prabhakar may engage with the ensemble of technology and Laxmi together as a resource to get immediate feedback of his exercises along with motivational words.

Another example is the Ball Funnel [Balaam et al, 2011], where the designers take advantage of the close relation between a mother who is undergoing rehabilitation and her child. They envision a design that the rehabilitee can engage with as a resource to integrate her exercises as part of a family game. The game involves her throwing a ball in a funnel, which is collected by her child and returned back to her. Further, each ball makes a particular sound when it passes through the funnel, enhancing the experience of game play. This keeps the child motivated to play, who in turn may motivate the mother to exercise by throwing the ball into the funnel.

This sub-pattern does not take off directly from the original I-patterns, as the I-patterns do not consider in depth the social aspects of embodied interaction. ‘Interactive and broadcast media combine to form a positive spiral of participation’ is the only pattern that considers the social aspects, but is focused on the larger social community rather than the close and intimate, one-to-one relationships.

12.3 SUMMARY

In this chapter, I synthesized my experiences of designing for embodied-self-monitoring in the form of three inspirational-sub-patterns. I position them as early inspirational material that the designers in the field can take on to expand their repertoire about designing for self-monitoring. In particular, these sub-patterns point to the three ways in which the designers can take advantage of the embodied ways of rehabilitee compliance: Everyday activities, familiar objects, and close social relations that the rehabilitees engage with to comply with their prescribed therapy.

13 DISCUSSION AND CONCLUSIONS

In this chapter I discuss the outcome of the thesis and draw conclusions based on this discussion.

Firstly, I present the primary outcome of the thesis: The compositional whole of this thesis. Following this, I discuss the implications the compositional whole offers to the field engaged in designing and developing pervasive self-monitoring technology for supporting rehabilitee compliance.

I then move towards broader and speculative implications of the compositional whole that arise as a consequence of engaging, firstly, with embodied interaction perspective on context, and, secondly, with the socio-political-local settings of physical rehabilitation across Denmark and India. These implications though speculative are grounded in the experiences of engaging in the design explorations presented in this thesis.

I discuss how the ontological and methodological device of ecology-of-resources points to a very early, yet promising avenue to explore in order to embrace the emergent context in the design for embodied interaction. Following this, I discuss how the design explorations, though carried out for the reason of exploring the possible scenarios of interacting with pervasive self-monitoring technology, indicate an approach towards addressing the broader concerns of the physical rehabilitation domain about the need to support rehabilitee compliance in order to reduce public healthcare costs. Within this section, I discuss the limitations of the findings and discuss the questions they open up.

13.1 PRIMARY OUTCOME: the compositional whole

Physical rehabilitation offers a rich case for the initiatives designing and developing pervasive technology to support compliance with a prescribed treatment process beyond the setting of a clinic. The clinic has various digital and other technological tools, and prescriptions that help the therapists to monitor and articulate the rehabilitees' exercise routines. Supporting the rehabilitees to access these tools, prescriptions, and routines during their everyday life at home seems a direct step to take in order to support them to effectively perform their exercises at home. As described in Chapter 3, both the theoretical concept of self-monitoring, and the aim to realize the ubiquitous computing vision of integrating digital technology as part of everyday life underlie the works taking this step. In this sense, moving the tools, prescriptions, and routines from the clinic and placing them in the 'container of the home' seems an obvious direction to take towards developing technological tools for supporting rehabilitee compliance.

However, as discussed in Chapter 3, recent field study works [Axelrod et al, 2009; Maitland & Chalmers, 2010] highlight how complying with treatment at home is situated in a particular social and material contexts. These works urge the emerging field to acknowledge the way compliance is situated in particular contexts in the design of pervasive technology for supporting rehabilitee compliance.

