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The Influence of User-Oriented Design Research on Framing

A Case Study of Including Patient Perspectives in Biomedical Engineering

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Abstract

Users' perspectives in health and assistive technology design are vital. However, bridging the gaps between different disciplinary approaches to framing problems that incorporate user experiences and values is challenging. The Patient-Centric Engineering in Rehabilitation (PACER) research project was selected to investigate the practical implications of insights into mobility from a focus group interview with lower limb prosthetic users. A follow-up ideation workshop with an interdisciplinary group comprising researchers from the PACER project was used to explore different disciplinary perspectives. Two ways to frame the project were identified: a technology assessment perspective and a human-centred design perspective. Our findings revealed that while all the disciplines in the workshop aimed to incorporate user perspectives, their ways of framing problems and solutions often reflected their methodological backgrounds and thus differed.

Introduction

In the design literature and design practice, framing has been proposed as a tool to create novel perspectives and engage with complex societal issues that transcend disciplinary boundaries (Dorst, 2015). Designers use *problem framing* and *re-framing* to produce frames, that is, new perspectives on situations, which help create novel standpoints to address the problems at hand (Pee et al., 2015, p. 1656).

The term framing was first introduced in the design literature by Schön (1992), who described the reflective practitioner. Schön's work contrasted with the more scientific approach to design as problem-solving, which was in line with Simon's (1988) definition of design as "changing existing situations to preferred ones". Whereas a more positivistic perspective towards problem-solving had been applied via previous methods, Schön described how practitioners approach the problems at hand through a process of *naming, moving* and *reflecting.* Using Schön's taxonomy as a starting point, scholars have explored the framing process to describe design processes in teams (McDonnell, 2018; Stompff et al., 2016; Stumpf & McDonnell, 2002; Valkenburg & Dorst, 1998).

Despite the importance of framing and collaboration, tensions and methodological difficulties may arise in collaborative research projects that involve practitioners from multiple disciplines with different framing practices. This challenge is particularly evident in health technology design, where technological complexities and innovation intersect with humanistic perspectives on health and well-being and require a shared understanding among practitioners across multiple fields (Giacomini, 2004; Owen et al., 2012). In health

technology design, the importance of including patients, next of kin and staff in the co-creation of healthcare services is recognised (World Health Organization, 2016). While Schön's (1992) foundational work on reflective practice has significantly shaped design thinking, his collaboration with Rein on frame reflection (Schön & Rein, 1994), which is critical for navigating political aspects of problem framing, remains underexplored. As design practices evolve into other domains, such as healthcare, the need exists for more explicit reflection on such problem framing because it occurs continuously in collaborative research involving other disciplines. Our study directly engaged with this aspect and aimed to incorporate frame reflection in interdisciplinary work. Given the inherently political and value-laden nature of design in the context of healthcare, the ability to reflect critically on one's own and others' frames is an indispensable skill for designers and their collaborators.

In approaches such as participatory design (Donetto et al., 2015; Spinuzzi, 2005), human-centred design (Steen, 2011) and person-centred healthcare (Leplege et al., 2007; McCormack et al., 2017), *lived experience* is essential from a methodological standpoint. However, including firsthand perspectives in a meaningful manner in the design process represents a gap in the literature (Oertzen et al., 2022). Although participatory and human-centred design inherently grapples with power dynamics (Bratteig & Wagner, 2016) and value differences (Détienne et al., 2019), explicit strategies for frame reflection within these methodologies remain an essential topic and underscore the need for our study.

It is therefore imperative to further explore the challenges presented by interdisciplinary collaboration during the early stages of the design and development of rehabilitation technologies. The available literature on the potential tensions and methodological challenges that may arise in collaborative research projects across multiple disciplines due to differences in framing practices is limited. Hence, knowledge is still needed on "how practices of other design professions might lead to the discovery of other frame creation practices and methods"(Dorst, 2015, p. 188). In particular, when participatory approaches are combined with quantitative methods, the framing of problems is not always easily described.

In this study, we focused on a particular problem-framing challenge through a case study of the Patient-Centric Engineering in Rehabilitation (PACER) project, which aimed to improve rehabilitation for lower limb prosthetic users. The PACER project consisted of an interdisciplinary team of computer science (Pinto-Orellana & Hammer, 2020a, b), human movement sciences (Mellema et al., 2021, 2022), design (Risnes et al., 2019, 2023, 2024) and biomedical engineering (Sherkat et al., 2019, 2020) professionals and received funding from

the Research Council of Norway to develop expertise in health technologies for the rehabilitation field.

Combining participatory design methods with biomedical engineering was both a challenge and an opportunity for the PACER project. A central perspective with respect to mobility in the project was to understand the human gait and mobility based on physiology and brain activity (Figure 1). The challenge was understanding mobility from this perspective alone, as it neither supports nor motivates lower limb prosthetic users towards improved functioning. The insights from a focus group interview with lower limb prosthetic users on limb loss and mobility were therefore used as a starting point for an ideation workshop with the PACER group to facilitate the integration of diverse perspectives. Using the ideation workshop data, we analysed how existing disciplinary frames from the literature could help describe the difficulties in achieving shared framing in interdisciplinary projects.

