Uppsala Studies in Human-Computer Interaction

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# Embodied Core Mechanics

## Designing for movement-based co-located play

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**Abstract**

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Movement-based interactive systems for play came into the spotlight over a decade ago, and were met with enthusiasm by the general public as well as the Human-Computer Interaction research community. Yet a decade of research and practice has not fully addressed the challenge of designing for the moving body and play. This thesis argues that often, the role of the technology to sustain the play activity, and to drive the design process, has been over-emphasized, and has resulted in limited design possibilities. This thesis explores an alternative design approach to address the problem through combining the design of the technology with designing aspects of the social and spatial context where the play activity takes place. The work is grounded in an embodied perspective of experience, action, and design. Methodologically, it belongs to the Research through Design tradition (RtD).

A core concept and a characterization of design practices are presented as key contributions. The concept of *embodied core mechanics* is introduced to frame desirable and repeatable movement-based play actions, paying attention to the way these are supported by design resources including rules, physical and digital artifacts, and the physical and spatial arrangement of players and artifacts. The concept was developed during the two main design cases: the Oriboo case, targeting dance games for children, and the PhySeEar case, targeting rehabilitative therapy for the elderly. It was further substantiated in subsequent external design collaborations. To support the design process, this thesis presents *embodied sketching*: a set of ideation design practices that leverage the embodied experience and enable designers to scrutinize the desired embodied experience early in the design process. Three forms of embodied sketching are presented: embodied sketching for bodystorming, co-designing with users, and sensitizing designers.

Through reframing the design task as one of designing and studying embodied core mechanics, this thesis establishes an alternative approach to design for movement-based play in which significant aspects of the embodied play experience, lead, drive, and shape the design process and the design of the technology.

*Keywords:* Embodied core mechanics, embodied sketching, movement-based interaction, phenomenology, embodied interaction, play, play design, research through design, social play, co-located, movement, technology-supported, interactive toy, robot, playification

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*To my mum, and the Luises of my life.*

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*This is going to be long... the scissors broke halfway through here, and I'm not going to get new ones just yet. But... go ahead, skip it, and read the thesis!*

Annika… I've always thought I start this section with you, but what I didn't know is how grateful, how deeply, deeply grateful I would feel towards you. When I "crafted" my crazy plan for this last year of my PhD after the summer, I was (semi-) aware of how intense and how hard it was going to be for me… I didn't realized I was also crafting crazy frenzy for you. And you were full in, completely onboard. They say a supervisor turns into someone like a mother, and I understand that now. It is not just about teaching, supporting, guiding… it's about watching one's back, about a degree of dedication and commitment that is not paid, like that of mothers. And sure, it's guiding too, but not in any way. You have guided me the way that I needed, my way, letting me be my own person, with all that takes not only for me, but for you too! Holidays, late hours, and a looooot of (text) cutting and (text) ironing! How can you ground a person and still allow her to fly free? Ask Annika.

I'm also lucky to have two people I really look up to, two role models and sources of inspiration, as my second and third supervisors: Kristina Höök (Kia), and Barry Brown. Both of you have helped, guided, and inspired me during my PhD. In your different ways, both of you set the bar, one I can only look up to and have to work hard just to approach. Kia, you've been there since the beginning, and you are the reason why I stayed in Sweden. It was your Affective Interaction course that first showed me that I wanted to do *that* type of research. And it was a letter from you to my International Program coordinator that enabled me to stay, convincing her that she should let me to continue my studies even if my Erasmus had finished. You brought me to Mobile Life, and to its people. Barry, you came in later, just before I was suddenly asked to send in a licentiate thesis. You cared, you've always cared. And somehow you have this empathy and this power to win over, to break down my barriers, that somehow leaves you at ease, relieved… and ultimately stronger.

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Officially, my PhD started just when I was in your lab there in New York, working with you and the wonderful people at the GIL lab. It's not by happenstance that I'm going with you to start this new phase after my PhD.

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The family is growing – and I hope it will keep doing so. Unofficially, I have an in-law family in Seville, with Clara and her family. And officially, my family has increased since the last thesis I wrote. I have married the love of my life, Luis. Every now and then, you can get to be a grumpy old man (no news there), but you also give me that other angle, "reality", I think they call it… you keep my feet on the ground. But that's not all… I thank you for the simplest things, the ones I cherish the most: your delicious and hearty meals, your infectious laughter, that infinite blue abyss in your eyes, that heartfelt hug that recharges my energy, spending time a while curled up with you on the sofa, under the blankets… That's all it takes to make my day worth it! With you my family has grown in Zaragoza. I want to thank to my parents-in-law, Maria Jesús and Luis, and my sister-in-law, Silvia. You have made me feel instantly part of the family. Thanks also to the rest of the family, who have welcome me so warmly, especially Charito and Pilarín.

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There are three people who are part of my life in a way that I can't barely articulate. It is not that they watch my back, but they form my very backbone, who I am: my father, my mother, and my brother. You three are part of me, the source of my energy, of my passion, of my strength. They say I have energy to spare, and I think you are the reason why.

Luigi, I set that "evil" test for you as a child, *la prueba del hombre*. All I wanted was for you to be able to lift me in the air so that we could dance and do acrobatics. But of course you were four years younger, and all we could

do was reverse the roles: I'd be the base and lift you up, despite your being the type who'd rather have solid ground beneath your feet. Now, of course you're a long way past that, and not just because you can physically lift me in the air… but because you got me. You'd lift me up every single time, infinite times, just as I would you. Luigi, Baloo, the fact that you are featuring in this PhD so much is not by chance. When I look back, I see us playing together, and when I look forward, I dream about us working (playing?) together.

As I've said a number of times, my father was to me a super hero (for real!) with super powers and all. There were plenty of facts to corroborate this, some told by himself, some by Nina y Lole – what better sources? :) He was the strongest and fastest man alive, I thought. And immortal… at least in my heart. I know that for a fact. I have only inherited a little bit of that build of yours, and a bit of your playful attitude to life and your capacity to enjoy it to the full.

But while my father carried the surname of "Guerrero" (warrior), the real fighter has always been my mother. You say you are not brave, but you are the bravest person I know. You say you are not the quickest learner, yet you get where you want, and your eagerness to learn and grow overwhelms us all. You say you are not creative, but I've seen you creating a whole world of magic around me, a bubble in the midst of… what would I know? Dad died, yet I can only remember a happy childhood. You made that happen. You will always be the person I admire the most. The real hero of my life.

# List of Papers

This thesis is based on the following papers, which are referred to in the text by their Roman numerals:

I Márquez Segura, E., Waern, A., Moen, J., & Johansson, C. (2013). The Design Space of Body Games: Technological, Physical, and Social Design. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI '13). ACM, New York, NY, USA, 3365-3374.

II Márquez Segura, E., Turmo Vidal, L., Rostami, A., & Waern, A., (2016). Embodied Sketching. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI '16). ACM, New York, NY, USA.

III Márquez Segura, E. (2015). Co-creating Embodied Sketches. Playing as a method to design with children. In *Proceedings of the 12th International Conference on Advances in Computer Entertainment Technology* (ACE '15). ACM, New York, NY, USA.

IV Isbister, K., Márquez Segura, E., Kirkpatrick, S., Chen, X., Salahuddin, S., Cao, G., and Tang, R. (under review). Yamove! A Movement Synchrony Game that Choreographs Social Interaction. Submitted to Human-Technology Choreographies: Body, Movement and Space [Special Issue]. *Human Technology: An Interdisciplinary Journal on Humans in ICT Environments.*

V Márquez Segura, E., Waern, A., Márquez Segura, L, and López Recio, L. (under review). Playification: The PhySeEar case. Submitted to *Proceedings of the 2016 Annual Symposium on Computer-Human Interaction in Play* (CHI PLAY '16). ACM, New York, NY, USA.

Supporting publications, not included in this thesis:


VI Márquez Segura, E., Márquez Segura, L., & López Torres, C. (2012). PhySeEar. Moving yourself to shine and sound in geriatric physiotherapy interventions. In *Proceedings of the 6th International Conference on Pervasive Computing Technologies for Healthcare* (PervasiveHealth '12). IEEE Press, Piscataway, NJ, USA, 179–182.

VII López Recio, L., Márquez Segura, E., Márquez Segura, L., and Waern, A. 2013. The NAO models for the elderly. In *Proceedings of the 8th ACM/IEEE international conference on Human-robot interaction* (HRI '13). IEEE Press, Piscataway, NJ, USA, 187-188.

VIII Márquez Segura, E., & Isbister, K. (2015). Enabling Co-Located Physical Social Play: A Framework for Design and Evaluation. In R. Bernhaupt (Ed.), *Game User Experience Evaluation*. Springer International Publishing, 209–238.

IX Márquez Segura, E., Turmo Vidal, L., and Rostami, A. (under review). Bodystorming for Movement-Based Interaction Design. Submitted to Human-Technology Choreographies: Body, Movement and Space [Special Issue]. *Human Technology: An Interdisciplinary Journal on Humans in ICT Environments.*

X Back, J., Márquez Segura, E., Waern, A. (under review). Playing with Structure: An Analytic Model of Transformative Play. Submitted to *ACM Transactions on Human-Computer Interaction* (TOCHI).

XI Turmo Vidal, L., & Márquez Segura, E. (under review). Sketching the Ephemeral. Submitted to *Proceedings of the 9th Nordic Conference on Human-Computer Interaction (NordiCHI'16).* ACM, New York, NY, USA.

# Contributions to Papers

**Paper I** is a long paper written by four authors. Regarding the work behind the paper, the author of this thesis is the person in charge of designing, conducting, and analyzing the user studies, under the supervision of Waern, the supervisor of this thesis. Early explorations were carried out with the aid of Johansson, and all of them with the technical support of Moen and the company Movinto Fun. The game designs tested were all created by the author of this thesis, and implemented by Movinto Fun. Regarding the writing of the paper, the author of this thesis was responsible for the major part of it, with substantial help from Waern, who supervised the content and helped with editing. Moen provided final feedback. Johansson was involved in drafting earlier versions of this article and in the initial stages of the design process.

**Paper II** is also a long paper written by four authors, the first of whom is the author of this thesis. This author designed, conducted, and analyzed all three studies, and was the main writer of the paper. The first author supervised the second, who helped conduct one study and analyze two, and contributed significantly to writing the paper. The third author participated in one study, and helped finalize the paper. The last author is this thesis's supervisor, who was involved in editing the paper for submission.

**Paper III** is a short paper written solely by the author of this thesis. The design practice introduced in the paper is the result of this author's work. The studies presented in the paper were designed by the author and conducted in collaboration with external helpers (acknowledged in the paper).

**Paper IV** is a journal paper under review. It has seven authors that were heavily involved in the design process of the game reported in the Yamove! paper. This author is second author of the article. The submitted article was written entirely by the first and second authors, but earlier versions of the paper were used, which were written by the third author too, and included input from the other authors. The final editing round was undertaken by the first author, who also led and supervised the whole project.

**Paper V** is a submitted paper written by the author of this thesis (first author), her supervisor (second author), and two other authors (the physiotherapist involved in the study, and this author's master student). The empirical data that will form the basis of the paper come from the PhySeEar project presented in this thesis. Hence, the studies presented were designed, conducted, and analyzed by the first author, with input from the physiotherapist. Regarding the writing of the paper, the author of this thesis was responsible for the major part of it, with substantial help from Waern, who supervised the content, helped to frame the paper and helped with the final editing of the paper submitted. This paper builds on papers VI and VII.

**Paper VI** is a short paper written by three authors. The first author (the author of this thesis), designed, conducted, and analyzed the study presented in the paper, and took the main role in writing the article. The third author is a psychologist who helped design the study. The second is the physiotherapist involved in the study, who helped design the technology used, conducted the study, and helped during the analysis phase.

**Paper VII** is a short paper written by four authors, presented as a demo at HRI '13. The first author was supervised by this author. Both were responsible for the design and testing of the technology, with help from the third author. The first author implemented the design, and the fourth author is this author's supervisor, and supervised the whole project.

**Paper VIII** is a book chapter written by two authors, with this author listed as the first. An earlier and broader version of the chapter was written solely by the second author (Isbister, 2010), while this version focuses on a subarea of social games: co-located social play. The first author was in charge of updating the body of work included in the chapter. Both authors contributed to the writing of the paper, and insights in it are based on empirical data and best practices from both authors' work.

**Paper IX** is a journal paper currently under review (accepted with minor revisions), written by three authors. Two design workshops are presented in the paper. The first author, the author of this thesis, is responsible for designing one of them, and for providing the method employed during the other. The goal for the second workshop was set by the third author. The first workshop was conducted by the first author, in collaboration with fellow students who participated in the workshop (acknowledged in the paper). The second workshop was conducted by the third author in collaboration with the first. The first and second authors were in charge of the analysis and writing of the paper (the second supervised by the first). The third author provided feedback and contributed relevant background on interactive performances.

**Paper X** is written in close cooperation by three authors, ordered alphabetically in the paper. The author of this thesis is listed as the second author in the paper. Each example case that illustrates the contribution of the paper was contributed by one of the authors, who designed, conducted, and analyzed the corresponding study. Regarding the content of the paper, the play engagement model with four modes of engagement is primarily a contribution from the first author, whereas the structural perspective originates from the second author's licentiate. The major work of structuring and editing this article was carried out by the third author, who also provided relevant background from game studies, as well as one of the example cases.

**Paper XI** is a submission under review, reporting insights from two workshops. This author is second author of the submission. The writing, and the work behind the paper, were led and supervised by the second author, who also designed the studies presented in the paper, and conducted one of them. The other was conducted in collaboration with both authors, helped by colleagues and a supervisor from the department at Uppsala University. Both authors analyzed the data from the workshops. The first author has taken the primary role in structuring this submission.