Aligning with these works, the thesis began with a motivation of exploring the prospects offered by the embodied interaction perspective towards *embracing* the context within which the rehabilitees comply with their treatment in the design of pervasive technology supporting self-monitoring of physical rehabilitation. I positioned embracing as a design stance that goes beyond acknowledging, but focuses on taking advantage of the ways through which the rehabilitees comply with their therapy.

Taking the embodied interaction perspective on the context where compliance happens meant considering it as a particular context where complying with a treatment makes sense: *A context for compliance* in other words. I defined the context for compliance as:

An emerging relation between the particular actions that the rehabilitees perform in order to comply with their treatment and the particular setting within which these actions are performed.

In Chapter 3, the thesis demonstrated how the recent works designing and developing pervasive technology to support rehabilitee compliance are underlined by the concept of self-monitoring. Taking the embodied interaction perspective on this concept of self-monitoring I formulated the theoretical concept of embodied-self-monitoring as:

Measuring, recording, observing, and performing other such self-monitoring actions through engaging with the particularities of a setting for complying with a prescribed treatment.

Following this, I defined ‘designing for embodied-self-monitoring’ as

Designing pervasive self-monitoring technology for offering opportunities for the rehabilitees to engage with the technology, and through this engagement, make the technology become a part of how they comply with their therapy.

Following a concept-driven research-through-design approach, I explored the design for supporting the embodied actions of self-monitoring in two series of design explorations: MagicMirror and ReHandles. I did this through the device of ecology-of-resources to frame the particular contexts for compliance and embracing such framing in design. These explorations brought forward different sketches that captured early versions of the design ideals of supporting embodied-self-monitoring, and the experiences of the participants enacting the possible scenarios of engaging with pervasive self-monitoring technology as a resource to shape their ways of compliance.

I synthesized these scenarios to highlight how supporting embodied-self-monitoring offers seven of the possible opportunities for the rehabilitees to engage with pervasive self-monitoring technology as one of the resources to shape the way they comply with the therapy. These seven opportunities were:

1. Opportunities for a rehabilitee to become one’s own reference for performing the exercises and monitoring the progress.
2. Opportunities for a rehabilitee to perform the actions of recollecting, reflecting, and articulating the performance of the exercises.
3. Opportunities for a rehabilitee to prepare for the periodic meeting with his/her therapists.
4. Opportunities for a rehabilitee to perform the actions of sharing with family and friends.
5. Opportunities for a rehabilitee to integrate exercises with the objects he/she lives with.
6. Opportunities for a rehabilitee to turn everyday activities as legitimate ways of exercising, and integrate the exercises with other everyday activities.
7. Opportunities for a rehabilitee to integrate the exercises with social relations.

In each exploration, I reflected on our experiences of framing-reframing the individual contexts for compliance as ecology-of-resources and taking advantage of such framing in

order to design for embodied-self-monitoring. I synthesized these reflections in the form of three inspirational-sub-patterns for embodied-self-monitoring. These sub-patterns were:

1. Embodied-self-monitored data is tied to positions of everyday activities
2. Material objects become tokens of embodied-self-monitored data
3. Embodied-self-monitoring is tied to close social relations of the rehabilitees

The understanding of the context for compliance, theoretical concept of embodied-self-monitoring, the design explorations, the findings and the sub-patterns, together constitute the *compositional whole* of this thesis. As a consequence of engaging in an in-situ concept-driven research-through-design, this compositional whole contributes to the different fields and domains it draws from at different levels (Figure 13.1).