We focused on different disciplinary framing practices with regard to including patient experience in an engineering and design project. We explored disciplinary perspectives to describe possible framing practices based on the workshop ideas of the PACER team. To achieve such an ambition, we adopted a broad conceptualisation of framing building based on the work of Schön and Rein (1994). Schön and Rein described how making frames explicit through reflective conversation could make actors aware of their frames so that they can move beyond them (van Hulst & Yanow, 2016, p. 105). We drew on Schön and Rein's (1994) definition that frames are "underlying structures of belief, perception, and appreciation" (p. 22). This conception of frames allows for a relational perspective, which includes contextual and collaborative aspects, such as cultural, political and historical discourses.

Although Schön's work is the most influential in the design literature on framing, the concept has a rich history in other fields. Notable contributions include frame analysis, which was first introduced by Bateson (1972, p. 72) and Goffman (1974) and elaborated on by other scholars (van Hulst & Yanow, 2016, p. 94). The concept of sensemaking is also relevant to the concept of framing, as it describes the constant process of acquisition, reflection, and action (Kolko, 2010). Kolko's (2010) work and a review by Naumer and Dervin (2009) provides a good overview of the literature on sensemaking from the perspectives of design and information science. Furthermore, van Hulst and Yanow (2016, p. 97) delineated how the concept of sensemaking could also be seen, together with Schön's (1992) work, as describing how the practitioner interacts with non-human elements, such as materials and artefacts. According to a review by Mesgari and Okoli (2018), a shortcoming in the concept of sensemaking is the limited notion of the role of technological artefacts. However, from a

different perspective, the similarly rich literature on material hermeneutics includes how humans make sense of technology (Ihde, 1999; Kudina, 2021; Verbeek, 2003).

FIGURE 1.

Illustration by Risnes of the integration of technology that could be part of a potential rehabilitation service (Risnes et al., 2023).
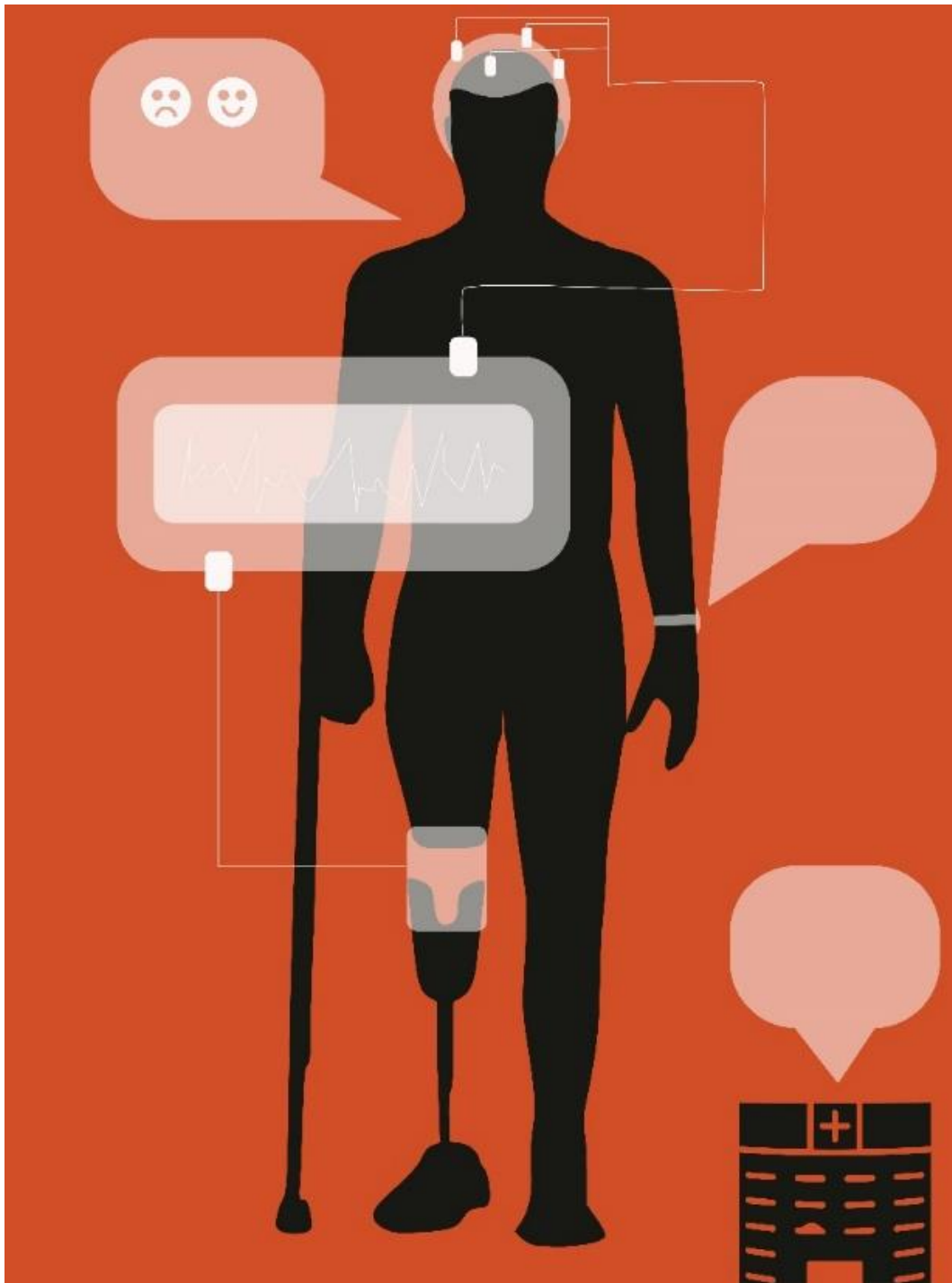
More knowledge about this topic is needed based on this state of the art. Through this study, we therefore sought to answer the research question: How does frame reflection influence interdisciplinary collaboration in the early stages of the design and development of rehabilitation technologies? In so doing, we aimed to shed light on the different ways of framing a project and to provide insights regarding the challenges faced in collaborative efforts across different disciplines.