# Images and credits

All images included in this thesis have been obtained with the permission of the participants involved, as well as the parent/teacher/tutor/guardian for the children, or the technical staff (therapists) for the elderly people. As part of the studies organized by this author, written consents were obtained for the right to use images of the participants, including still photography and video, as well as audio recordings generated during the studies, to be used for research purposes, in publications, and other communications related to research, both on- and offline. All the pictures included are reprinted with permission from their owners. Those listed below are credited to persons other than this author alone:

Figure 1, Figure 2, and Figure 3 have been designed by this author and created by Laia Turmo Vidal.

Figure 4. Two Oriboos.", is credited to Jonas Kullman. Jin Moen holds its copyright.

Figure 10. The NAO robot.", is credited to Aldebaran.

Figure 21. Scene from the movie LIV", is credited to RATS Teater.

Figure 28, Figure 29, and Figure 30 have been designed by Laia Turmo Vidal and this author. The version of the "Bodystorming Braid" in Figure 28 is created by this author. The representations in Figure 29, and Figure 30 are created by Laia Turmo Vidal.

# Contents

# Chapter 1. Introduction

## The design domain of embodied play

The work in this thesis is located under the broad umbrella of embodied interaction, and focuses on the application domain of designing for movement-based co-located social play.

For the last two decades, this application domain has attracted great interest and fascination in both industry and research (Isbister, Rao, Schwekendiek, Hayward, & Lidasan, 2011; B. Simon, 2009), and has also received a warm reception from the general public. In console gaming, the fascination of novel movement-based interfaces translated into an expansion of the gaming public (Tanenbaum & Tanenbaum, 2015).

It is possible that some of the success arose from the fact that these games used movements, and were co-located and social. Regarding the social aspect, previous game scholars have highlighted how digital games that predated the 2000s were mainly designed for individual play (Costikyan, 2002; Zagal, Nussbaum, & Rosas, 2000), which was seen as a temporary oddity (Costikyan, 2002) mainly associated with technological limitations (Costikyan, 2002; Zagal et al., 2000).

Some technological advances, in particular ubiquitous Internet connectivity, brought back to digital gaming the social aspect of play that Costikyan found missing, as reports from the Entertainment Software Association (ESA) noted at the time[1]. At the same time, the renewed focus on physical play is associated with new advances in movement-sensing technologies, and the incorporation of controllers with movement-sensing mechanisms, such as the Nintendo Wii[2] and the Kinect[3].

Taken together, these advances in digital gaming brought in the social and physical aspects of play, and hence the familiar aesthetics of traditional playground games, and party or casual games. Digital gaming shed its secluded character (Zagal et al., 2000), to become considered a social activity (De Kort & Ijsselsteijn, 2008), and the game console a meeting place for friends and family (Voida & Greenberg, 2009).

[1] The number of players that reported playing with others increased from 59% in 2008 to 62% in 2011 – although it decreased to 56% in 2015 (Entertainment Software Association, 2008, Entertainment Software Association, 2011, Entertainment Software Association, 2015).

[2] https://www.nintendo.co.uk/Wii/Wii-94559.html

[3] http://www.xbox.com/en-US/xbox-one/accessories/kinect-for-xbox-one

Previous research in HCI has highlighted the promising opportunities arising from these aspects in digital gaming. For example, movements increase arousal (Isbister et al., 2011; Lindley, Le Couteur, & Berthouze, 2008) and engagement (Bianchi-Berthouze, 2013; Bianchi-Berthouze, Kim, & Patel, 2007; Lindley et al., 2008), which in turn have positive effects on the social context of play, fostering an increased feeling of connectedness (Isbister et al., 2011; Lindley et al., 2008). Social play in co-located settings brings about similar positive effects (Ravaja et al., 2006). These effects opened up new possibilities for digital game designers and advanced what can be thought of as a paradigm shift in console gaming, concomitant with the inclusion of gestural control (Tanenbaum & Tanenbaum, 2015).

However, this vision dissipated, as shown by the big decrease in purchases of movement-based game platforms (Dobra, 2011; Moscaritolo, 2014). One of the major reasons related to technological limitations, in that the sensors would capture only a little of what was going on in front of the screen (Benford et al., 2005; B. Simon, 2009), which often resulted in instrumentalizing (Höök et al., 2015) and constraining the moving body (Tanenbaum & Tanenbaum, 2015; paper I).

While it is some time since these initial technological limitations dominated game design, we have not yet witnessed the promised paradigm shift. Movement-based interactive experiences do not overcome the initial "novelty effect"[4] (Tanenbaum & Tanenbaum, 2015), but instead tend to fade from use after the first explorations. This is acknowledged by big game consoles companies: "[…] great tech, probably not so great applications so far […]," Sony admitted about its PlayStation Move (Svetlik, 2012). One possible explanation is that design lacks directions, which could be provided by design-oriented research. Yet, as is commonly observed, technology has gained ground without a parallel advance in research (Dourish, 2001). But what is it that research could offer to design practice in the domain of movement-based co-located social play?

In a talk at the Mobile Life Centre, Richard Harper, Principal Researcher at Microsoft Research in Cambridge, UK, argued that a critical aspect of successful scholarship that can advance innovation is that of "asking the right questions" in HCI. He showed how in the history of HCI, arguably "wrong questions" have led to faulty approaches and dead ends (his examples included speech interfaces and reading technologies when they first appeared).

In the domain of movement-based technologies, O'Hara et al. (2013) have argued that researchers have very frequently asked a positivistic question focused on the representational problem of movement. When the question was constructed as one of specifying, representing, and modeling movements, without deep considerations of the context where the activity takes

[4] The appeal of novel technology and the thrill of engaging with novel artifacts.

place, it reduced the challenge of designing in this domain to a matter of engineering. The consequence was a focus on developing technology that could capture "natural gestures" so users could interact with it in a way the same as (or similar to) how they interact with one another.

Identifying the design challenge as a representational problem might fall within the type of reasoning that Harper cautioned about during his talk. This author thinks that in this domain, the questions asked might have led to a dead end. It is no surprise, then, that despite the advances in technology, movement-based interfaces are not ultimately convincing. The design of movement-based technologies is still technology-driven, in the sense that the *main* design problem is framed as recognizing as much as possible, and only once the technology is in place are gestures and other activity elements tied together, in what Tanenbaum and Tanenbaum complained to be an "afterthought" (Tanenbaum & Tanenbaum, 2015). Although technology is and should be an enabler in the design process, mainstream approaches are unbalanced. They omit additional consideration of important interactional aspects of the designed experience (O'Hara et al., 2013), and consideration of "the in situ and embodied aspects of interaction with such technologies" (O'Hara et al., 2013, p. 5:3).

This author takes a constructive design perspective to advance research in the field and influence design in the application domain of movement-based co-located social play. This thesis contributes by offering an alternative design approach, and alternative design tools to mainstream ones. While there has been increased attention to the social and physical context where play takes place, this has not yet materialized in generative tools that allow the design of technology to harness these aspects, and hence the design space of movement-based games remains narrow.

How can the in situ, and in-the-moment, embodied experience drive design? Consider the picture from the cover of this thesis, a re-enactment of a game developed during an ideation session included in this thesis (see Chapter 7). The participants are designers, tasked with generating novel interactive movement-based games.

> Five players are in the scene. Isa, the girl in the center, is playing a game in which lasers appear (represented by the pink elastic bands). In the game, four players control lasers, choosing the direction of their laser beams in coordination with one another. At the count of three, the lasers appear, and Isa needs to pull herself up. After three counts, the lasers change and move. Isa can step down whenever she wants, as long as she doesn't touch the beams. She has it under control. The players are keeping a fixed laser grid that is only rotating around the vertical axis. Isa barely lifts her feet, and smiles. She keeps her head down, looking at how the grid moves, and where to land.

This excerpt illustrates the design and analytical focus of this thesis: the identification and support of interesting play actions that are *worth doing*;

these are called *embodied core mechanics*. This is what the participants on the cover are bodystorming. They are examining how these can be supported by different design resources including imaginary technology, along with ordinary playthings and fitness equipment, and they use their own experience of the actions to refine the resulting game.

This first embodied core mechanic can be further developed:

> Players controlling the beams have started “easy”. Enough for the warm-up. Soon, they increase the challenge, while Isa laughs and tells them off. The beams are now taking off from the floor forcing the girl to lift herself higher and higher. Now the beams are in the three-dimensional space, so she needs to control her coming down to the floor. This means more time up in the air, and perhaps a slower and more controlled descent, which might cause more muscle fatigue. She laughs and screams, and cannot seem to keep her head down on the lasers as she maintains herself in the pulled up position. The rest of the players seem to enjoy making it difficult for Isa. They communicate with one another through gestures and talk to coordinate the position of the beams, while monitoring Isa’s movements. Finally, she touches a beam. The game is over and all five players are laughing. Now Vic steps in to try this “mission impossible” game.

The group has introduced a second embodied core mechanic, one that seemed to work well for them, judging from their reactions. Together, these mechanics could very well form the sketch of a game that progressively increases the challenge. There are still many loose ends before finalizing the game. Is there any scoring system? Will the scoring be calculated by the technology, or by a referee player? What would be scored? Perhaps the game’s duration? Maybe how long are feet off the floor?

In this thesis, the focus is not on the full game, but on how to think about those small units of play activity, the embodied core mechanics. While these can be strung together and complemented, for example by scoring, this thesis argues that the focus and driver of design should be these very small, in-the-moment, situated, and embodied actions.

## Research questions

This thesis focuses on designing for movement-based interactive play in a way that foregrounds the physical and social experiences. The research questions in this thesis are contrasted to mainstream approaches to design in the domain of movement-based co-located games or play activities. This has required re-thinking the domain’s important design goals, and how designers can achieve them. This thesis is framed through an open and explorative research question:

> How can we design movement-based interactive play in a co-located social setting in a way that foregrounds the physical and social engagement in the play activity?

Physical and social engagement are key elements in this framing. To create a physically and socially engaging activity means in this thesis not only the play activity unfolding in a social context and using movements as an interaction modality, but also that this social context and these physical actions are key to sustaining play and making it meaningful and worthwhile for the participants. Both are key to making the activity possible and interesting for the participants.

This overarching question could be addressed from different perspectives depending on, among other things, the disciplinary context. This thesis takes an explorative and constructive design-oriented approach, and this author has focused on two aspects of the overarching question, formulated as two sub-questions related to investigating design opportunities. The first sub-research question involves the identification of important design aspects. The second examines how these aspects can be considered to generate design ideas early in the design process. Their answers should be considered this author's contribution to answering the main research question.

> What is it that we can design to foreground the physical and social engagement in the play activity?

With this question in mind, this author first explores design possibilities by focusing on designing and studying play actions that are worth doing, using technology only in a supporting role. An important aspect in designing those interesting play actions is the various elements, besides the technology, that can sustain the activity and make it physically and socially engaging: the design resources.

Second, this author tries to unpack design aspects and considerations of such physically and socially engaging activities. Relevant questions here include why some elements in the activity (design resources) and not others are important in supporting a certain experience. Or what it is in a particular experience that is interesting.

The second sub-research question is mainly methodological, examining how to support the design of play actions that are worth doing, in a way that is not tied to the capabilities and degree of development of the technology involved. It concerns the articulation of an alternative design approach to mainstream ones, which supports designers in creating and experiencing embodied core mechanics. The approach sought is, in particular, one that is not uniquely technology-driven, and that respects, considers, and leverages the interplay between the social and physical aspects of where play happens.

> How can we understand and consider relevant aspects of the physical and social play activity, and explore and generate design ideas?

## Contribution

This thesis contributes to the advance of design research in the domain of movement-based interactive play with several intermediate-level concepts (further elaborated in Chapter 4), and with a variety of particulars whose main role is to empirically ground and to illustrate the concepts.

An overall approach is presented as an alternative to technology-driven design approaches. It extends and complements them by embracing, respecting, and harnessing our physical and social ways of being and acting in the world when creating engaging physical and social play activities. This approach relies heavily on the two intermediate-level contributions in this thesis: the concept of *embodied core mechanics*, and the design practice of *embodied sketching*.

The concept of embodied core mechanics complements existing design approaches in movement-based co-located play by re-focusing the design goal on small in-the-moment situated actions. Embodied sketching complements by including movements and social play early in the design process. It also extends existing *ideational* methods in IxD by suggesting practical ways of foregrounding the physical and social experiences.

Both contributions translate abstract theoretical constructs within embodied interaction into practical utility for the IxD community working with physical and social experiences.

## Limitations

This thesis uses a Research through Design (RtD) approach to address its research questions. The contributions presented are based on two extended design processes as well as a set of smaller design exercises, some of them in the form of ideation workshops or game design studies in collaboration with external partners.

The work is limited primarily by its *explorative* character. The goal has been to explore an alternative design approach for movement-based play in a co-located social setting. Hence, the work concludes by presenting not truths but options: concepts that frame the design space as such, and ways to explore it.

Play and playfulness have a privileged status in this thesis, although this thesis argues that they need not be a design goal set from the start. In one way or another, in all the design projects and interventions presented in this text, play is also held or adopted as a design value. In some of the works, play and playfulness have been design goals in themselves from the outset of the design project (e.g. the Oriboo case), but in some works they have emerged as important design values during the design process (e.g. the PhySeEar case), and embraced by the stakeholders involved. There is therefore no empirical evidence to suggest their validity as a design method in non-playful design domains. Strategies for design projects outside our domain remain as very relevant future work.

Finally, this thesis does not examine one of the most pertinent challenges for movement-based games: that of creating play activities sustained over longer periods. Although there are two design processes included in this thesis, neither of them examined play engagement over long periods, but kept the focus on in-the-moment play actions that are worth doing.