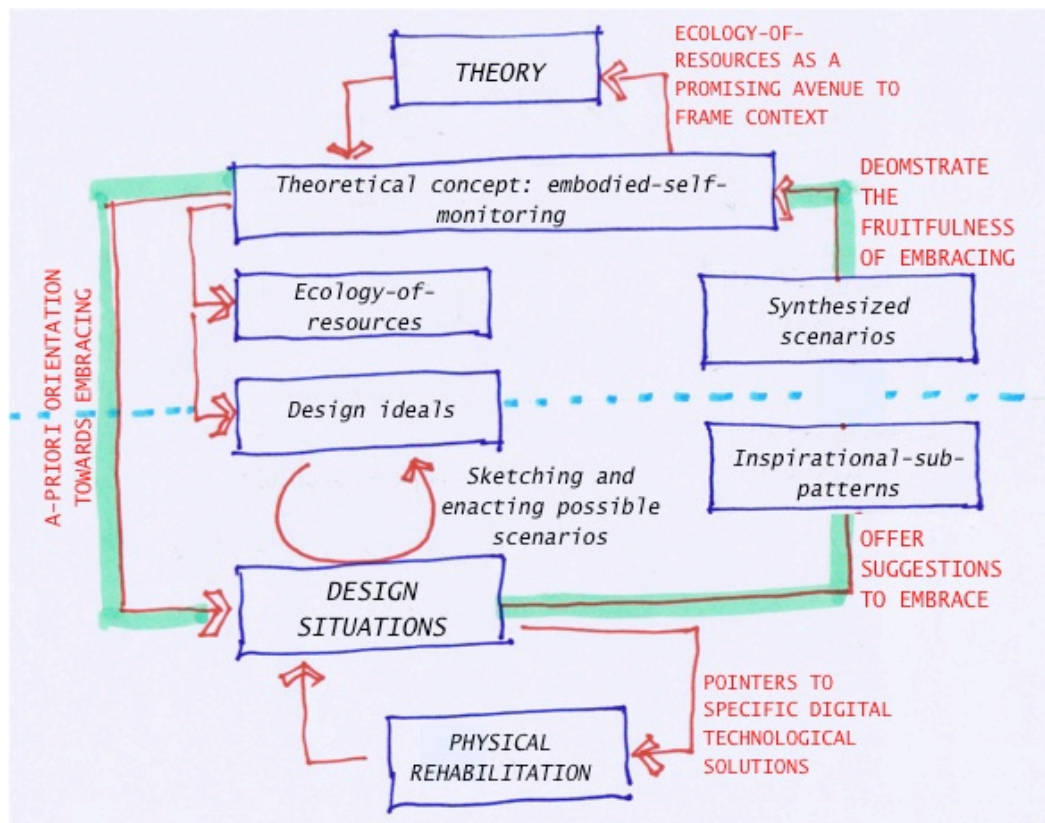


Figure 13.1: The compositional whole

Offering conceptual and empirical contributions towards the field of designing pervasive self-monitoring technology to support rehabilitee compliance is the central role of the compositional whole. This compositional whole offers contributions towards both, the research and design community engaged in the design and development of pervasive self-monitoring technology to support rehabilitee compliance. This dual nature of the contribution is due to the way knowledge is constructed in a concept-driven interaction

design research: Engaging with actual design situations of physical rehabilitation in order to explore the prospects of a theoretical concept. Below I deliberate on these contributions, highlighting the conceptual and empirical aspects of these contributions.

13.1.1 Conceptual Contributions

The compositional whole, firstly, suggests a conceptual shift for considering what is a context: It is a *context for compliance* that emerges through a rehabilitee's engagement with the particularities of the setting in order to comply with therapy.

Secondly, the theoretical concept of embodied-self-monitoring offers an a priori orientation to the researchers and the designers to *embrace* this emergent context for compliance. As mentioned before, embracing here is a design stance of taking advantage of the way a particular context emerges through the rehabilitee's engagement with the particularities of the setting. Further, the theoretical concept reminds how self-monitoring is not a feature to be designed into the digital technology, but *an embodied action that has to be designed for*.