Method

A case study approach was chosen as a suitable method for this study because of the intricacies of the empirical phenomena in the PACER project and the context-specific nature of the project (Dubois & Gadde, 2002, p. 555). The case study description included a description of two activities in the PACER project as the main source of data:

- A focus group interview with lower limb prosthetic users conducted by the PACER members

- An ideation workshop that included the PACER members

The analysis involved identifying frames based on the ideas generated during the ideation workshop and the overall case description. We consulted the literature on paradigms from the various disciplinary backgrounds within the PACER team to analyse how the overall project and disciplinary frames either constrained or assisted the participants in the workshop in integrating ideas from the focus group interview into their ideation. We used Rein and Schön's (1994) description of frames as a theoretical framework for the analysis.

The overall strategy for this work can best be depicted as a description of a case study using systematic combining, namely, "a process where theoretical framework, empirical fieldwork, and case analysis evolve simultaneously" (Dubois & Gadde, 2002, p. 555).

The PACER case description: Focus group interview with lower limb prosthetic users

A focus group interview was initiated by two of the PACER members in the early phase of the PACER project. The purpose of the focus group interview was to broaden perspectives on mobility based on users' experiences. The goal of the PACER project was to improve rehabilitation for the user group by applying novel brain activity sensor technology. However, in this early phase, the goal was to describe some of the challenges related to rehabilitation that the user group experienced on a more general level. These insights

included a multifaceted understanding of daily life after lower limb amputation, such as the psychosocial aspects of experienced mobility. A semi-structured focus group interview was conducted on the open-ended topic of daily life mobility with five lower limb prosthetic users. The data were analysed in accordance with Braun and Clark's (2006, 2020) reflexive thematic analysis. The analysis included three main themes and interpretations based on the participants' quotations. The coding and analysis were documented according to Braun and Clark's six steps (2020, p. 4) to ensure rigour by tracing the evolution of the themes.

TABLE 1.

Insights from a focus group interview of lower limb prosthetic users on mobility and limb loss.

Theme	Interpretation	Exemplar quotation
State of emergency: *Direct consequences of the amputation* *The conversation about mobility and rehabilitation was held with some of the participants relatively soon after their respective amputations, and mobility in relation to rehabilitation was affected by the amputation's direct physical and psychological effects.*	**Being prepared** Many of the participants expressed that they were not mentally prepared for the experience of losing a leg. For some of the participants, the amputation was a consequence of illness over time, and the amputation was planned in advance. For others, it happened without notice because of trauma. The participants experienced different levels of healthcare, and their opportunities to talk with a psychologist varied. Some were missing the service, while others did not feel the need for it at the time.	"The better prepared you are for something, the better it is, no matter what happens to you." "I was not prepared for anything, and I thought they had a psychologist, for instance, because it is quite traumatic to lose a limb. You cannot imagine it until you have experienced it."

Theme	Interpretation	Exemplar quotation
	Coping with the situation The participants had had different amputation experiences, but there was an overall theme of change from the ordinary. They needed to adjust in some ways to cope with their new situations.	"During the first period, you end up in a bubble, you are in a situation of attack." "I was so focused on walking again. But I hit a wall because I wanted to progress too fast." "And then no-one checks on you because you don't pull the cord and say you have problems."
Loss of independence: *Indirect consequences of the loss of mobility* *From the beginning of the interview, the term mobility was interpreted negatively by the participants because some of them could not move independently from one place to another. Because of the relatively short time since the amputationtheir experiences of mobility were their loss of independence. This loss of independence had many indirect consequences for*	**Changing roles** For many of the participants, mobility was connected to their roles in their households and closest social networks. With restricted mobility, the participants discussed how their roles changed pre- and post-amputation in terms of daily activities and household chores. Again, there was a difference between the newly amputated and the experienced prosthetic users who had had longer experience in regaining	"What I noticed when I got home was that I constantly had to ask for help." "Well, from being in the position of managing everything and fixing everything for everyone, you suddenly have to place yourself on the other side."