## Outline

This is a compilation thesis. The first part works as an overview ("kappa" in Swedish) that provides the reader with a common thread that ties together the selected papers that compose the second part of this thesis. This overview is structured as follows:

Chapter 2 covers related work. First, it explains the trends in design research and practice in the form of issues in the domain of movement-based co-located social play, which this thesis addresses. It also covers other works that offer interesting design alternatives to the approach suggested in this thesis and that in part has informed it, as well as design frameworks that help to frame the work presented here.

Chapter 3 presents the theory that is relevant to the design and research approach of this thesis. The chapter draws mainly from phenomenology, social psychology, and game design.

Chapter 4 presents the research tradition behind this thesis, detailing its research methodology, the type of knowledge produced, and the criteria for assessing its contributions. The chapter concludes by unpacking important aspects of the research process employed.

Chapter 5 summarizes the two main design projects as well as a set of design and research collaborations that together form the empirical basis of this thesis.

The main contributions of this thesis are presented in Chapter 6 and Chapter 7. The first sub-research question is primarily addressed in Chapter 6, presenting the concept of *embodied core mechanics*, which establishes a focus on the in-the-moment activity. The approach proposed foregrounds an ecological one for the design of movement-based interactive play, looking at how this activity can be supported by the technology, but also other contextual elements of the play activity.

The second sub-research question is primarily addressed in Chapter 7, where several design practices developed during this PhD are described, grouped under the common concept of *embodied sketching*. The goal of *embodied sketching* is to help generate *embodied core mechanics* and understand important aesthetic aspects of them, as well as how they can be supported by design resources.

Finally, in Chapter 8 the work presented in the overview is summarized and the research questions are revisited. The main contributions are discussed against established criteria in RtD. The chapter concludes by briefly mentioning other more general contributions that are not specifically related to the research questions, and with a brief discussion regarding the implications for future research and design in the domain.

# Chapter 2. Background

The "third wave" in HCI (Bødker, 2006) is marked by a focus on the experience of use (Blythe, Overbeeke, Monk, & Wright, 2003; Gaver, 2002), and a heightened appreciation for aesthetic experiences: the sensual (Bardzell & Bardzell, 2011). There is a strong social and cultural turn (Bardzell & Bardzell, 2011; Harrison, Sengers, & Tatar, 2011), and a hermeneutically oriented perspective, highlighting the co-production of meaning (Bardzell, Bardzell, & Koefoed Hansen, 2015). The "social, cultural, and physical situatedness of both users and analysts" is acknowledged and embraced (Harrison et al., 2011, p. 385).

Yet many of these themes "remain secondary considerations in HCI practice" (Bardzell & Bardzell, 2011, p. 265).

> As a field, we historically have begun with a set of functional needs and/or a sense of a particular interface in mind, and we have iterated on it, before starting to evaluate it in terms of usability or user experience (Bardzell & Bardzell, 2011, p. 265).

This description is fitting for mainstream approaches in movement-based interactive play. However, the design turn in HCI, also characteristic of this third wave, offers alternative ways that can extend the design space of movement-based games. In the domain of this thesis, several trends are mapping options, populating the design space with examples and interesting ways of doing design.

This chapter will portray mainstream design approaches and some of their issues to which the work in this thesis reacts, before focusing on some interesting alternative design approaches offered within HCI. The choice of examples and methods is motivated by how they help to position the works in this thesis.

## Movement-based interactive play

The appearance of movement-sensing technologies and their adoption by the video gaming industry were commonly seen as a paradigm shift (Tanenbaum & Tanenbaum, 2015). Movement-based games reached people who had never played video games before, and changed the general perception of video gaming (ibid.). A new video game genre emerged, focused on casual family or party play featuring movement as the core interaction mechanism.

Many commercial movement-based games were produced for the major game consoles, in particular the Nintendo Wii (and more recently the Nintendo Wii U), Microsoft's Xbox 360 (and the later Xbox One), and Sony's PlayStation 3 (and later 4). These use different game controllers (the Wii remote controller, the Kinect, and the PlayStation Move) that all implement gesture recognition and pointing using motion-sensing technologies.

Movement-based games were marketed under the powerful narrative of the whole family playing together in the living room (B. Simon, 2009). Social play and the sociality around play are known to be major reasons why people engage in console gaming (De Kort & Ijsselsteijn, 2008; Gajadhar, de Kort, & Ijsselsteijn, 2008; Voida & Greenberg, 2009), and practices of co-located digital gaming at home show that the living room can turn into a family meeting place, a "digital hearth" (Voida & Greenberg, 2009).

The new genre also contributed to a shift in focus, from what happened in the virtual game world to considering as much what happened in the physical space. A new aesthetic emerged, concerning first the kinaesthetic engagement of players, but also the visual spectacle for a witnessing audience (B. Simon, 2009). This aesthetic largely centered on a nostalgic illusion of engaging together in physical play, in a "sensually immersive bubble in which the living room becomes a tennis court, a bowling alley or a shooting gallery" (B. Simon, 2009, p. 8). To attract a casual audience, the narrative of using "natural gestures" to participate in and control the activity was used extensively in marketing (O'Hara et al., 2013).

However, the experience of moving in front of a console lay very far from the activities it tried to simulate. Although movements become "a simulacrum or pretense of effort in a way that a button press on a traditional controller could never be" (B. Simon, 2009, p. 16), the play activity could easily result in an instrumental economy of effort toward the goal of scoring in the game, which overrode "any implied gestural system of effort" (B. Simon, 2009, p. 16). Hence, a flick of a wrist would pull off the trick and score more effectively than a fully fledged realistic movement that would not be sensed and rewarded by the technology, despite the more realistic type of physical engagement being be more fun (ibid.).

Efficiency and cost effectiveness in game design (B. Simon, 2009), as well as technical limitations, were held responsible for this failure to capture expressive and natural movements (Benford et al., 2005).

Alhough time has passed, and technology has advanced, movement-based games are still not as exciting as promised (Tanenbaum & Tanenbaum, 2015). Movements sensing has not fulfilled the promised paradigm shift in interaction (ibid.).

First, there is a dominant screen interaction that not only requires visual attention, but also a strict bodily orientation and action towards it. One's body is modeled and represented in the screen, and one's actions have effect when oriented towards the screen (B. Simon, 2009).

Simon (2009) discusses how playing together typically imbues these games with a sense of social spectacle, increasing performative and expressive engagement in which players engage in "gestural excess". This is what makes the games fun, despite the fact that the technology neither acknowledges nor rewards the spectacle.

However, De Kort and Ijsselstein discuss how the location and orientation of players in many games typically lead to a "sociofugal dynamic" (De Kort & Ijsselsteijn, 2008, p. 18:7) that counteracts habitual social signals such as mutual eye contact (Marquardt & Greenberg, 2015). The location and orientation of players are externally imposed, and cannot vary with the type of activity or the needs for communication and expression, such as when actors are not bodily constrained (Marquardt & Greenberg, 2015).

In addition to a fixed bodily orientation, the vocabulary of bodily interaction remains narrow (Tanenbaum & Tanenbaum, 2015) despite advances in technology. Tanenbaum and Tanenbaum (2015) describe Kinect games as puppeteering interfaces, in which the narrative and theme of the game can change but the core mechanic remains the same: moving so as to match the movements of a figure on screen.

All these issues may have contributed to the decline in public interest in these games, as shown in the decreased engagement with casual social games (Entertainment Software Association, 2008, Entertainment Software Association, 2011, Entertainment Software Association, 2015), and the lower sales of movement-based games (Dobra, 2011; Moscaritolo, 2014).

Two aspects of the design stance behind these games are highlighted and addressed in this thesis. First, the design of gestural interfaces is typically driven by an engineering approach, focused on being able to capture, model, and represent human movements (O'Hara et al., 2013). Tanenbaum and Tanenbaum (2015) comment on how the actual design of bodily interaction usually comes as "an afterthought rather than a central component of the experience". Second, in relation to the goal of recognizing and leveraging our "natural movements", O'Hara et al. (2013) describe a tendency in design in which the design of movements is focused on the representational problem of action (O'Hara et al., 2013).

> In this [positivistic] perspective, the aim of natural interfaces is to leverage and "draw strength from" pre-existing actions that are used in everyday life by people to communicate and to manipulate objects in the world. The defining idea behind these interfaces, within this perspective, is to make computer interactions through them "more like interacting with the real nondigital world" [Jacob et al. 2008] (O'Hara et al., 2013, p. 5:3).

This perspective assumes that there are static and standard "natural interactions" that can be defined, modeled, and represented for the creation of "natural interfaces" with which we would interact in the same (or in a similar) way to how we interact and communicate in the social and physical world. Naturalness is seen as a characteristic of the interaction that an interface can bring, independently of contextual factors concerning where the interaction takes place, such as the social context (O'Hara et al., 2013) of play.

## Capturing movements at a representational level

In this thesis, the representational aspect of movements is studied *as well* as other interactional aspects.

In the analysis of movements at a representational level, a useful framework that foregrounds the capacity of the technology to capture and use movements is Benford et al.' "sensed, expected and desired" (Benford et al., 2005), which is helpful in understanding potential design issues. The authors distinguish between movements that are *expected*, i.e. those that naturally performed when the user interacts with the technology, those *sensed* by the sensing mechanisms of the technology, and those *desired*, or required, by the application or game. The authors use a Venn diagram to show how, ideally, these categories would overlap; the fact that typically they do not reveals potential issues and opportunities for design. This framework was important in this thesis in realizing design problems, in particular identifying when the desired was not making full use of what could be sensed. It also inspired this author to consider ways of *making sense* (instead of sensing) important aspects of movements, which in this thesis is achieved by a collective socio-technical effort instead of by a technological effort alone (see Chapter 3): the technology does not have sole responsibility for sensing and interpreting movements for the players; the players also play a big role in this regard.

Another relevant framework for studying the representational aspect of movements is *Labanotation*, or *Kinetography Laban*, a system created by Rudolf Laban to systematically and rigorously analyze, transcribe, and design movements (Guest, 2005). Labanotation provides a written means of capturing choreographies, with movements written on a staff, analogous to that used in music. Loke et al. (2005; 2007) extend the transcription system to include transcriptions of events in the interface, so as to contextualize the movements transcribed in relation to the game. This framework is particularly useful for analyzing movements in systems where there is a correspondence between users' movements and actions in the system, like the Eyetoy games studied by Loke et al. (2005), or many of the games for the Kinect. Labanotation was used in early work in this thesis[5]. However, it was deemed inappropriate for transcribing movements in a situation of multiple players

[5] This author received basic training in Labanotation (see Chapter 3).

playing different games or responding to different contextual stimuli. The fine-grained type of analysis was nevertheless useful for pinpointing particularities of movements, such as when children in mirroring exercises performed slightly different movements without noticing the difference.

## Alternative movement aesthetics

This thesis aims to explore an alternative design approach that focuses primarily on the *interactional challenge*, on "the in situ and embodied aspects of interaction with such technologies" (O'Hara et al., 2013, p. 5:3). Within HCI research are found alternative aesthetics from the concept of "naturalness" and the focus on capturing and sensing particular movements. Those that have had the biggest impact on the work presented in this thesis are discussed here.

### Exertion games

*Exertion* has been explored extensively as a core aesthetic value for movement-based social play, opening the design space of movement-based games through many game examples under the broad umbrella of *exertion games* (Mueller et al., 2011) or *exergames* (Sinclair, Hingston, & Masek, 2007). These are interactive games that require physical effort, and which typically result in physical fatigue as with sports. Examples of exertion games include novel interactive forms of table tennis and jogging with non co-located players, as well as more stationary forms of interactive play that use the core mechanic of hanging off a bar (Mueller et al., 2011, 2012). Some are played in a co-located setting, others use technology to mediate presence and participation between players in different locations. Some make use of big screens or displays, others wearable technologies. What they have in common is exertion at their core.

An interesting aspect of exertion games is that the focus is not on performing or recognizing certain precise movements, but on physical exhaustion. This extends the repertoire of possible actions, because there is a looser relationship between what users do and what is sensed. Design works in this domain are inspirational for this thesis, and although the works here have not sought exertion as a main design goal, it has sometimes appeared as a result of certain designed activities.

To design and study exertion games in particular, but also movement-based games, Mueller et al. introduced the exertion game framework (F. Mueller et al., 2011). It was created to help designers create "more engaging exertion experiences mediated by technology" (Mueller et al., 2011, p. 2653). Borrowing four themes or lenses from Jacob et al.'(2008) work (naïve physics, body awareness and skills, environment awareness and skills, and social awareness and skills), the authors propose four layers that represent different types of bodily engagement with exertion games. The *responding* *body layer* relates to physiological data (and addresses our interoceptive sense[6]). The *moving body* layer reflects the body and its position in space (and addresses the proprioceptive sense). The *sensing body* layer concerns the interaction with objects in the space (exteroceptive sense), and finally the *relating* body layer is added to represent social aspects of the play activity.

Mueller et al. (2011) suggest using these body layers to think about game design aspects. They illustrated this by creating a grid with the body layers on one axis, and three known game design areas or schemas from Salen and Zimmerman on the other, i.e. rules, play, and context (Salen & Zimmerman, 2003). For each game schema, the authors suggested interesting play aspects to consider when designing from a particular body lens perspective.

While this creates an overview of interesting aspects to consider in movement-based game design, the resulting framework remains at the same time complex and shallow because a deeper analysis of the different layers is missing, and the interplay between the different aspects (game schemas and body layers) remains obscure.