Following the concept-driven methodology, the fruitfulness of this orientation towards embracing is demonstrated by the seven of the possible opportunities opened by the explorations for the rehabilitees to engage with pervasive self-monitoring technology as one of the resources to shape the way they comply with therapy. These opportunities together give a picture, which though is not complete in any sense, that points to seven of the possible ways through which the rehabilitees can engage with pervasive self-monitoring technology and *through this engagement incorporate* it as part of their ecology-of-resources. In this sense, these statements exemplify the prospects offered by embodied-self-monitoring in opening new avenues for the design of pervasive self-monitoring technology through which the researchers and designers can work towards offering a range of opportunities for the rehabilitees to shape their ways of compliance.

Thereby, the compositional whole offers embodied-self-monitoring as a fruitful theoretical concept that can be developed into one of the core theoretical grounds informing the field of designing pervasive self-monitoring technology. In particular, it informs the design of digital self-monitoring technology that opens opportunities for the rehabilitees to engage with the technology and incorporate it as resources working in concert with other resources to shape the ways of compliance.

13.1.2 Empirical contributions

Our experiences of engaging in the explorations packaged in the form of the three inspirational-sub-patterns inform the community of design practitioners within the field

of designing pervasive self-monitoring technology. In particular, the sub-patterns remind the designers towards how they can take advantage of the everyday activities, familiar objects, and close social relations that the rehabilitees engage with in the design of digital technology for supporting embodied-self-monitoring. In this sense, they serve as early inspirational material, expanding the repertoire of examples for design practitioners in different design situations of designing for embodied-self-monitoring.

Further, the format of the sub-patterns opens up the suggestions as invitation to the interaction design researchers for engaging in a discourse about designing digital technology for embodied-self-monitoring. In line with Löwgren, I provide this format for other interaction designers and researchers to criticize, modify, reject, and extend the group of suggestions, thereby, developing these sub-patterns towards more established knowledge formats of a designerly discourse about embodied-self-monitoring.

At the same time, the compositional whole also offers pointers and indicators that open new avenues towards addressing specific concerns in the broader field of designing for embodied interaction, and towards addressing the larger societal concerns about increasing rehabilitee compliance. In the following sections, I deliberate and discuss these contributions in the focus of what new they have to offer for the respective fields and domains.

13.2 EMBRACING THE CONTEXT IN DESIGNING FOR EMBODIED INTERACTION

As has mentioned frequently, the thesis takes the embodied interaction perspective to consider and embrace the emergence of a context for compliance. However, the central aim of taking this perspective was to explore the design of digital technology to support the rehabilitees' embodied actions of self-monitoring. Yet by embracing the various contexts for compliance across the design explorations, the thesis pointed to how the tension, between understanding a 'context' as emergent and relational and designing digital technology that can be engaged with and made a part of this context, can be resolved.

As discussed in Chapter 4, 'context' is much discussed and analyzed in the field of ubiquitous and pervasive computing. The aim of integrating digital technology as part of everyday activities inherently means taking account of the context where these activities happen. Thereby, the field is engaged in a discourse about how to design digital technology to be integrated as part of a context [Abowd et al, 1999; Dey, 2001].

Within this field, works of Dourish [2001] and Svanaes [2001] take a phenomenological perspective to provide an alternative view of context. They highlight how context is not a pre-given stable container, but an emerging relation between human actions and their settings. Dourish, in particular, proposes embodied interaction as a fruitful framework for generating designs of novel digital technology that can be engaged with and incorporated in the emergent context.

However, taking the embodied interaction perspective in a particular design situation is still a challenge that the designers face [Fernaes et al, 2008; Hornecker & Buur, 2006]. The particular challenge is to formalize or frame a context that is constantly emerging. The understanding of context leaves not much of room for the designers to formalize or model the context into entities and their inter-relationships, as these are constantly evolving over time and space. Thereby, there is a room for a concrete approach that can give a designer a better handle on the emergent context [Chalmers, 2004]. As described in Chapter 4, there seems to be a tension here between the need to formalize for design, and the need to be open for considering the situated and emergent aspects of human interaction. I read this as a methodological tension arising with a move from understanding ‘how the world is’ to a position from where a designer can propose ‘how the world could be’.