Theme	Interpretation	Exemplar quotation
social activities, family life, activities, self-esteem, etc.	mobility and adapting to some of these activities.	
	Changing relationships As a consequence of their changing roles and adaption to amputation and prosthetic use, the participants shared how this had contributed to changing the family's identity or their close relationships.	"The children feel it, that we're a bit different." "And I have a wife who has gotten used to it. Because it's about the relatives adjusting too."
Improving mobility *The concept of mobility or improving mobility consists of different practical aspects, such as planning, setting goals, mastering daily life and trusting the prostheses. These aspects were often closely connected to the participants' psychosocial environments.*	**Planning** he participants described planning differently, from planning each step when walking to planning whether to engage in social activities due to physical barriers, like the weather or stairs.	"It takes time to plan, and it is tiring." "Everything takes so much time, so you have to plan everything you're going to do."
	Setting goals Setting goals was an important part of rehabilitation and motivation for improved mobility. The importance of the role of personal goals was discussed. These goals were qualitative and concerned with achieving daily activities, such as going shopping, or pre-	"I think that those who are going to treat people have to be a little careful when setting goals for people. It requires tremendous insight into that person to set a goal for a person." "For some, just getting up in the morning and going to the toilet can be absolutely everything they imagined that day, and just being able

Theme	Interpretation	Exemplar quotation
	amputation activities, such as sports.	to do it can be an equally bold goal as skiing." "It was the last day today, and I had the goal of managing to go out and take the bus to the store or the city centre, and it is uphill on the way to the bus, and I achieved that goal now. I am so happy for that."
	Mastering daily life For those with new amputations, mastering daily life was considered essential to understanding their mobility. Mobility did not only relate to walking. Other assistive devices, such as an electric wheelchair, were, for some, an opportunity to regain some independence. However, some of the participants experienced stigma related to using a wheelchair. Being able to drive was another tool of independence for some of the participants. Participation in social activities with friends and	"There has been a lot of talk about having everything, but when I talk about mobility, it's about managing daily life with all the chores one normally did in an acceptable way." "So, towards the children, you do like this to make daily life work as best as possible all the time."

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Theme	Interpretation	Exemplar quotation
	family was also seen as essential.	

## The PACER case description: An ideation workshop

Because the PACER project was a research project, it could have a different structure compared to a purely practical project. Individuals had their own research goals and objectives outside of the project's main objective, which made it more challenging to define the roles and connections in the project (Risnes et al., 2019). However, the project had a clear cross-disciplinary agenda, and the ideation workshop aimed to connect technological developments with patient insights into rehabilitation and mobility issues. Although they had a mutually shared agenda of collaborating on a shared problem, the project members also had varied collaborative aims (Risnes et al., 2019).

The PACER members were invited to the digital workshop to ensure the inclusion of a variety of disciplinary perspectives on the insights gained from the focus group interview. Due to COVID-19 restrictions, the workshop was conducted via Zoom using the digital whiteboard Miro. Before the workshop, the PACER members received the findings from the focus group interview (Table 1). They were prepared to discuss the connections between their work and the focus group interview findings. A protocol was created to introduce more qualitative perspectives and to facilitate the participants' recognition of multiple ways of framing. The 10 PACER members in the workshop were from four disciplines: two from computer science, four from biomedical engineering, two from human movement sciences and physiotherapy and two from design. After two warm-up exercises to familiarise themselves with the Miro software, the participants were asked to discuss and ideate using the interview as a starting point in three smaller breakout rooms.

The facilitators comprised four of the 10 participants in the workshop: two from design and two from human movement sciences and physiotherapy. One of this article's authors led each breakout room to facilitate the discussions. The workshop ideation resulted in a mind map with the findings from the focus group interview as the starting point, and the ideas mentioned in the workshop were written down according to these findings. Due to challenges with the digital format, the participants had the opportunity to follow up on the workshop through a written elaboration of their thoughts and an informal conversation on the topic based on the mind map.

FIGURE 2.

Contributions from the different fields in the ideation workshop (Detailed examples in Figures 3 and 4).
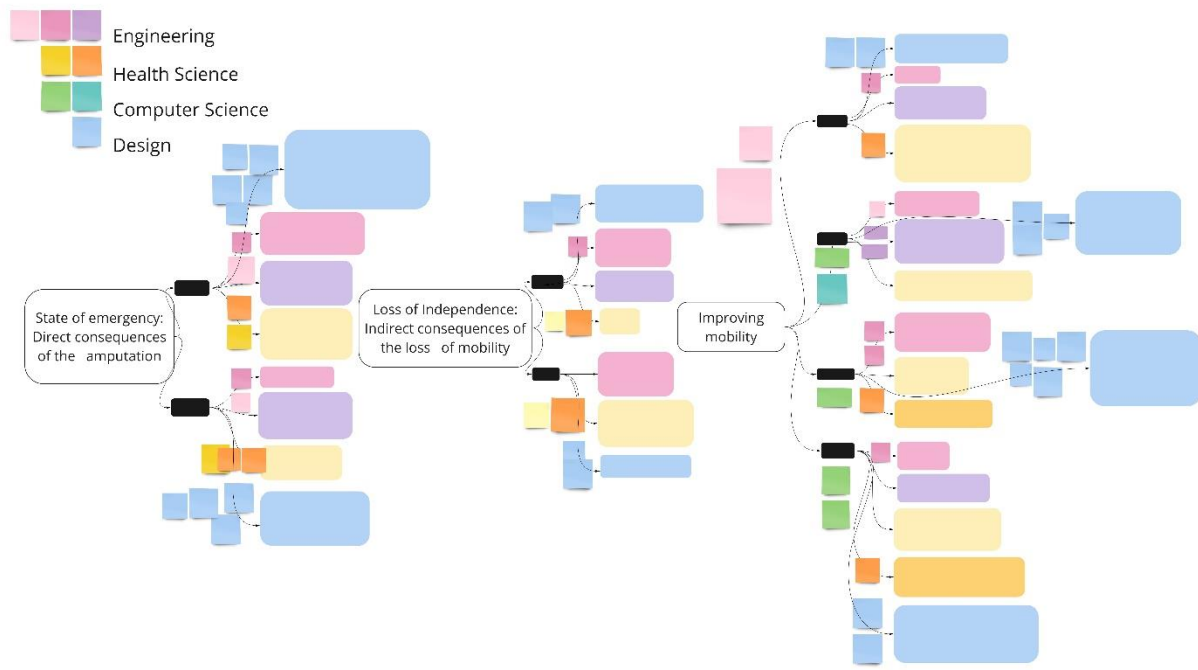
Analysis