**Interactive play objects**

Interesting work centered around designing interactive play objects to support and invite social play is carried out in Eindhoven (Bekker & Eggen, 2008; Bekker & Sturm, 2009; Bekker, Sturm, & Eggen, 2010; Sturm, Bekker, Groenendaal, Wesselink, & Eggen, 2008). This group focuses on the design of open-ended play for children, inspired by children's play with toys and playground games.

> Open-ended play is play without predefined (game) rules in which players can attach meaning to the design properties and the interactions themselves while playing. Its goal is to trigger a player's creativity by leaving room for interpretation (De Valk, Bekker, & Eggen, 2013, p. 97).

The group distinguishes between open-ended play and free play in the degrees of freedom given the structure framing the play activity, which they associate with the designed rules that shape the activity; this in turn influences the degrees of freedom offered to the players, and how 'free' the play activity becomes. To achieve open-ended play, the authors focus on designing the rules in the form of the interactivity of the technology and its physical aspects (e.g. the form factor), leaving space for children to improvise and

[6] This thesis uses the conventional understanding of exteroception, regarding sensations produced by external stimuli that are picked upon our senses, like temperature. In contrast, interoception involves internal sensations, such as hunger or thirst (Craig, 2002). Finally, proprioception deals with the awareness of the relative positions and movement of one's body segments, provided by sensations in the muscles, tendons, joints, and skin, and vision and audition (Lackner & DiZio, 2005).

generate play activities by inventing their own rules and goals (De Valk et al., 2013).

A design example is the interactive design *LEDtube,* cylinder-shaped devices that emit light at their ends, changing its colors and behavior as they are moved, and the later version *ColorFlare* with increased interactive behavior including communication and color transmission between tubes (Bekker et al., 2010). Bekker et al. (2010) observed how children not only explored the artifacts in free play, but also generated their own more or less complex games by creating and negotiating the goals and rules of play .

This approach is closely related to Gaver's concept of self-effacing play (Gaver, 2002):

> This is an engagement that has no fixed path or end, but instead involves a wide-ranging conversation with the circumstances and situations that give it rise. Rules may emerge and goals may be sought, but these will be provisional inventions, makeshift tools to help the advance of curiosity and exploration.

For the design of tangible play objects that support physical and social play, Bekker et al. (2014) present a toolkit in the form of four lenses of play. Their toolkit poses questions that designers can use to reflect on the type of play activity, and the play objects they create (Bekker et al., 2014). This framework has served as inspiration for some of the work in this thesis. For example, the first lens speaks about the relationship between designed structure and the degree of free play, raising questions about whether and to what extent goals and rules are defined, or fixed, and which design aspects are left open for the players to modify. The second lens looks at different possible forms of play; the third refers to the stages of play that children typically face when playing with open-ended interactive play artifacts; and the fourth refers to different play experiences that can be supported. Although the lenses pose interesting considerations, this author has found them more valuable as an evaluative tool than a generative one. Furthermore, the framework is not a perfect fit in many of its considerations, given that it is focused on designing a singular artifact that sustains the activity, instead of designing contextual elements.

### Tangible Interaction

More generally, Hornecker and Buur (2006) present a framework for the design space of tangible interaction that considers the physicality of artifacts as well as the social context. Four thought-provoking themes are presented to facilitate "design sensibilities" (Hornecker & Buur, 2006): *tangible manipulation* (the objects of physical manipulation and their material qualities), *spatial interaction* (highlighting how objects are embedded in the space, and how interaction requires movement and physical engagement), *embodied* *facilitation* (how action emerges influenced by the configuration of objects in the space)*,* and *expressive representation* (related to "the material and digital representations employed" (Hornecker & Buur, 2006, p. 439)).

Although all these perspectives are relevant to this thesis, two of the themes are particularly interesting and have been further developed in Chapter 3: spatial interaction and embodied facilitation. Spatial interaction tackles questions such as the configurability of the space, the characteristic non-fragmented visibility aspect of co-located social interaction, and the notion of using the whole body for action, interaction, and expression. Embodied facilitation is a complex concept, but one of the considerations that is particularly interesting for this thesis is how the properties of the objects and their arrangement in space may facilitate and constrain action. Hornecker and Buur (2006) introduce the concept of *access point* to refer to the options and resources offered to the users to observe, access, and interact with objects in the activity. They recommend designing multiple access points to lower the threshold of interaction. This is a fundamental design consideration in the works in this thesis, given the technology-supported design approach followed (see Chapter 3).

**Head Up Games**

When dealing with mobile devices, it is easy to adopt a style of interaction that becomes very artifact-focused (Tholander & Johansson, 2010). The form factor and the interaction with the device create a private sphere of gaming that can become isolating from the social and physical context (Ducheneaut, Yee, Nickell, & Moore, 2006; Szentgyorgyi, Terry, & Lank, 2008).

Reacting to mobile devices that fix the players' heads towards the screen, Soute et al. have proposed the concept of Head Up Games (HUG) (Soute, 2007; Soute, Kaptein, & Markopoulos, 2009; Soute, Markopoulos, & Magielse, 2010; Soute & Markopoulos, 2007). HUGs use technology that does not attract the players' visual attention, and hence lets them keep their heads up, attentive to the surrounding activity and environment. One HUG example is *HeartBeat* (Magielse & Markopoulos, 2009; Soute et al., 2010). Inspired by several traditional outdoor children's games, such as *hide-and-seek, tag,* and c*apture the flag,* this HUG explores the use of physiological signals as a design resource. The game is played outdoors in two groups, attackers and defenders, the latter having to protect a virtual treasure. The attackers have to tag the defenders by physically approaching a defender; they win if they tag the defender with the virtual treasure. Players are equipped with wirelessly connected mobile devices and a heartbeat sensor. The technology in this game randomly assigns players to the two groups, and the treasure to a defender. It is also tasked with coarsely monitoring and indicating the position of players (with an audio signal) within a certain range, and revealing players whose pulse rate exceeds a preset value, enabling the opposing team to "feel" nearby players even if they are hidden.

A specific HUG that is particularly aligned with the works design approach in this thesis is the game *Weather Gods and Fruit Kids* (Johansson et al., 2011). The game is staged in a gym equipped with sensing technologies that provide audio and tactile feedback. In this installation, children play and learn about energy consumption. One group plays the role of "fruit kids", and must collect fruit cards distributed in the space, which give them energy. However, their movements while collecting the cards deplete their energy level. To add to the challenge, the other group plays the "weather gods", whose movements can invoke thunder and lightning that will decrease the energy of the fruit kids. The children are equipped with Wii remote controllers, which are used to estimate their energy consumption, and to trigger thunder (in the case of the gods). The design team included physical and spatial considerations in their design, for example by arranging gym equipment in the space. Furthermore, social, non-implemented rules were essential. Another interesting aspect of this game is the focus on movement qualities instead of discrete types of movements. Children learnt about energy by moving carefully to "save energy" and they would "charge energy up" by moving energetically. Yet another interesting design choice was that of providing feedback on the status of the game and the players' energy using haptics and sound, instead of a screen.

## Introspective sensations

The works introduced above share a focus on movements, promoting a third-person and social type of awareness. However, researchers have also looked "inwards", to both kinaesthetic sensations and felt experience.

### Physiological technologies

With technological advances in sensing physiological activity combined with movement-based technologies have come interactive experiences in which the technology focuses on capturing both interoceptive and proprioceptive sensations and signals. Designs that tap into the former often relate to the users' emotions (Mandryk et al., 2013; Mandryk & Atkins, 2007; Nijholt, Reuderink, & Oude Bos, 2009). They vary in what they measure (cardiac activity, respiration, temperature, electrodermal activity, etc.), the type of contact with the body, and what the measurements are used for. Physiological responses have been used not only as an evaluation tool for entertainment technologies, but also as a new interaction modality (Fairclough, 2009; Mandryk et al., 2013; Mandryk, Inkpen, & Calvert, 2006; Nacke, Kalyn, Lough, & Mandryk, 2011; Nacke & Lindley, 2008; Nijholt, Reuderink, et al., 2009). Players' physiological responses can also be used as a mechanism to adapt some parameters of the game to make it more fitting to the players' psychophysiological state (Gilleade & Dix, 2004; Gilleade, Dix, & Allanson, 2005).

Pope and Palsson commented on how physiological technologies might "re-wire our minds", sharpening our psychological skills (A. T. Pope & Palsson, 2001) and physiological and emotional responses (Nacke et al., 2011; A. T. Pope & Palsson, 2001). Regarding interaction with digital games, physiological computing offers the possibility of designing adaptive responses, offering assistance, leveling the challenge of the interaction, and reinforcing positive emotions (Fairclough, 2009).

From a more phenomenological stance in the area of HCI and sports, Tholander and Nylander (2015, 2014) move past the psychophysiological relationship to focus on the felt and subjective experiences too. The authors study the intertwining of the felt experience and the measured body signals, to inform and enrich different sport practices, some of which are described by users as helping them have "the right feeling during exercise" (Nylander & Tholander, 2014, p. 132) while still focusing on their activity.

### Somaesthetic experiences

Most of the body-sensing applications discussed so far have taken a quite instrumental view of bodily interaction. Höök et al. criticize this, arguing that they tend to become quite normative (Höök et al., 2015):

> "Our bodies are there to be trimmed, perfected, and kept free from illnesses and bad influences […]. By placing some sensors on our body and then having the data fed back to us, we are supposed to be able to change our bad habits, become healthy and beautiful, and live a long life" (Höök et al., 2015, p. 27).

An alternative design stance has been proposed in a range of design projects that target interactive aesthetic experiences centered on the "felt experience". Much of this work builds on theories of somaesthetics (Shusterman, 2008, 2012) further discussed in the next chapter, and in particular it adopts the goal of improving self-awareness and reflection. Some of it focuses on facilitating critical reflection, and on helping users orient their attention to their inner selves in order to reconnect deeply with their felt bodily experience. Representative examples in this area include the live-art works by Khut and Loke (Khut, 2007, 2007; Loke & Khut, 2011; Loke, Khut, & Kocaballi, 2012). For example, in *Cardiomorphologies*, Khut uses heartbeat and breath sensors, as well as a video projection and a soundscape that represent the participant's breathing and heart rhythm, to raise awareness of and reflection on non-conscious bodily activities (Khut, 2007; Khut & Muller, 2005; Neumark & Khut, 2007).

Work grounded in the somaesthetic experience targets not only physiological measurements, but also broader bodily sensations and actions, including touch and breath (e.g. Schiphorst, 2007, 2009), as well as movements and bodily stance (e.g. Loke & Khut, 2011). For example, in Loke and Khut's (2011) interactive art experience, they explore balance in an installation that includes a Nintendo Wii balance board, contextual background music, a suspension mechanism attached to the participants' feet, a recording of a Feldenkrais Method®[7] lesson, and a facilitator guiding the participant through the installation. In this installation, the artist invites critical self-reflection around the concept of balance by having the participants experiencing gravity in their bodies as they shift their weight when invited by the facilitator's pulling the suspension mechanism.

A common challenge in works grounded in somaesthetics is the facilitation of a deep bodily experience, which usually requires disruption of our default everyday type of awareness and attention (third-person). Typically this is achieved using technological objects and installations, as well as external facilitation and guidance. For example, Wilde uses technological artifacts (see her hipDisks (Wilde, 2012) or Light Array (Wilde, Cassinelli, & Zerroug, 2012)) to extend and project the body and create "shifts in attention from gesture to the technologically embodied results of gesture, to change qualities of attentiveness" (Wilde, Schiphorst, & Klooster, 2011, p. 23).

To sensitize designers and improve their somaesthetic appreciation, Höök et al. engage in a joint practical somaesthetic activity, like the Feldenkrais Method®, which helps them turn their attention inwards and differentiate subtle sensations (Höök et al., 2015; Höök, Jonsson, Anna, & Johanna, 2016). This exercise requires guidance, instruction, and facilitation, in this case by an instructor in the Feldenkrais Method®.

Schiphorst (2011) presents a layered and directional view of perception. Everyday awareness is a "third-person" type of consciousness involving an outward look that is attentive to the context around us. By contrast, a "first-person" perspective involves looking inwards, discovering important aspects of the self. Schiphorst privileges a second-person type of consciousness that combines both of these perspectives and involves perceiving the world "through the self", aware at the same time of the inner sensations, and the world that influences and is influenced by them (Schiphorst, 2011). Schiphorst uses practical somaesthetic methods to facilitate participants' "access to more subtle qualities of experience and emergent bodily knowledge […]" (Wilde et al., 2011, p. 23). She introduces the concept of the "somatic connoisseur" (Schiphorst, 2011) as a facilitator who can help disrupt the everyday type of awareness to facilitate a shift towards a first-person perspective. The facilitator needs to have a second-person perspective; a heightened somatic sensibility, an empathy to resonate with the expe-

[7] http://www.feldenkrais.com/whatis

rience of the participants and help them discriminate and inspect different qualities about themselves and the world that previously remained elusive (Schiphorst, 2011).

For the design and analysis of movement-based interactive systems, Loke and Robertson (2013) propose to use two of the above perspectives (Loke & Robertson, 2013), which they call the mover's perspective (a first-person type of experience) and the observer's perspective (a third-person spectator's view). They add the machine's perspective, which considers the capabilities and limitations of the sensing technology, focusing in particular on the input/output mechanisms used.

## Concluding remarks

This chapter has provided an overview of the design issues in the domain of movement-based co-located social play, and the way some of these have been addressed in HCI.

The discussion shows that while in design practice there has been a strong focus on recognizing movement using technological means, research has also explored and developed design approaches less focused on movement sensing. It has also been noted how other design goals have been foregrounded, in particular play and playfulness and the felt experience and the goals of self-inspection adopted from somaesthetics.