Over the course of the design explorations, this thesis attempted to resolve this tension so as not only to acknowledge, but also embrace, the emerging context for compliance. The thesis did this through the *framing device of ecology-of-resources*, which is informed by the phenomenological perspective on ‘everyday human coping’ [Dreyfus, 1991] and a designerly approach [Schön, 1983].

13.2.1 The framing device of ecology-of-resources

Aiming to design digital technology for supporting embodied-self-monitoring meant taking a stance of *embracing* how the participant rehabilitees considered their home as a rich source of resources for compliance, and through their engagement with these resources made their homes particular contexts for compliance.

In order to do so, we employed ecology-of-resources as a *framing device* to frame a particular context of a rehabilitee, and take advantage of what was framed. As described in Chapter 4, I took help of Dreyfus to understand the minute and nuanced aspects of how people engage with the particularities of a setting, and through this engagement make emerge a particular context for their actions. This understanding led to the formulation of ecology-of-resources as:

*A frame to **see** the phenomenon through which a person engages with the particularities of a setting, turning them as available resources so as to perform purposeful actions; in other words a frame to **see** the phenomenon of an emergence of a particular context.*

In line with Schön's [1983] understanding of design, 'seeing' here is beyond looking and understanding at how things are, and involves taking an active stance to explore how things could be, in conversation with the design situation. Reflecting on the explorations, as evidenced in the summaries of each exploration, it becomes clear how this act of framing or 'seeing' a particular context as an ecology-of-resource was not a one-time formalization of the context, but we had to constantly modify the framing through a situated and 'designerly' engagement with the context, and in turn modify the context itself. We had to frame and reframe the emerging context in each exploration, actively and collaboratively choosing what relations to take advantage of.

This framing-reframing of an emergent context for compliance was a matter of forming 'framing judgments' [Nelson & Stolterman, 2003]. We had to actively make judgments, in collaboration with the participating rehabilitees, their spouses, and professional therapists about what particularities constitute their context for compliance, and what does not make sense to engage with. In this sense, making these framing judgments was an activity of conducting a series of 'frame experiments' [Schön, 1983]. As Figure 13.2 illustrates the framing-reframing of a context as an ecology-of-resources involved a constant conversation with the design situation; they constantly modified each other.



Figure 13.2: Framing as a conversation with the design situation

For example, we entered the MagicMirror exploration with an initial frame of how Anna moved across her home and clinic in order to comply with her treatment. This was reflected in the sketch for recording exercise videos across the home and clinic. However, this broad framing had to be tempered with how Anna employed the stairs rather than

the stepper, and the chair in the dining room. Taking advantage of this modified frame, the sketch of the display was modified to a portable form.

Meanwhile, the therapists were on board with the initial idea of videos as the central form of recorded data that they could engage with to collaborate with Anna. However, as the exploration evolved, we encountered the possibility of how watching the videos would mean an increased investment of therapist's effort and time, and they would rather look at the processed overview from the recorded sensor data. At the same time, Anna imagined how recording her exercises in the format of videos helped her not only to gauge her own progress, but also employ them as materials to articulate how she performs her exercises at home. In this manner, we framed and reframed Anna's emerging context for compliance through the activity of sketching, collaboratively deciding what object, people, and technology could become a resource in this ecology. This framing made way for us to take advantage of how Anna already engaged with the various resources to comply with her therapy. The ReDiary sketch came about through this process of framing, reframing, and taking advantage of the framed context. The sketch pointed at the various ways through which Anna can engage with the digital technology as a resource in concert with the steps, the chairs, her built awareness of progress, the therapist's instructions, etc. in order to shape the way she complies with her therapy.

This collaborative process of framing-reframing and taking advantage was the common pattern across the explorations presented in this thesis. Thereby, the design explorations can be seen as early examples of how employing the framing device of ecology-of-resources opened a space for speculating and exploring various scenarios about digital technology that can be engaged with as resources, not in isolation, but in concert with the already engaged resources, and through this engagement be incorporated in the particular contexts.