The workshop data analysis was guided by the principle of frame reflection put forth by Rein and Schön (1994). This perspective suggests that framing is an often implicit process in which individuals define boundaries to make sense of situations, and it influenced how problems were approached within the PACER project. Hence, the ideas produced during the workshop revealed insights into the participants' explicit and implicit problem framing. Rein and Schön (1977) argued that "the questions we ask shape the answers [i.e. policy solutions] we get" (p. 236). We examined the ideas generated during the workshop to identify the problems the participants were trying to solve. We then constructed questions that could be answered by these ideas to organise the data thematically. We identified three key questions from the workshop data related to understanding mobility issues and altering the environment to accommodate them using techniques or technology:

- Can we use this technique or technology to understand some of the issues mentioned in the focus group interview?

- How can we best alter the environment to accommodate these issues?

- What knowledge do we need to understand mobility?

We then employed a pattern-matching strategy (Yin, 2017, p. 175) using the literature on patient participation based on the disciplines in the PACER project. Through this pattern-matching strategy, we aimed to analyse the workshop discourse and identify the underlying frames that could include ideas. The literature review included how disciplinary traditions with different participation practices influence the framing and innovation process. In our analysis, we also considered the potential constraints posed by the overarching framing of the PACER project. The pattern matching between the ideas thematically organised by the questions and participant practices in the literature led to the construction of two themes that described two different ways of framing the project.

Findings

Based on the PACER data, two different ways of framing the project were identified:

- A technology assessment perspective on possible applications

- A human-centred design perspective on psychological care within the health system

A technology assessment perspective on possible applications
The theme of the technology assessment perspective was constructed based on the logic identified through the question: Can we use this technique or technology to understand some of the issues mentioned in the focus group interview? Examples from the workshop included using non-invasive brain monitoring to understand phantom pain and human motion better and to develop prostheses and rehabilitation services accordingly (Figures 3 and 4).

One topic discussed in the workshop was how qualitative findings could be connected to the quantitative engineering research in the PACER project. The biomedical model is a central perspective in biomedical research (Mead & Bower, 2000). A biomedical model takes humans' biological and physiological functions as the foundation for comprehending bodily processes and functions to understand health and disease. In this context, technology is often made sense of as a device observing or improving these functions.

The biomedical model was not mentioned explicitly during the workshop, but historically, it was harder to connect to the holistic perspective of the focus group interview. An indication of this challenge from comments in the workshop included the limitations of technology to

improve the psychosocial aspects of the amputation process based on the focus group's insights.

Figure 3.
Examples from the ideation workshop supporting a technology assessment perspective of applications.
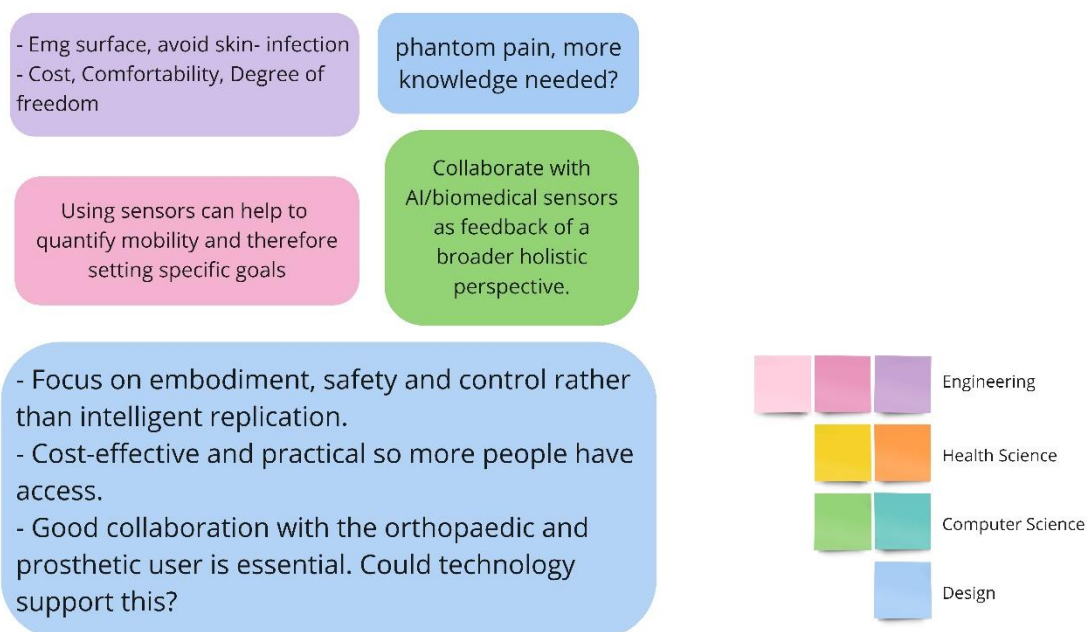
From a technology assessment perspective, the practical use of the interview reflected an awareness of the limitations of the biomedical model, such as its exclusion of user experience as part of the conceptualisation of mobility in technology development. In particular, the findings on trust and safety as essential qualities of prostheses resulted in an awareness of the importance of an engineering perspective that focuses not only on replicating able-bodied motion in prosthetic technology. Similar findings were reported by Walker et al. (2020), who framed a prosthetic design to support user autonomy.