However, there exist only a few examples of approaches that are not centered on the development of a singular technological artefact. This thesis moves away from a technology-driven perspective, to consider and design both the technological and other contextual aspects of the experience.

Finally, an important design goal adopted from HUG is to move away from the artifact-focused interaction that happens when the technology requires too much attention from the user. Instead, the design stance this author advocates promotes a focus on and an awareness of one's movements and the surrounding context.

Several design approaches and frameworks that deal with some of these issues, which are used to position the work in this thesis, have also been presented.

# Chapter 3. Conceptual premises and underpinnings

## Embodied Interaction and movement

This thesis is situated in the domain of *Embodied Interaction* within HCI, a denomination introduced to HCI by Paul Dourish in his book *Where the Action Is: The Foundations of Embodied Interaction* (Dourish, 2001). Embodied interaction is an approach to interaction design that focuses on the physical and social aspects of interacting with technology (Svanæs, 2013). It is particularly well suited to studying and designing technology that inhabits our world, a world of both "physical and social reality" (Dourish, 2001, p. 3), both of which are "intertwined and inescapable aspects" (Dourish, 2001, p. 99). It provides a theoretical backdrop well suited to this thesis, given its focus on physical and social play. "The physical" and "the social" form the basis from which the concept of embodied interaction emerges. Yet "the physical" and "the social" are a simplification of what embodiment means: "Embodiment is the property of our engagement with the world that allows us to make it meaningful" (Dourish, 2001, p. 126). A more accurate definition of embodied interaction with relation to what is designed is proposed by Dourish:

> Embodied Interaction is the creation, manipulation, and sharing of meaning though engaged interaction with artifacts (Dourish, 2001, p. 126).

Dourish's relationship between action, being, and meaning is grounded in phenomenology, and in related disciplines and traditions. In particular, he draws from Gibson's ecological psychology for the coupling between perception of physical objects and action, and on ethnomethodological scholars, who explore meaning and action from the perspective of the social actors involved.

Many scholars have added to the theory of embodied interaction by translating theories with the concept of embodiment at their core into intermediate-level theories and concepts that are useful for interaction design, including Winograd & Flores (1987), Svanæs (Svanæs, 2000, 2013), Dourish (2001), Fällman (2003b), and Robertson (1996, 1997, 2002). Covering all this work is outside of the scope of this thesis. In this section, only those theoretical constructs that are particularly relevant to positioning the contribution of this thesis will be sketched.

The brief phenomenological account that this thesis presents draws primarily from the works of Dourish (2001) and Fällman (2003b), complemented by that of Svanæs (Svanæs, 2000, 2013), which extends Dourish's work by delving deeper in Merleau-Ponty's concept of perception and the lived body. The theoretical background around the body is extended through Shusterman's somaesthetics (Shusterman, 2006, 2008, 2013), which contributed a more practical normative stance that has been methodologically useful in this thesis.

## Understanding in action

Dourish (2001) argues that meaning lies not in the head, but in our practical encounters with the world, in our acting. This proposition can be tracked back to Heidegger's phenomenology. A disciple of Husserl, who is considered the father of phenomenology, Heidegger departs from the Cartesian dualism of body and mind, the physical and mental worlds (Dourish, 2001; Fällman, 2003b; Svanæs, 2000). For Heidegger, thinking and the body are not separated, but rather our physical *being* in the world is what shapes our understanding of the world.

> [T]hings in the world are not meaningful through what we know about them mentally, but rather so from the way they reveal themselves to us when we encounter and deal with them (Fällman, 2003b, p. 22).

This new understanding of meaning and action in HCI challenged the classic, more static and passive, views of perception that leant on Cognitive Science (Svanæs, 2013). Originating in Suchman's work (1987), the perspective on action as planned, and composed of the sequence of perception, meaning making, and action was questioned (Fällman, 2003b; Svanæs, 2013).

To this practical endeavor of meaning making, Merleau-Ponty adds the fundamental role of the body. The French philosopher bridged Husserl's focus on perception with Heidegger's concept of being-in-the-world, by foregrounding the role of the body in perception and action (Dourish, 2001). Svanæs describes this perspective on perception as an "active process of meaning construction involving large portions of the body" (Svanæs, 2013, p. 8:10). In perceiving, we have all senses active (Svanæs, 2013), even in quite static perception examples, such as when observing an object: our body may orient towards that observed, or we orient the object to ourselves, for example while examining an object in our hand and moving it to see different aspects of it.

While meaning emerges and is sustained during interaction, Heidegger emphasizes that the world is already meaningful to us (Fällman, 2003b).

Both the concept of life-world from Heidegger (Fällman, 2003b) and that of a phenomenal field from Merleau-Ponty (Svanæs, 2000) reflect this. The "world is not 'one thing' to everyone" (Fällman, 2003b, p. 24), and the way we perceive it depends on our background of experiences, training, and habits, the context where it is created, and the task at hand (Svanæs, 2000, 2013).

## Movement, body schema, and concrete kinesphere

Through classic pragmatists, including William James and John Dewey, Shusterman focuses even closer on how skills and habits shape our bodily ways of orienting towards and acting in the world (Shusterman, 2008).

An important concept regarding our perception of the self and our ways of acting is that of *body schema* (Svanæs, 2013). The body schema is "our nonconscious knowledge of our lived body and of our potential for bodily actions in the world" (Svanæs, 2013, p. 8:12). This includes proprioceptive, exteroceptive, and interoceptive sensations. Larssen et al. (2006) use the concept of *kinaesthetic sense* to refer to proprioception. Moen uses it to include exteroceptive sensations too (Moen, 2006, p. 12). Laban also includes the interoceptive senses such as perceived muscular effort (Larssen et al., 2006; Svanæs, 2013). All three are aspects of our tacit knowledge of "the structure and specifics of our body" (Svanæs, 2013, p. 8:12).

Related to our body schema is the immediate (physical) context of action. In Laban's theories of movement, the concept of *kinesphere* was introduced to describe the immediate space around one that one can reach with extended limbs without stepping out of one's stance (Laban, 1966; Newlove & Dalby, 2003). Moen calls this the *personal interaction space* (Moen, 2006, p. 14):

> [It] is the three-dimensional space that is immediately surrounding a person's body and which is continuously changed and created along with that person's movements (Moen, 2006, p. 14).

The kinesphere refers to a person's range of movements, and it depends not only on bodily differences such as size, but also on physical skills, such as how flexible a person is. Svanæs connected this concept to an actor's degrees of freedom:

> The bodily space is different from the external space in that it exists only as long as there are degrees of freedom and a skilful use of this freedom. The bodily space is mainly given by the subject's specific potentials for action. Different bodies give rise to different spaces, and so do external factors such as clothing, tool use, and different kinds of prostheses. The bodily space is also changed by learning a new skill, as it changes the body's potential for acting in the world (Svanæs, 2013, p. 8:12).

Kinespheres are dynamics, because they follow us as we move, and can also change as we train and acquire skills that allow us to act differently. In this thesis, the phenomenal field and, in particular, habits are considered important factors that shape our kinespheres.

To explain this, Merleau-Ponty's concepts of *concrete* and *abstract* movements (Svanæs, 2000, 2013) are useful. Concrete movements are those performed instrumentally as part of an activity that has a focus, such as when we want to leave work, and we walk out of the building. In contrast, abstract movements are those performed purposefully, as goals themselves, and they are the focus of our attention, such as when we re-train our gait with the help of a physiotherapist and we focus on the position of each foot, the weight we put on it, etc. In this case, walking becomes not only the goal, but also the object, of our attention.

The concept of the kinesphere reflects the space that a person *can* actually reach and act on when performing abstract movements. However, in our everyday lives, and our everyday actions, not the whole kinesphere is used; our habitual repertoire of movements constrains us to only a part of it. An interesting concept that emerged during the work in this thesis is the *concrete kinesphere*, as the sphere that a person actually reaches when engaged in concrete movements. Concrete kinespheres are smaller than abstract purposeful kinespheres, and are related to habits, age, and mindset. We tend to favor an economy of movement and therefore do not exploit the whole space that we can reach. However, this does not mean our movements are efficient, as Shusterman shows (Shusterman, 2008). This is different for children, whose concrete kinesphere will likely reach more of the "absolute" kinesphere because their concrete kinesphere is not yet tied to the instrumentality of adults' movements (for a child, walking out of home could be performed by crawling on the floor or jumping).

## Objects and body schema

An important aspect from Heidegger's work is his analysis of both objects and the world as tools through which we act, which was introduced to HCI by Winograd and Flores (1987) (Dourish, 2001; Svanæs, 2000). Heidegger distinguished between the concepts of *ready-to-hand* and *present-at-hand*, both ways of encountering objects in the world and acting through them. When we act through an object, it becomes an instrumental tool for something else, and equipment, i.e. ready-to-hand. In contrast, when we focus on the object itself, it becomes an entity and the center of our attention, i.e. present-at-hand.

The archetypal example is Heidegger's carpenter, hammering a nail. The hammer for the carpenter is transparent, something that "withdraws" from the carpenter's attention, until a problem or *breakdown* makes it *unready-to-hand* (Svanæs, 2000).

Merleau-Ponty extends Heidegger's view of objects, elaborating on how they not only disappear from our attention, but are also incorporated in our body schema. A classic and often cited example from Merleau-Ponty is that of a blind man, his use of a stick to assist navigation and walking, and how this equipment becomes an extension of his sensing apparatus, and even of himself with habitual use (Brey, 2000a, 2000b; Svanæs, 2013).

> Once the stick has become a familiar instrument, the world of feelable things recedes and now begins, not at the outer skin of the hand, but at the end of the stick. One is tempted to say that through the sensations produced by the pressure of the stick on the hand, the blind man builds up the stick along with its various positions, and that the latter then mediate a second order object, the external thing […]. But habit does not consist in interpreting the pressures of the stick on the hand as indications of certain positions of the stick, and these as signs of an external object, since it *relieves us of the necessity* of doing so. The pressures on the hand and the stick are no longer given; the stick is no longer an object perceived by the blind man, but an instrument with which he perceives. It is a body auxiliary, an extension of the bodily synthesis (Merleau-Ponty, 2002, pp. 175–176).

For Merleau-Ponty, objects in the world already have meaning, but this depends on our habits, on the context, and the task at hand.

> […] what an object is depends on its use and the perceiver's frame of reference. The same is also true for how objects relate to the body (as objects in the world, as tools, or as extensions of the senses) (Svanæs, 2013, p. 8:13).

Hence, the cane for the blind man can extend not only his perception of the world, but also his kinesphere and potential for action, for example when the cane is used as a tool for pushing an object away. In a similar way, we can drive without needing to make any extra effort to navigate through traffic, by considering our dimensions and mobility "as cars" (Svanæs, 2013). The examples reflect a change in the bodily schema once the object is incorporated, a process that may require skill and practice. The cane becomes "part of the body schema by becoming a medium through which *perceptual skills* are expressed" (Brey, 2000a, p. 9). As we handle objects, the bodily schema is continuously updated (Svanæs, 2013).

## Social actors in play

Embodied interaction builds on tangible computing, which exploits familiarity with everyday objects, harnessing the way we interact with the world (Dourish, 2001; Hornecker & Buur, 2006). It also builds on social computing, and the way participants make sense of the social world where we act (Dourish, 2001).

This makes interaction an embodied and situated social phenomenon. For the former, we have resorted to Merleau-Ponty and Heidegger, but to study the social phenomenon we need to extend the phenomenological question beyond the individual to the social context where interaction takes place. Schutz provides a theoretical grounding for approaching the problem of *intersubjectivity*, and how we get to understand one another and share an "objective experience" of the world. For Schutz, meaning emerges "within the context of the actor's own experience of the world" (Dourish, 2001, p. 111), a context that is social. Actors in this context share social and cultural understandings and agreements, as well as similar or related "lived experiences". Intersubjectivity emerges as a practical problem that "is solved" by interacting. Actors (or interactants) act as sociologists in practice, using the fact that social action is ordered, maintained in, and used for interaction. This is the basis for ethnomethodology, which studies the way members or actors make sense of the social world, using mechanisms to understand, negotiate, and maintain social order.

This ethnomethodological perspective is well complemented from a phenomenological one by the concept of *intercorporality* from Merleau-Ponty, and *mutual incorporation* (Fuchs & De Jaegher, 2009), which has been touched upon briefly in the section above.

> The dynamical agentive systems approach observes and describes the interaction as a coordination process between intentional and embodied agents. It regards their actions as exhibiting an inherent and 'visible' intentionality and as being related to each other in a meaningful way, although so far, it has disregarded the subjective experience of the process. The phenomenological approach takes an immersive perspective, starting from a first- and second-person take on the same process and describing the experience of the mutual engagement in phenomenological terms (Fuchs & De Jaegher, 2009, p. 467).

From a phenomenological perspective, mutual incorporation refers to the "reaching out" of embodied selves (Fuchs & De Jaegher, 2009). The concept of extending one's bodily schema incorporating other objects was dealt with in the previous section. This is what Fuchs and De Jaegher call "unidirectional incorporation" (Fuchs & De Jaegher, 2009, p. 474), as we extend our bodily schemas using tools and objects, which requires (tacit or not) "coordination *to*" the object.

A different type of coordination is required when dealing with different actors rather than actor and object. Bodies can also be incorporated into our bodily schemas. A useful example in HCI is given by Höök, who takes a phenomenological approach in her study of horseback riding to suggest design considerations for bodily interactions. She describes the relationship with the horse as "sensitive and delicate" (Höök, 2010).