13.2.2 Discussion

There have been several studies within HCI that take an ecological approach to understand the context of human meaning making and create ontological models that can be applied in the design of digital technology [Nardi & O'Day, 1999; Crabtree & Rodden, 2008; Lindtner et al, 2008]. In the following sections, I discuss how the framing device of ecology-of-resources, as informed by the phenomenological and designerly perspectives, differs from these studies. Through this discussion I intend to highlight the early promise held by the framing device towards addressing one of the challenges of the

field of ubiquitous computing and designing for embodied interaction: to design digital technology to be integrated with the context.

13.2.2.1 Taking an ecological perspective to understand context

Chalmers and Galani [2004] term this context as ‘heterogeneous media’ that consist of both physical and digital media that the people engage with to deal with their everyday activities. Crabtree and Rodden, [2008] argue that the recent combinations of mixed reality environments with ubiquitous computing infrastructures have lead to the formation of ‘Hybrid Ecologies’: geographically distributed environments, which merge interaction across physical and digital environments. An ethnographic study [Lindtner et al, 2008] of collaborative practices across the physical environments of China’s Internet cafes and the gaming world of War of Warcraft suggests a broadening of the existing notions of physical-digital hybridity as a multi-dimensional environment. Inspired by information ecologies [Nardi & O’Day, 1999] the work furthers the notion of hybrid-ecology as ‘Hybrid Cultural Ecology’. They position this ecology as an analytical framework to look at and understand the dynamic relationships of cultural value systems with the digital and physical artifacts and environments, in other words, the context.

Elsewhere, the phrase ‘ecology-of-resources’ has been employed as an ontological framework to model a context of a learner [Luckin, 2006; 2008]. Luckin draws from socio-cultural theory and the discourse about context in the ubiquitous computing field to propose a learner centered model of context. The central aim for this modeling is to characterize the various social, physical, and cultural resources that are available for a learner within a particular context, so as to design educational technology to scaffold learning. Luckin proposes that a learning context be considered as an ecology-of-resources, which is, “*a set of inter-related resource elements, including people and objects, the interactions between which provide a particular context*” [p. 452, Luckin, 2008]. This ecology consists of a learner at the center, and is categorized into the constituents of ‘knowledge’ that is shaped by a ‘curriculum’, and ‘resources’ that are influenced by an ‘administration’. In this sense, ecology-of-resources is an ontological model that formalizes a context of learning into these broad categories, with an aim of designing pervasive educational technology.

13.2.2.2 Ecology-of-resources: an ontological and methodological frame

Ecology-of-resources in this thesis, however, is employed not only as an ontological frame to understand how a context for compliance emerges, but also as a methodological frame to embrace in design this emergence of a context.

Following a phenomenological perspective means moving away from any fixed, permanent and a predetermined categorization of the exact resources that people engage with. As detailed in Chapter 4, things, people, and cultural norms *become* resources through people's engagement with them. Hence, any a priori fixation of resources leaves out the emergent aspects of the context.

By employing ecology-of-resources as both an ontological and a methodological device, we could frame reframe various contexts for compliance throughout the explorations, collaboratively identifying which of the things, person, and norm becomes a resource for compliance. Through this process, we could fruitfully take advantage of the framing and explore possible scenarios of how a digital self-monitoring technology can be engaged with and incorporated or appropriated as part of this context.

From this experience of embracing the various contexts for compliance, I suggest, for the broader community of ubiquitous computing and designing for embodied interactions, that the framing device of ecology-of-resources could be a fruitful avenue to explore. More than answering the question of how to frame a particular emergent context in the design for embodied interaction, the thesis opens up the following question:

What if we consider framing as simultaneous ontological and methodological acts influencing and shaping each other, rather than categorizing the ontological relations in a context first and then moving towards design?