FIGURE 4.

Activities from the lab using wearable non-invasive brain monitoring technology (Risnes et al., 2023).
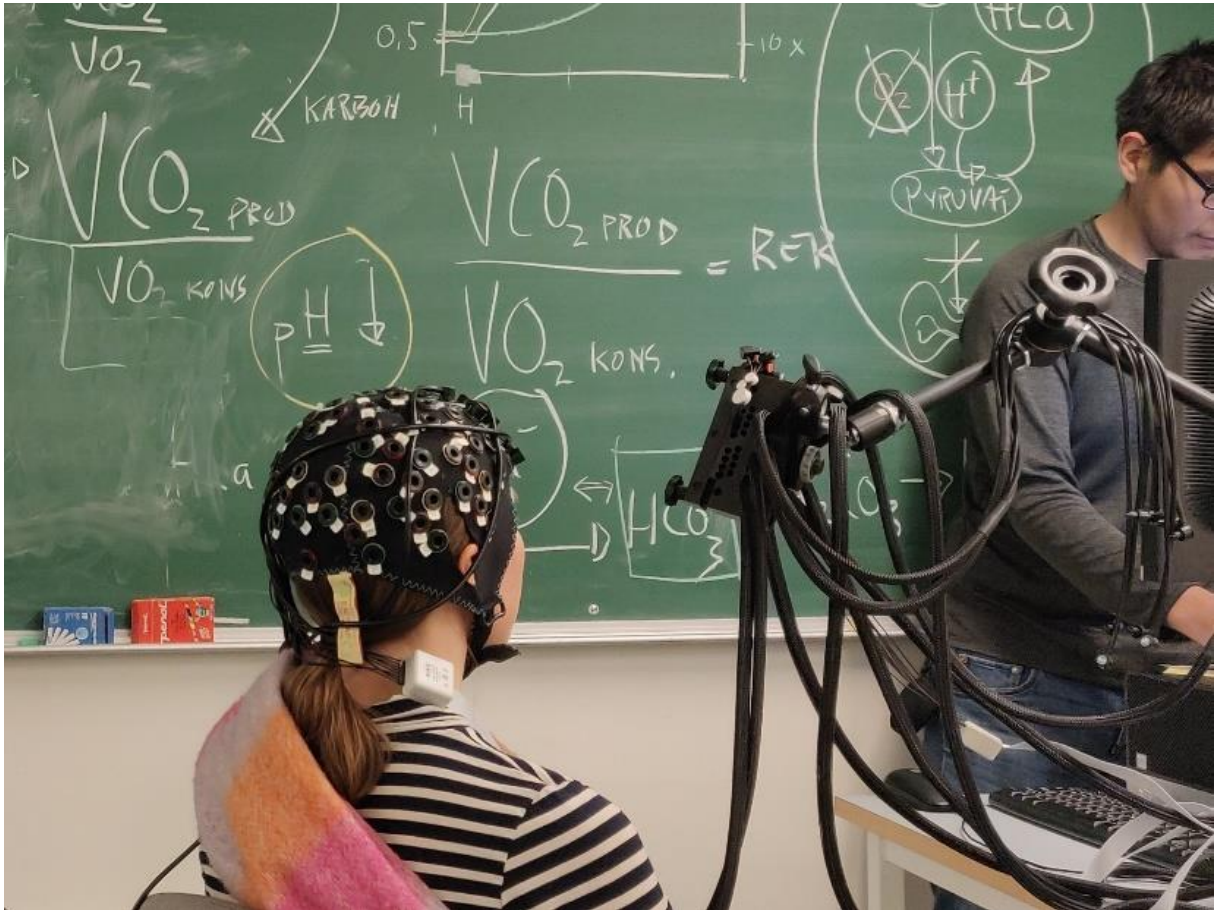

A human-centred design perspective of psychological care within the health system

We identified the human-centred design perspective through the transformative aspects of the comments and ideas generated during the ideation workshop. In practice, a transformative action requires the latitude and involvement of problem owners through stakeholders. The PACER members in the workshop used hypothetical problem owners or stakeholders, such as healthcare providers, to create the necessary latitude for potential change. Possible changes can be achieved through systemic thinking and digital solutions. One example of such systemic change is improving the provision of psychological care before and after the amputation process, which was explicitly communicated through the focus group interview with the lower limb prosthetic users. This complex issue requires additional project stakeholders.

FIGURE 5.