> […] of wordless signs and signals that represent, in the case described, two bodily agents – a human and a horse. When the human-horse relationship is really successful, it can be described as rare moments of becoming a centaur (Höök, 2010, p. 226).
>
> When things go really well, I feel the presence of the horse's way of being in the world as part of my own and we act together. This sense of another agent being present relies on a process of recognition. The horse and my self become one, as the centaur mentioned above (Höök, 2010, p. 231).

The example above takes practice, "true sympathy", and communication, and happens only "rarely" (Höök, 2010). It illustrates mutual incorporation, since it implies "coordination *with"* (Fuchs & De Jaegher, 2009).

In mutual incorporation, there is a sense of otherness, but also of a *shared* operative intentionality. Merleau-Ponty uses *operative intentionality* to refer to the "prereflective meaningful connection that the body established with its environment, based on the inherent connection of perception and action" (Merleau-Ponty as cited by Fuchs and De Jaegher (2009, p. 475)). Fuchs and De Jaegher relate this to our perception of spatial and physical cues from the environment, drawing from Gibson's concept of *affordances*. They also relate this to the inner self, commenting how this intentionality is born from the body, the "*centre of gravity* of operative intentionality" (Fuchs & De Jaegher, 2009, p. 475). This changes in a social co-located situation, which has a "centre of gravity" of its own, lying somewhere in between that of each social actor.

> The 'in-between' becomes the source of the operative intentionality of both partners. Each of them behaves and experiences differently from how they would do outside of the process, and meaning is co-created in a way not necessarily attributable to either of them (Fuchs & De Jaegher, 2009, p. 476).

## An approach to the design of movement-based embodied interaction

Fällman uses Ihde's understanding of technology as a non-neutral object that changes our perception of and action in the world (Fällman, 2003b). Ihde proposes three types of relations between actors and objects in the world: the embodiment relation, the hermeneutical relation, and the alterity relation.

*Embodiment relations* present objects as mediating tools that are "taken into my own perceptual-bodily self experience" (Fällman (2003b) citing Ihde (1990, p. 73)), transparent to our acting, through which we act and perceive the world. Fällman uses the example of a pair of glasses in this category. *Hermeneutical relations* present objects that help us interpret the world, reading out aspects of it, without enhancing our capacity to act in the world, like the speedometer of a car. Finally, *alterity relations* present technology as "otherness", objects towards which we direct our attention and actions, our immediate world. Here computer games and VR technologies are good examples. The rest of the world remains de-emphasized, set aside as a backdrop. Fällman presents these categories without clear-cut borders in a continuum, with hermeneutical relations somewhere in the center. They depend on the technology, the actor, and the task at hand, and can change over time (Fällman, 2003b).

This thesis attempts to move design away from alterity relations towards embodiment relations. The concepts and theories presented in this section reflect this focus.

## Phenomenological design attitude

Fällman draws phenomenology as a vast field, and as such it is problematic to propose one "phenomenological method" (Fällman, 2003b, p. 32). He echoed several phenomenologists, such as Ihde and Van Manen, highlighting how difficult it is to really understand phenomenology without practicing it (Fällman, 2003b).

> […] it is important to keep in mind that phenomenology is not so much a method as it is an attitude to how things in the world are to be approached, dealt with, and understood (Fällman, 2003b, p. 32).

One of the main contributions of Husserl to phenomenology is methodological. For him, "phenomenology was primarily a means of examining human experiences to gain a deeper understanding of the nature of our everyday life and of how meaning is founded" (Fällman, 2003b, p. 20). Husserl proposes to understand human experience by getting to the essence of things, to "the thing itself", following a set of very defined and fixed steps: epoché, phenomenological reduction, imaginative variation, and synthesis (Fällman, 2003b).

In epoché, the goal is to suspend the phenomenological field, and privilege perception and experience over any interpretation, judgment, and reflection (Fällman, 2003b). Phenomenological reduction means looking for both patterns and particularities in that experienced, to get to "the essence" of things. The goal of the phase of imaginative variations is "to create alterations of the experienced phenomenon", approaching things from diverse angles and perspectives. Through this, properties of the phenomenon reveal themselves. With synthesis, Husserl sought a cohesive and universal statement of the essence of the phenomenon, "the quality without which a phenomenon would not be what it is" (Fällman, 2003b, p. 39).

Although these strict steps are not followed in this thesis, some strategies proposed foreground core aspects of them. To change situations, a particularly interesting aspect has been to bring awareness to the things themselves, in particular, how some actions are performed, and disrupt this normality either to change things or support reflection.

### Disrupting bodily schema and concrete kinespheres

Various *disruptions* can cause the tool to be the focus of our attention, according to Capurro (Capurro, 1992), and a breakdown or malfunction is a simplification of those presented by Heidegger. Heidegger focused on the way a tool is subjectively experienced, independently on whether it is working[8]. Independently of the type of disturbance, the effect is what Heidegger named a *change-over*; the tool is suddenly seen as something else; and there is a revelation about the instrument at hand, its handling, and the whole environment around (Svanæs, 2000).

For this thesis, a particularly interesting type of disruption is one that makes a concrete movement abstract, or that extends our repertoire of movements and hence our concrete kinesphere.

A concept about disruption in movement and perception is described by dancer, choreographer, and philosopher Sheets-Johnstone as “making the strange out of the ordinary” (Sheets-Johnstone, 2011). By making changes in our ways of moving and observing habits, we change our habitual perceptions of ourselves and the world. These changes can be small, such as initiating a movement from a different body part. These subtle changes allow us to scrutinize the familiar, focusing our attention on uncovering elusive aspects of our habitual ways of moving and our experience of moving, hence “making the familiar strange”, in which we “familiarize ourselves anew with the familiar” (Sheets-Johnstone, 2011, p. 123).

This concept has been used in arts and performance as strategic artistic expression that disrupts everyday perception (Loke & Robertson, 2013), and researchers in HCI with a somaesthetic tradition have used it in the design domain of movement-based interaction. For example, Wilde uses the concept of *defamiliarization* (Wilde, 2008; Wilde et al., 2011) and Loke and Robertson’s concept and method of *making the strange* (Loke & Robertson, 2013), by providing participants with opportunities to explore, at the same time, affordances and constraints.

In this thesis, technology and physical artifacts have been used to modify the way participants move and their concrete kinespheres. Because they are handled, and the way they are handled, they constrain the mover’s movements, but they can also extend the mover’s concrete kinesphere by offering new possibilities for interaction, and by disrupting the mover’s habitual

[8] One disruption can be *conspicuousness*, when the object ready-to-hand is not appropriate for the task at hand, such as when the tool is damaged. Another is *obstrusiveness*, when something is missing in the tools, which “*seem* to lose their character of readiness-to-hand completely” (Capurro, 1992). Finally, *obstinacy* happens when something disturbs us and calls for our immediate attention. “The un-readiness-to-hand means, in this case, that we have to do something before we can go on with our concerns” (Capurro, 1992).

movements. Disruption has also been used in this thesis to foster creative thinking. Loke and Robertson summarize the use of this technique in Interaction Design, for example Djajadiningrat et al.'s interaction relabeling (Djajadiningrat, Gaver, & Frens, 2000).

**Somaesthetics to disrupt and improve**

The strangeness that Sheets-Johnstone refers to can come from making a concrete movement abstract, in Merleau-Ponty's terms, and by discriminating changes in performance and outcome, which requires somatic sensibility. This author finds in somaesthetics an ally in this endeavor.

Somaesthetics is an interdisciplinary field, grounded in pragmatism, that includes theory and practice to foreground the body as "a locus of sensory-aesthetic appreciation (aesthesis) and creative self-fashioning" (Shusterman, 2008, p. 19). Shusterman presents somaesthetics as "art of living" (Shusterman, 2008), focused on improving one's experiences by working with one's sensibility (perception and appreciation), performance, and self-presentation. The first two are key aspects for this thesis.

Somaesthetics has found a warm welcome in HCI and IxD (Lee, Lim, & Shusterman, 2014; Shusterman, 2013). Its theoretical position connects the pragmatist approach in HCI with the embodied approach (commentary by Bardzell in (Shusterman, 2013)). This is particularly useful considering the designerly turn in HCI, and in particular for design to be grounded in and connected to theory (commentary by Bardzell in (Shusterman, 2013)). It also helps to complement theories of embodied interaction bringing in a strong focus on the body, which is largely missing in Dourish's (2001, 2013) original book. Nevertheless, somaesthetics is not purely theoretical, analytical, and descriptive—this is only one branch of somaesthetics: *analytic somaesthetics*[9]—but also prescriptive, in the sense that it presents embodied consciousness as something that can "improve" through methods and techniques for somatic awareness. This is covered in the branches of *pragmatic* and *practical somaesthetics*. While pragmatic somaesthetics involves methods, tools, and techniques for somaesthetic improvement, practical somaesthetics deals with the actual practice of an activity (Shusterman, 2008, 2013).

This goal of improving the somaesthetic experience is particularly relevant for this thesis, as it provides a useful normative stance that can "help us lead or shape our lives and to recognize what a good life is" (commentary by Bardzell in (Shusterman, 2013)). While a normative stance can be criticized, it is very much in line with the way research through design has been framed as "research of the future" with a "focus on concretely defining a preferred

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[9] "[…] *analytic somaesthetics*, is an essentially descriptive and theoretical enterprise devoted to explaining the nature of our bodily perceptions and practices and their function in our knowledge and construction of the world" (Shusterman, 2008, p. 23).

state" (Zimmerman, Stolterman, & Forlizzi, 2010, p. 310), in line with Simon's understanding of the goal of design as "changing existing situations into preferred ones" (H. A. Simon, 1996, p. 111) (see Chapter 4).

In recent years, there have been notable efforts in IxD to bring in bodily experience and awareness in interactive works and in design processes (some examples have already been covered in Chapter 2).

## Technology-supported approach

The concept of technology-supported was proposed by Waern as an alternative approach to the mainstream perspective on digital games as technology-sustained (Waern, 2009). Waern suggests that the play activity should entail more than interacting with a certain technology. In technology-supported approaches, the role of the technology is partially to sustain the activity, which happens in the world around and is supported by other elements.

This concept was influenced by, and influential in, the design and study of pervasive games, i.e. games that transcend the typical console gaming boundaries of space, time, and social context, to be played instead in the three-dimensional everyday world, for example public spaces such as malls, museums, and otherwise non-typical game places, where people around are carrying out everyday activities (Montola, Stenros, & Waern, 2009).
Waern commented how pervasive games circles refer to the technology-supported approach as one in which "the game is not in the technology, but the technology in the game" (pers. comm.). This is related to the phenomenologically inspired concept, of *designing objects in the world* as opposed to designing *worlds of objects,* proposed by Fällman in his thesis (Fällman, 2003b).

> If we think of a mobile device as a world of objects, similar to how we conceptualize a desktop computer, we will be inclined to focus our attention on what goes on ‹inside› the device. But where mobile interaction is concerned, what happens ‹outside› the device is just as important. Focusing solely on the inside, virtual world makes us forget both the role of the body in interaction as well as the role played by context, whether physical or social (Fällman, 2003b, p. 361).

In pervasive games, this means to design an activity so as to take into account the various scenarios that the play activity can pervade, and the social interactions that can happen in those places. In this thesis, taking a technology-supported approach means that the design focus and study concentrate not merely on the technology, but also include other elements that influence the play activity. In particular, in the context of co-located social play, both the space and the players are seen as design resources, and are key for instantiating this concept.

## Affordances of the socio-technical space

In HCI, the understanding of "situatedness" has been shaped by Suchman's work (Suchman, 1987). Suchman suggested that independently of how purposeful activity is, the actions we carry out form an ongoing and improvised activity that depends on features of the setting and on the evolution of the activity, the moment-to-moment situation (Suchman, 1987).

Two concepts from ethnomethodology are important in this thesis: those of *accountability* and *reciprocality* of action. Dourish presents *accountability* to refer to actions being "observable" and "reportable" by members who share a "common sense understanding" of the context where the activity unfolds (Dourish, 2001, p. 78). The concept of *reciprocality* of action postulates that the methods we use to make sense of others' actions are the same as those we use to contribute to and participate in action. Dourish uses the terms to criticize the heavy reliance on abstractions in traditional technology design that, although necessary and useful in software design, often result in hiding information relevant to the participants, such as the accounts of their own activity.

The concepts of accountability and reciprocality are central to Hornecker and Buur's framework for the design space of tangible interaction, considering the physicality of artifacts as well as the social context as important aspects (see Chapter 2). Of the themes in their framework, spatial interaction and embodied facilitation are "those most concerned with understanding and supporting social interaction" (Hornecker & Buur, 2006, p. 439). Yet they all "support social interaction in indirect ways, e.g. by lowering participation thresholds, making action publicly available, or providing shared references, while being important for single users as well" (Hornecker & Buur, 2006, p. 440).

These concepts and themes are complemented in this thesis in the domain of co-located technology-supported play by revisiting the old concept (in HCI) of affordance. Hornecker and Buur's first theme of tangible manipulation is extended by, and serves to revisit, the old concept of affordances in HCI. Important concepts that belong to Hornecker's themes of spatial interaction, embodied facilitation, and expressive representations come later as affordances of the socio-spatial configuration.

### Technology affordances

The concept of affordances emerge from Gibson's ecological approach to psychology as "the fundamental objects of perception", "encapsulating ideas about ecological physics, perceptual information, and the links between perception and action" (Gaver, 1991, p. 79). Gibson's affordances refer to what the environment (or an object) offers an actor. It is a relational concept, because it depends on attributes of both the object and the actor. It depends not on the actor's perceptions, needs or values, but on how this actor is "equipped" to act with regards to the object (Gibson, 1979).

The term affordance was introduced to HCI by Don Norman, but as a perceptual construct related to the form and function of interactive devices, which missed the relational property between actor and object (Dourish, 2001). He later clarified his affordances to be "perceived affordances" in relation to Gibson's. However, the concept mostly used in HCI is the aspect of salience or utility, strongly related to perception and invitation for action (Nye & Silverman, 2012).