I suggest that the framing device of ecology-of-resources as employed in this thesis becomes a precursor of an approach to answer this question.

13.3 TOWARDS SUPPORTING REHABILITEE COMPLIANCE: reducing the cost of healthcare to society

Chapter 2 described the challenges faced by the domain of physical rehabilitation to support the rehabilitees comply with their therapy at home in order to reduce the healthcare costs on society. The thesis, though engaged with actual rehabilitees and their actual settings of rehabilitation, cannot claim to offer a defined and specified solution addressing the concerns of the rehabilitees, mostly due to its orientation towards theorizing about interaction with digital self-monitoring technology. However, as a consequence of engaging in the *in-situ* explorations, the thesis both opens up pertinent questions, and together with other situated design approaches [Balaam et al, 2011] points at some possibilities for the development of specific digital technological solutions.

Before I discuss the questions and possibilities opened up by the thesis, I briefly discuss the limitations of the design explorations.

13.3.1 Limitations of the explorations

Firstly, the explorations are situated in the settings of individual rehabilitees, sketching early versions of bespoke digital technology that is oriented towards addressing the particular rehabilitee, their family, and therapist's concerns. Following a concept-driven research methodology makes it viable for synthesizing the various individual scenarios envisioned and experienced in these explorations can be fruitfully synthesized. As demonstrated in Chapters 11 and 12, through this synthesis the thesis theorized about how the scenarios indicate at seven of the possible ways through which the rehabilitees can engage with digital technology designed for embodied-self-monitoring as a resource to shape their ways of compliance. However, synthesizing these findings across the broader population of rehabilitees is foolhardy, and opens up the research for critique about very small sample size. Hence, the thesis makes no explicit claims about how the explorations actually offer solutions to improve the situation of the rehabilitees, but due to the in-situ engagement, point at possible solutions that could address the situation of the individual rehabilitees.

Secondly, due to the time factor and the decision to engage in a range of design explorations, the technological component of the sketches is very nascent. The sketches could only demonstrate what can be called as very early visions of possible solutions, and did not go towards the level of prototypes. While these open-ended sketches augur well for a concept-driven exploratory research, they leave a lot of room for further development of specific technological solutions. Hence, the thesis makes no explicit claims about how the sketches represent specific technological solutions.

13.3.2 Questions and possibilities

The thesis, however, opens up what I believe to be pertinent questions to the people engaged in developing specific technological solutions for encouraging rehabilitee compliance beyond the boundaries of academic research. These questions are as below:

1. How to engage with and design for non-compliant rehabilitees?
2. How does the introduction of digital technological solutions affect the ongoing practices and relations?
3. How to legitimize the different ways of rehabilitee compliance?
4. How to design for a broader set of rehabilitee populations?

13.3.2.1 How to engage with and design for non-compliant rehabilitees?

The rehabilitees participating in the design explorations were all almost complying with their rehabilitation, though in different ways than prescribed. The only exception was

Madhav who performed the knee exercises only when it pained. While this engagement with compliant rehabilitees goes well with the aim of the thesis to embrace the ongoing ways of compliance, it leaves out a larger set of rehabilitees who do not comply with their prescribed therapy. However, I believe, the example of Madhav gives an anecdotal example of how a designer can engage with such non-compliant rehabilitees and evolve towards a solution that can help them perform their exercises along with performing more favorable activities.

13.3.2.2 How does the introduction of digital technological solutions affect the ongoing practices and relations?

The design explorations did not go extend beyond a month of engagement with the participants. However, within this short-term engagement, we could see how introducing novel digital self-monitoring technology may change and affect the ongoing practices and relations. For example, in the MagicMirror exploration, the therapists, who were initially enthusiastic about using video as a medium of communication, realized the effort and time they have to invest to go through the myriad videos produced by the rehabilitees as the exploration evolved. MagicMirror brought forward a brief glimpse of how a personal device such as ReDiary can change the relation between the therapists and the rehabilitees and modify the way they practice rehabilitation currently. I believe that being open for such glimpses in the early phases of design may be fruitful towards a better adoption and appropriation of the technological solutions.