Examples from the ideation workshop that support a human-centred design perspective of psychological care within the health system.
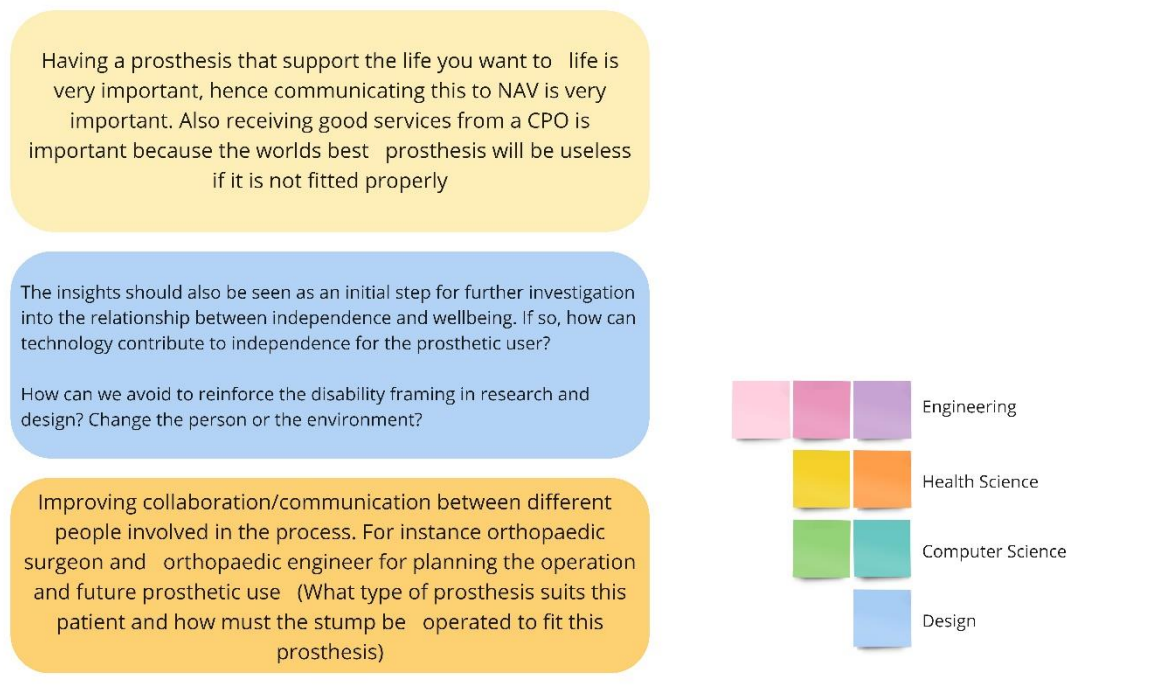
Re-framing (Dorst & Cross, 2001) could be a strategy for finding alternative ways to improve or change complex situations. An example from the workshop was the concept of independence. Walking is a prerequisite for participating in many activities in society. Walking with a prosthetic leg is essential to rehabilitation and a vital component of independence. Comments during the ideation workshop indicated that independence could be achieved to a greater degree through universally designed public spaces or the provision of digital resources. The participants in the focus group interview also discussed mobility in terms of independence in activities other than walking, such as using a scooter, driving and taking a taxi or bus. However, technology is not simply a means to an end in these contexts. As mentioned by the participants in the focus group interview, a possible stigma was attached to the design and use of some assistive devices.

The last topic of the workshop was how monitoring technologies could positively and negatively affect perceived health (Figure 5). Caution must be exercised when considering such a solution as part of rehabilitation. Based on the focus group interview findings, the

psychosocial aspects of mobility are essential. The participants described the relationships with and support from physiotherapists and orthopaedic engineers as essential factors in rehabilitation. Differences between individuals were also emphasised during the focus group interview. A holistic perspective on improving mobility must consider the personalisation of experience and learning. Compromises are usually necessary with regard to the availability of public health resources, especially the time spent with health professionals. In this context, digitalisation projects must avoid a narrow understanding of mobility.

Discussion

In this study, we sought to explore the complex dynamics of interdisciplinary collaboration in the early stages of the design and development of rehabilitation technologies. Central to our investigation was the research question: How does frame reflection influence interdisciplinary collaboration in these early stages? In our findings, two ways of framing the research project were identified: a *technology assessment perspective* and a *human-centred design perspective*. Furthermore, we wanted to discuss how these two perspectives influenced interdisciplinary collaboration in the context of the PACER project.

One of the main differences between these perspectives is the degree to which transformation is a goal. Drawing on Simon's design definition (1988), a transformative objective could be seen as "changing existing situations to preferred ones". This change includes the normative perception of an improved state. The following question identified the *human-centred design perspective*: How can we best alter the environment to improve these issues? Changes in the environment and practices are among these results. The central approach includes the users of such changes defining the preferred state and hence human-centeredness. User orientation and participation is therefore an essential component in this direction. Insights from the patient group were relevant to the framing because they broadened the scope of what rehabilitation and mobility are and its meaning for individuals. For example, by including psychosocial issues from the time before amputation, rehabilitation could include the design of new services that could improve the patient experience between primary care and rehabilitation services.

In contrast, the other approach, a *technology assessment perspective* on possible applications, did not include transformative perspectives in the same manner. The exploration of technology assessment perspectives highlighted the interdisciplinary challenge of integrating technical opportunities with patient participation and shed light on the study's aim of examining the impact of frame reflection on collaborative rehabilitation

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technology development. The insights gained from the qualitative focus group interview provided perspectives that are valuable for both technology assessment and human-centred design perspectives without necessarily providing shared framing.