Gaver's paper, *Technology Affordances* (1991), helped clarify these differences, and used Gibson's separation of properties and attributes of an object or environment with respect to an actor from the perception of such attributes. He extended Gibson's concept with a taxonomy of properties with their perception. For Gaver, a perceived affordance is one that is perceived, but there are also affordances that are not perceived (hidden), and false affordances (when a false functionality is perceived) (Gaver, 1991). Gaver highlighted the relationship between perception and action:

> People perceive the environment directly in terms of its potentials for action, without significant intermediate stages involving memory or inferences (Gaver, 1991, p. 79).

Gaver emphasized how affordances and their perception appear over time as we interact with the world, and introduced the concept of *sequential affordances*. He used the classic example of a door handle that affords grabbing. Once the handle is grabbed, tactile feedback from the handle in response to the weight of a hand on it, or simply to casual manual exploration, might reveal the affordance of turning the handle. Once the handle is turned, and in its new vertical position, it indicates the affordance of pulling.

This is an important aspect when dealing with interaction that involves movement, of both the participants and the objects involved, because moving and handling digital and physical artifacts can reveal affordances to the person on the spot, and to others present, who witness how the effects of manipulating an artifact offer new possibilities. An important factor in co-located social interaction is that sequential affordances can be revealed not only when interacting directly with an object, but also while watching others interacting with it.

**Affordances of the socio-spatial configuration**

A recurring concept in this thesis is the *socio-spatial arrangement* or *configuration*, which refers to the social and spatial context where the play activity takes place, with an emphasis on its layout, the role of elements in this space, and how this forms the structure that supports play. These factors are always relevant, as we move and act in the world, but they acquire additional importance in the domain of movement-based social interaction. The concept is deeply influenced by embodied, situated, and ecological perspectives of perception, action, and design.

In this thesis, it is often stated that the *space* where the activity happen is designed. This might sound like an inflated claim, considering that this author is not designing an interactive installation, but only arranging elements in the space. However, Dourish explains how this configuration contributes to creating *space*:

> "Space" is largely concerned with physical properties (or metaphorical physical properties). It concerns how people and artifacts are configured in a setting, how far apart they are, how they interfere with lines of sights, how actions fall off at a distance, and so on. By configuring the space in different ways, different kinds of behaviours can be supported (Dourish, 2001, p. 89).

In this excerpt, Dourish exemplifies how physical properties can be manipulated. Gaver proposes the concept of *nested affordances*, which involves those that are "grouped in space" (Gaver, 1991, p. 82). Gaver used the example of the handle (above) to combine it with the affordances for manipulation that a door offers, being partially disconnected from the wall. The handle is "nested" in the door and so it transfers its affordance of pulling to the door's affordance of being manipulable. The concept of nested affordances hints at the importance of considering how adjacent or connected objects can offer affordances different from those they offer on their own.

Dourish's excerpt above mainly concerns the "physical properties" of the space, yet these also involve the physical location, orientation, and position of the participants in "how people […] are configured in a setting".

This is picked up in proxemics, a field introduced by Hall (1963, 1966) that studies the spatial relationships of objects and people, and how these influence and are influenced by our actions and interactions (Marquardt & Greenberg, 2015; Sommer, 2002). People arrange the space and adopt different bodily orientations depending on, among other things, the relationship between social actors, the type of activity they are engaged with, and their characterizing interaction dynamic (e.g. whether it is competitive or collaborative) (Marquardt & Greenberg, 2015; Sommer, 2002).

Interesting concepts for analyzing bodily orientation come from Kendon's spatial-orientational study of arrangements of people with regards to artifacts and other people (Ciolek & Kendon, 1980; Kendon, 2010): F-formation (face- or facing-formation), and the transactional segments. F-formations look at the bodily orientation of people engaged in mutual interaction, while the transactional segment refers to the space in front of a person, the focus of attention and action (Ciolek & Kendon, 1980; Kendon, 2010).

People tend to orient themselves to share a transactional space with their co-interactant that is relevant for the type of interaction taking place (Kendon, 2010). People conversing and addressing their attention to the same object favor "side-by-side" arrangements (Kendon, 2010), so that their transactional segments partially overlap and include the object of attention. People collaborating and directing their attention and actions towards one another and the overlapping transactional segment tend to orient their bodies toward one another, favoring more face-to-face arrangements (Kendon, 2010).

In proxemics, the overlapping transactional space between two interactants is called the o-space, and is typically represented by a circle between the actors (ibid.). Outside and circling this o-space, including the participants' bodies and the objects they carry, is the p-space. Outside these two spaces is the r-space, which participants monitor peripherally but do not actively use in their interaction (Kendon, 2010).

Transactional segments are also studied with relation to people and objects. People orient themselves towards the object of interaction in a way that can be comfortably sustained during the period of interaction. During interaction with a big display, or watching television, for example, the transactional segment drawn between the person (typically in front of the display) and the display takes the form of a cone opening towards the display (Kendon, 2010). Concepts in proxemics have been influential in the CHI and CSCW communities (Mentis, O'Hara, Sellen, & Trivedi, 2012).

Returning to the original definition of the concept of affordances, Gibson also discusses how the space and its inhabitants (objects, surfaces, and people alike) contribute to shaping the affordances for action (Gibson, 1979, p. 135).

The idea of a landscape of affordances supplied by an assemblage of people, artifacts, and spatial features has been noted by researchers interested in social interaction and experience in the field of digital gaming. This thesis borrows the concept of socio-spatial context or configuration as introduced by De Kort and Ijsselsteijn (2008) in the paper *People, Places, and Play: Player Experience in a Socio-Spatial Context* (De Kort & Ijsselsteijn, 2008). The authors characterize digital gaming as a "situated experience, shaped by socio-spatial contingencies" (De Kort & Ijsselsteijn, 2008, p. 18:1).

The socio-spatial context has been shown to influence the player's emotional experience (Jakobs, Manstead, & Fischer, 1996; Manstead, 2005). In particular, it has been associated with the experience of fun, as well as with arousal and excitement (Mandryk et al., 2006; Ravaja et al., 2006). The co-located aspect of play brings in social pressure, which can trigger self-awareness and evaluation apprehension, based on the players' perception of their performance and of the expectations of others (De Kort & Ijsselsteijn, 2008). This in turn can impact players' performance (De Kort & Ijsselsteijn, 2008; Jakobs et al., 1996).

De Kort and Ijsselsteijn (2008) further analyze the *socio-spatial characteristics, contingencies, or context* as involving the physical presence and spatial arrangement of things and people, along with the roles of players and other actors present in the activity, the interaction pattern designed in the game, and particularities of the game and the game interface, such as their input/output mechanisms. Together, these give rise to particular *social affordances*, which are key to shaping behavior. De Kort and Ijsselsteijn describe how social affordances:

> […] allow for social interaction processes such as awareness, monitoring, mimicry, reinforcement, verbal communication and nonverbal immediacy behaviors (i.e., approach behaviors that reduce psychological distance (Mehrabian, 1981) (De Kort & Ijsselsteijn, 2008, p. 18:5).

All relevant elements in the activity (the game, the space, other players and their roles, physical and digital artifacts), and their social affordances form the *sociality characteristics* of a game, a concept that De Kort and Ijsselsteijn borrow from Jakobs et al. (1996).

This thesis uses De Kort and Ijsselsteijn's term of *socio-spatial* to emphasize the spatial aspect, the way people are distributed in the space in the array of physical and technological artifacts and spatial fittings. The concept is used to include the role that the players take in the activity, as well as the roles, tasks, or functions of other elements in the space to help sustain action. The socio-spatial context is used together with other formal elements in game design (e.g. the rules, or the goal of the activity) to design the *structure* that frames the ongoing activity. The terms *arrangement* and *configuration* are sometimes used interchangeably to emphasize the fact that the socio-spatial context is not a given, and can be designed, set up, and changed to fit the ongoing activity. Design in this thesis therefore involves both the design of technology and the design or arrangement of socio-spatial features.

The socio-spatial configuration can be influenced by the technology design (De Kort & Ijsselsteijn, 2008), as illustrated in Szentgyorgyi et al.' (2008) study of the social use of the Nintendo DS handheld game console (Szentgyorgyi et al., 2008). The authors observed how the single-user interface became associated with the creation of a *private game sphere* around the player and game console, despite the players' social context. This interaction pattern has become known as "playing alone together" (Ducheneaut et al., 2006; Szentgyorgyi et al., 2008; Turkle, 2012). Many of the designs in this thesis strive to avoid what De Kort and Ijsselsteijn (2008) call *sociofugal* arrangements, a concept drawn from proxemics to refer to arrangements "aimed at discouraging interaction" (Sommer, 1967, p. 149).

A useful concept related to the accountability of actions from a third-person perspective comes from the work of Reeves et al. (2005) regarding public interactive interfaces. Those authors present a taxonomy of interaction, and distinguish interfaces according to whether their manipulations and effects are visible to an audience (Reeves et al., 2005). When they are not, we encounter a secretive interface; when they are, we have an expressive interface. A magical interface hides the manipulation, but the effects of such manipulations are visible to an audience. Finally, a suspenseful interface hides the effects, while the manipulations are visible (Reeves et al., 2005).

While the design of some interfaces shapes the visibility of manipulations and effects from a third-person perspective, the socio-spatial context in which they are immersed influences this visibility. Reeves et al. exemplify this with mobile technology, like mobile phones, whose interactions are not usually visible from a third-person perspective. Yet certain special configurations of actors can change this. For example, a tall person looking over the shoulder of an adjacent person using a mobile phone will probably be able to see this person's manipulations and their subsequent effects.

## Play

This thesis is concerned with designing playful activities. Play is a very basic human activity (Huizinga, 1955) that has long stimulated research interest from scholars in various fields, such as psychology (e.g. Piaget (1962, 1997)), anthropology (e.g. Bateson (2006)), and sociology (e.g. Goffman (1961)). An influential early description of play was presented by Johan Huizinga in his book *Homo Ludens* (Huizinga, 1955). Huizinga demonstrated the importance of play in culture. Huizinga's influence originates in how he succinctly foregrounds important characteristics of play (Caillois, 1961).

> Play is a voluntary activity or occupation executed within certain fixed limits of time and place according to rules freely accepted but absolutely binding, having its aim in itself and accompanied by a feeling of tension, joy and the consciousness that is "different" from "ordinary life" (Huizinga, 1955, p. 28).

Huizinga thus presented play as an activity inherently social, and motivated this by its role in culture. Later scholars share a similar understanding of the boundaries of play as socially framed (e.g. Deterding (2009), Goffman (1961), Stenros (2015)), as something that can be socially recognized as 'different' from 'ordinary life'. This contrasts with psychological characterizations such as Apter's (1991) view of play as subjective perception, appreciation, and attitude (as presented by Montola (2012)).

Stenros describes the activity of play as externally observable, originating in "an internal playful state" (Stenros, 2015, p. 71), which Stenros calls *playfulness*, Salen and Zimmerman (2003) call *being playful,* and Back (2016) *playful engagement*. Stenros (2015) argues that "play is an activity, while playfulness is an attitude" (Stenros, 2015, p. 71).

A distinction particularly relevant for this thesis is one initially sketched by Huizinga, and further developed by Caillois: *paidia* and *ludus* (Caillois, 1961). Caillois presents them "not as categories of play, but of ways of playing" (ibid., p. 53).

Paidia is derived from the Greek word for "child" (Caillois, 1961, p. 28), or "of or pertaining to the child" (Huizinga, 1955, p. 30) (Huizinga, 1955, p. 30), and refers to children's typical way of playing – open, spontaneous, and emergent – and includes examples such as children engaging in pretense play (Fein, 1981) and playing house, or their urge to explore new objects, "to touch, grasp, taste, smell, and then drop any accessible object" (Caillois, 1961, p. 28).

In contrast, ludus describes a more structured way of engaging in play, typically in games, as goal-/performance-seeking activities bound to arbitrary rules or conventions. Caillois presents ludus as "complementary to and a refinement of *paidia*, which it disciplines and enriches" (Caillois, 1961, p. 29). Suits described what it is to play a game:

> To play a game is to attempt to achieve a specific state of affairs [prelusory goal], using only means permitted by rules [lusory means], where the rules prohibit use of more efficient in favour of less efficient means [constitutive rules], and where the rules are accepted just because they make possible such activity [lusory attitude] (Suits, 2005, pp. 54–55).

And the simplified version of his definition:

> (P)laying a game is the voluntary attempt to overcome unnecessary obstacles (Suits, 2005, p. 55).

The definitions above highlight the importance of a particular attitude (lusory attitude) so that play happens, as well as the existence of a set structure formed of rules, goals, means, and obstacles, with which the player engages.

The existence of a structure that is designed and that shapes the players' experience is particularly interesting from a design perspective. It explains the inclination in game design to study games as systems or artifacts that the players use, to the detriment to studying play as an activity that emerges as players engage with a game design (Stenros & Waern, 2011).

As designers, we cannot design the players' activity or attitude. Salen and Zimmerman characterize play design as *second-order* (Salen & Zimmerman, 2003).

> The challenge, of course, is that the experience of play is not something that a game designer directly creates. Instead, play is an emergent property that arises from the game as a player engages with the system. The game designer creates a set of rules, which players inhabit, explore, and manipulate. It is through inhabiting, exploring, and manipulating the game's formal structure that players experience play […]. The game designer only *indirectly* designs the players experience, by *directly* designing the rules (Salen & Zimmerman, 2003, p. 316).