13.3.2.3 How to legitimize the different ways of rehabilitee compliance?

In the Danish explorations, the therapists played a key role, deciding what counts as an exercise and what does not count. For instance, when the therapists saw how Anna engaged with the stairs, the therapists suggested her some modifications in the stepping exercise so as to take into consideration the increased riser of the stairs as compared to the plastic stepper. However, in the Indian explorations, the physiotherapists were absent, except for Ravi, Madhav's therapist. The question then is how can Gita know for sure that the way she engages with the swing is a 'legitimate' exercise. While she is experienced enough to know that she is benefiting from exercising her knees by moving back and forth, what about new rehabilitees?

This thesis represents a move away from tele or remote monitoring, and stresses on self-monitoring. However, based on the experiences of engaging in the Indian explorations, I believe that for regions where accessing professional physiotherapists is difficult, a combination of remote and self-monitoring could be fruitful approach. Alternatively, identifying experienced rehabilitees such as Gita and giving them responsibility and

technological support to guide a community of new rehabilitees at the local level may also be a fruitful approach. This may be termed as a ‘community-monitoring’ approach.

13.3.2.4 How to design for a broader set of rehabilitee populations?

The design explorations, as has been repeatedly mentioned, involve individual rehabilitees and their rich settings. How to move the early visions of the possible technologies as represented by the sketches towards specific solutions that a larger set of rehabilitees can engage with?

This question has also been discussed by Balaam et al [2011]. In this work, the authors present four design explorations of similar bespoke technological solutions to support rehabilitee compliance. Based on the lessons from the four situated design approaches, the authors propose a ‘toolkit’ approach for the design of digital technology for motivating the rehabilitees to comply with their treatment at home. They urge the designers to work with the professional therapists and the rehabilitees, engaging them in their actual homes for on a long-term basis to design a toolkit consisting of simple input and output devices. The therapists and the rehabilitees can assemble them, customizing them to suit their therapy requirements, and how well it would fit with their everyday life.

I believe that such a toolkit approach could be a fruitful avenue to explore to move the early visions towards specific solutions for a broader rehabilitee population. The designers can engage with a set of therapists and rehabilitees to figure out what kind of sensors and displays may be fruitful for their situations. The therapists can offer this kit consisting of attachable sensors and displays that the rehabilitees can then attach to positions around where they perform favorable everyday activities, to their favorite objects, and/or wear them. By configuring both the sensors and displays along with the particularities of their setting, the rehabilitees can integrate the technological solutions as part of their particular context for compliance. The therapists then may fine-tune what the individual thresholds of the sensor should be, what the sensors should measure, etc. As described in Chapter 2, this fine-tuning is very close to their current role of fine-tuning the broad therapeutic prescriptions to suit the individual situation of the rehabilitees.

Finally, I believe such a toolkit approach acts as, what Suchman calls, ‘artful integrations’ [Suchman, 2011] where a close engagement with the particularities of a design situation leads to new technologies that open up the ongoing, familiar activities to new modes of action and configurations. These artful integrations are not radically new, but small,

continuous interventions that work through an engagement with localized, ongoing practices of rehabilitation.

13.4 CONCLUSION

Finally, I place the compositional whole as an argument for taking a phenomenological perspective in the design of pervasive self-monitoring technology so as to embrace the situated and embodied ways in which the rehabilitees comply with the prescribed therapy. In particular, I conclude by restating the central argument of the thesis: *Embodied-self-monitoring offers an a priori orientation to fruitfully embrace the emergent context for compliance in the design of pervasive self-monitoring technology for supporting rehabilitee compliance.*

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