From a rehabilitation perspective, the experience of mobility is essential for understanding the relevance of research in practice and from the perspectives of lower limb prosthetic users. Hence, the focus group participants were part of shaping what was relevant to this research. The insights from the focus group interview described the experience of mobility as a phenomenon rather than contributing to framing a problem space.

Similarly, the technological assessment perspective requires that the phenomena investigated through technology are relevant to prosthetic users. This project trajectory requires an internal reflexive process as the technology is used and assessed. These two processes may use different quantitative and qualitative methods. Switching from this critical perspective to a more biomedical one could be challenging from a collaborative perspective. The process often occurs outside an article format and in project discussions, also referred to as the "messy back-stage" (Mosleh & Larsen, 2020).

Consequently, activities such as workshops are required to create a meeting point between biomedical work and its relevance for patients. Framing in this direction involves adapting the technology to the end user. Hence, the solution is partially defined. This limits the frame creation process, as the input from prosthetic users is more relevant in terms of usability, which may limit the reframing possibilities. This is not an issue in and of itself, but from a collaborative perspective, when the problem space is defined differently, the iterative collaborative process of framing and reframing is challenging (Dorst, 2015).

The PACER project was similar to the human-centred approach in design and person-centeredness in rehabilitation (Leplege et al., 2007), which necessitates specific practices that involve user participation. In the case of the PACER project, understanding patient centricity was relevant for the project framing as a whole. The project could also be understood without defining the participants' involvement. Consequently, many project trajectories with different purposes existed, as described in the findings. At a project level, these trajectories raise the question of what defines a project – methods, patient groups, technology and members' professional skills?

In the interdisciplinary PACER project, several professional practices required specialisation; examples ranged from working with qualitative research to working in a positivist paradigm. Collaboration in research is challenging because it is less flexible to changes in purpose and

methods as a result of such specialisation. Suppose many frames of the project were accepted. In this case, it is evident how incorporating user perspectives would be helpful in several directions in different ways but would require different user involvement for future work. A patient-centric perspective based on a human- (Giacomin, 2014; van der Bijl-Brouwer & Dorst, 2017) or person-centred tradition (Leplege et al., 2007) refers to the inclusion of a human or person as part of the procedure, as patient-centric results are difficult to define (Détienne et al., 2019).

The goal of the ideation workshop was to encourage collaboration. However, the workshop highlighted that distinct paradigms influenced the various interpretations of patient involvement in the project. Discussing ideas and methods can be challenging in the early phases of collaboration. Consequently, workshop analysis is a helpful tool for addressing issues on the surface.

The use of the focus group interview insights by the workshop participants in the PACER project varied and resulted in different practical outcomes. Furthermore, how technology was appropriated depended on whether an individual viewed it as a skill or a tool, which defined its role in the project. In the PACER workshop, framing encompassed not only the interpretation of the project context but also the perception of technology as a contributor.

Limitations of the work

When first looking at the data from the ideation workshop, there were fewer ideas and connections to the focus group interview than expected. A possible reason for this could be that one of the main ideas of the PACER project was the use of brain-monitoring technologies in rehabilitation. Consequently, many of the participants in the workshop had worked in-depth with technical opportunities, and patient participation was not a relevant part of their professional research activities. Other reasons could involve practical difficulties, such as not being familiar with the Miro board or the limited opportunity to follow up with the workshop participants. However, the purpose of this study was not to draw conclusions regarding the influence of disciplinary frames on individual reasoning. We believe that the work's relevance was in describing how disciplinary belonging emphasises certain framing practices and how they impact collaboration from the perspective of practice. Notably, the PACER members who participated in the workshop were not asked to represent their respective disciplines. Their comments reflected both personal and disciplinary perspectives. Nonetheless, these contributions shed light on the essential aspects of framing from different professions, such as physiotherapy, design and engineering.

Conclusion

In this study, we described two perspectives identified during a workshop based on the PACER project: a *technology assessment perspective* and a *human-centred design perspective*. This study highlights both how disciplinary belonging can impact collaboration practices and the importance of considering patient participation to accommodate the limitations of the biomedical model in patient-centric rehabilitation technology projects. Understanding user participation was essential for the collaborative process in the PACER project. These findings are critical because collaboration relies on a shared understanding of a project's framing, which influences the selection of the ideas and research that should be pursued. The new understanding resulting from our analysis calls for reflection on the PACER project's focus, with a move from several separate monodisciplinary research approaches to more cohesive interdisciplinary research that includes the experiences of prosthetic users in the conceptualisation of mobility. Explicitly discussing a project's framing can enhance the interdisciplinary understanding. It can further promote the creative collaboration required for success across human and natural sciences, where user orientation in the design research tradition is relevant. In conclusion, we believe that frames are valuable for analysing interdisciplinary perspectives.

Future work

The frames in this work were based on matching the ideas in the ideation workshop with existing frames identified in the relevant literature, which thereby logically underpinned the reasoning from a case study methodology (Yin, 2017). In future work, we suggest a study design that includes workshop participants' thoughts and reflections on their cognitive processes in frame creation, from more implicit to explicit, to provide a more comprehensive understanding of the phenomenon. Furthermore, several other aspects of framing are relevant to design practices, such as collaborative aspects, which include the negotiation process with a focus on how different disciplinary perspectives are reconciled to form a shared understanding or approach to a problem. This research could examine the dynamics of power, language and non-verbal communication in shaping the negotiation of frames.

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