In this thesis, the play design is usually described as "design for play" precisely due to the impossibility of designing play directly, but rather as something else that supports play. From a design perspective, this author finds particularly useful the minimalistic yet broad definition of play from Salen and Zimmerman as "free movement within a more rigid structure" (Salen & Zimmerman, 2003, p. 304).

Upton elaborates on this by relating Salen and Zimmerman's understanding of play to Huizinga's concept of separation from "ordinary life" (Huizinga, 1955). He argues that it is very often the construction of a system of rules, and the freedom to move within them, that make play "different" from ordinary life.

Upton's highlighting of the design of a system of artificial rules fits particularly well in the context of IxD. What these components represent depends on what is considered as "system". This could be the "packaged" digital or physical game, the "game as formal system". But it is also possible to consider the system of a game when played, the "game as experiential system", focusing on the interaction between players and the designed structure (Salen & Zimmerman, 2003).

As an example, when Salen and Zimmerman analyze the game of chess as a formal system, the objects are the pieces, whose attributes refer to the rules governing their moves and positions, and whose relationships include how they can take each other. As an experiential system, the objects are the two players competing, the attributes are the pieces they control and the game state, and the relationship involves the players' interaction mediated through the game ("social play" according to (Stenros, Paavilainen, & Mäyrä, 2009)) as well as the social interaction that happens parallel to the game ("sociability" according to (Stenros et al., 2009)).

In this thesis, the structures in focus exist primarily in the experiential frame. The reason is that the objects of design in this thesis are not "packaged" games, but play activities constructed and co-constructed in a co-located social setting. Hence, in a formal analysis of such activity, the objects comprise not only the physical and digital artifacts, but also the players and spatial elements around. Elements that would typically be considered in the context category, such as spatial and physical features of the space, are here actually considered as objects of design. This does not contradict Salen and Zimmerman's definition of objects, since they can be physical yet also abstract elements or variables within the system. The attributes refer to the rules governing their interactions. Finally, the relationships are best understood in terms of how positions and possible actions influence one another.

Nevertheless, the distinction between the experiential and formal systems is relevant for this thesis. The formal elements, such as the rules, the goal, the conflict and obstacle designed, the means and resources the players can use to reach a desired outcome, are key to achieving interesting play experiences. However, these are very seldom considered *fixed*; they are modified in the moment together with the experiential system to create such experiences.

This thesis takes a structural understanding of play, and focuses on designing structural aspects of an activity to shape the players' actions and indirectly their experience.

## Rules

Rules appear as the central element of most games definitions (Myers, 2009). They establish the relationship between the elements in the play activity (Fullerton, 2008), and are key to sustaining, framing, and shaping the play experience.

> […] In framing games as PLAY, we must consider not only the rules, but also the rule-system as a contest designed to deliver a particular experience of play for the game's participants (Salen & Zimmerman, 2003, p. 104).

Salen and Zimmerman present them as "[…] the inner, essential structures that constitute the real-world object known as games" (Salen & Zimmerman, 2003, p. 103). The rules of a game or play activity establish the means and resources available for the players, and they manage and organize players' actions (Salen & Zimmerman, 2003; Suits, 2005) and the progression to the various game states (including the final end or goal of the game), dictating how a game can progress and advance towards a final end.

However, there are many types of rules that influence play both in games and in more open-ended play, and there exists no taxonomy of rules that is commonly accepted within game studies. Game design literature typically focuses primarily on designing and studying the formal rules of play (Jakobsson, 2007). This is understandable, given that they can be directly shaped by the designer, in contrast with non-formal rules like the implicit rules governing social play (Salen & Zimmerman, 2003). However, the potential to shape behavior also exists with any other type of rule.

> In a strict understanding of rules, only formal rules (and game goals defined through formal rules) are to be understood as game rules. However, in order to understand the practices of play, the inclusion of non-formal rules becomes necessary, as the explicit formal rules of a game are no longer the only standpoint directing the activity of the player (Montola, 2012, p. 38).

Besides formal rules, Montola (2012) considers as rules social conventions, norms, and other external regulations (e.g. human laws), as well as internally defined and validated rules (when players set a goal for themselves to fulfill). Of particular interest for this thesis are two sets of rules that Montola proposes, influenced by Searle's social constructionism: *materially embodied rules* and *brute circumstances* (Montola, 2012). Materially embodied rules are those that are physically implemented, such as algorithms in digital games, physical artifacts used in the game (e.g. the ball in volleyball), or game controllers and other peripherals. Brute circumstances include natural and biological realities, for example how gravity imposes constraints in the way we move and make things move.

Given the importance of the moving body in most works in this thesis, these two types of rules are essential when designing activities. They are considered as important and influential as any other rule, including formal and social rules. This is not a novel suggestion, given how the same aspects influence constitutive rules in sports games[10].

In a similar manner, "house rules" or unwritten social rules are taken in this thesis as seriously as pre-designed constitutive rules. When articulated (verbally or non-verbally) and suggested by a participant, a house rule can become a rule as important as the pre-defined constitutive rules of a play activity, in that both can shape behavior, define a goal, and include or limit means for reaching such a goal.

> Let us say, then, that a game is an activity in which observance of rules is part of the end of the activity, and where such rules are non-ultimate; that is, where other rules can always supersede the game rules; that is, where the player can always stop playing the game (Suits, 2005, p. 42).

## Players as co-designers of play

Another particularity of the understanding and use of rules in this thesis is that very little importance is placed on adherence to them. To some extent, this relates to this author's focus on designing play activities that might or might not be games. Those activities share with games a pre-designed structure that forms the skeleton of an activity. However, more often than not, the end or goal of the activity is quite open, and frequently this author seeks to define it during play. Hence, there is no "sacred goal" to reach, or rules to obey, but certain behaviors that appear interesting and worth supporting with structural design elements.

This author is not the first to present a "lax" relationship to rules. Prominent examples have been noted by Bowyer (1982), Consalvo (2009), Kücklich (2007), and Wilson (2011).

### B.U.T.T.O.N. and cheating

Recently, cheating has been presented as a powerful component of co-located social play (Wilson, 2011). An illuminating example is the game

[10] Montola discusses the importance of brute circumstances, for example gravity in sports games such as basketball, where the weight of the ball is stipulated as a constitutive rule.

B.U.T.T.O.N. (Brutally Unfair Tactics Totally OK Now) (Wilson, 2011), where cheating is encouraged and even designed for.

In this game, several players stand in a line a few steps away from a big screen and their game controllers, which is the starting point from which the players race towards the controllers' buttons. The goal of the game is simple: the players need to be the first to press these buttons, or perhaps they need to prevent others pressing them, depending on the written rules displayed on the screen at the beginning of the round (Wilson, 2011). Cheating is presented explicitly as a means for the players to reach their goal, through numerous hints in the game and because the game cannot test whether players follow its instructions.

Wilson describes the game B.U.T.T.O.N. using Gaver's concept of *self-effacing*, introduced in Chapter 2 to refer to open-ended and ambiguous designs that prompt participants to reflect on and consider uses and possibilities, and to engage and interact with design artifacts, finding new interpretations and personal ways of understanding and influencing designs.

> Open-ended and personal, they encourage us to play – seriously – with experiences, ideas and other people (Gaver, 2009).

In this thesis, the concept of self-effacing is relevant in all three aspects pointed out by Gaver: experiences, ideas, and people. A particular design value that pervades this thesis is the facilitation of the players' exploration of, and playing with, ideas and experiences that involve others. Wilson focuses in particular on the negotiation of rules and modes of playing in social play. Both the gap between the rules set and what the technology can track, and the recurring invitations to cheat, present the rules as negotiable. From Gaver's definition, Wilson highlights the aspect of a form of play that is "self-motivated" and "beyond the purely instrumental" (Wilson, 2011):

> […] unachievements encourage theatrical performance of instrumentality, as opposed to the instrumentalization of performance. Unachievements invite the meta-game to intrude upon the game system (Wilson, 2011).

Designing for unachievement shifts the focus from the design, crafting, and polishing of a particular game, to the creation of a *festive context of play*, which Wilson states to be the primary objective of the game designer (Wilson, 2011).

### The Well-Played Game

Strategies for empowering players to find their own rules and ways of playing are also central in DeKoven's concept of *the well-played game* (DeKoven, 2013) and the related idea of *coliberation* (DeKoven, 2011). DeKoven defines a *well-played game* as one that "becomes excellent because of the way it's being played" (DeKoven, 2013, p. xxiv), opening up opportunities for players to change how it is played. DeKoven's "excellence" refers to the players being fully engaged and playing at their best (DeKoven, 2013).

An illuminating example that shows the transformative power of a well-played game comes from one of DeKoven's personal play experiences, when he was playing Ping-Pong with a friend who outplayed him by far. Due to the difference in skill levels, the game was not particularly enjoyable for either of them. However, changing a few rules or the goal of the game changed this. When the superior player started to play with "the wrong hand" and the goal of the game was changed to volleying the ball instead of scoring, the skill levels became balanced and the players were collaborating with the same goal. We can envision a range of rules that could be added on the fly to increase or decrease the challenge: setting distances from where to hit the ball, blindfolding one of the players, or changing the goal of the game so the superior player is tasked with hitting the other player's paddle.

DeKoven often suggests strategies to transform a competitive play activity into one that is collaborative, in which players are engaged in seeking a common goal. This is motivated by the outcome sought: the feeling of "playing well together", instead of scoring, winning, or beating another player. DeKoven describes this experience as *coliberating* or mutually empowering. DeKoven argues that coliberation is a powerful, enlightening, and deeply transforming experience that has as its core the social experience of togetherness (DeKoven, 2011, 2013).

This thesis takes from DeKoven his understanding of, respect for, and value of the role of the players as designers of their own play activity (DeKoven, 2013). They are well suited to judging whether the play activity is working for them, and to finding ways to fix it if it is not, or to enhance elements that are working particularly well to support the experience they are seeking.

**Guidelines to "play well"**

DeKoven sketches important considerations to motivate players to become play activity designers, briefly sketched below in order by this author. First, DeKoven emphasizes the prerequisite of play of being a *voluntary activity* (Caillois, 1961; Huizinga, 1955). Without willingness to play, play does not exist. The same can be said about the will to transform an existing play structure; players need to be open to play, and also to fine tune their activity to suit them (DeKoven, 2013).

A very important aspect listed by DeKoven is *safety*, i.e. that the players are safe in their play activity, not risking more than they are willing (DeKoven, 2013). The New Games Movement presents its games with the motto of "Play Hard, Play Fair, Nobody Hurt" (DeKoven, 2011; Fluegelman, 1976). DeKoven, co-director of The New Games Foundation, explained this maxim:

> The "nobody hurt" part was probably the most important of the three, because if people couldn't feel safe enough to play, they generally couldn't play. And if they couldn't play, they'd never experience the coliberation we were there to share (DeKoven, 2011).

Safety cannot be enforced and ensured externally (DeKoven, 2013; Salen & Zimmerman, 2003). Ultimately, it is up to the players how they engage with a certain play activity, and how they understand and act upon what happens in the magic circle of play, and with one another as part of the social contract on which they implicitly agree when playing together (Salen & Zimmerman, 2003).

Rules are instrumental for this, since they shape the boundaries of the "magic circle" of play and "determine what 'holds' in the temporary world circumscribed by play" (Huizinga, 1955, p. 11), which can be different from daily life (Caillois, 1961; Huizinga, 1955). So it is important that the players share an understanding, agreement, and acceptance of the rules that support their shared activity, and can safely assess what is allowed in the game (Fullerton, 2008). In order to build trust, DeKoven suggests using *familiarity*, i.e. familiar game and play elements, as well as social *conventions*.

Trust is related to the last guideline suggested by DeKoven: to arrive at a common understanding of the players' intentions and expectations of play. This is something that needs to be revisited and negotiated continuously as play unfolds. DeKoven describes how seeking to play well together can transform an existing game, changing its rules and goals, and how easy it is for new play activities to focus suddenly on performance and winning/losing conditions. That is an acceptable alternative, but no longer focuses on empowering all participants and getting the best from them (DeKoven, 2013).

## Core mechanics

At the beginning of this section, it was established that a major design goal of the works included in this thesis was shaping the players' actions during a play activity.

An important concept for this purpose is that of *core mechanics* (Salen & Zimmerman, 2003), also known as *core gameplay* or *game mechanics* (Mäyrä, 2008), and *interaction mechanism* (Järvinen (2002) as cited in (Mäyrä, 2008, p. 104). It concerns what it is possible to do in a game:

> […] everything a player can do while playing the game, and also game rules that govern these actions […] (Mäyrä, 2008, p. 17).

Salen and Zimmerman delimit the above definition:

> A core mechanic is the essential play activity players perform again and again in a game (Salen & Zimmerman, 2003, p. 316).

Core mechanics can involve simple actions, like throwing dice to advance in the game snakes and ladders, or activities ("a suite of actions" (Salen & Zimmerman, 2003, p. 316)) like dodging "bullets" in paintball while looking around for enemies and shelter.

In digital gaming, the concept of core mechanics is multifaceted, as happening in both the digital and physical world, given how actions of the player holding the game controller can be mapped to virtual representations of the player such as an avatar. They are also considered deeply coupled with game states. Salen and Zimmerman illustrate this with the game Donkey Kong:

> In Donkey Kong, the core mechanic is using a joystick and jump button to maneuver a character on the screen (Salen & Zimmerman, 2003, p. 316).

Core mechanics can be physical actions, like the physical steering of a joystick controlling Donkey Kong (above); they can involve verbal input, like answering questions in Trivia; or even activities that are less observable, like considering strategies (Salen & Zimmerman, 2003).

> In a real-time strategy game such as Starcraft, the core mechanic combines resource management and wargame strategy and rapid mouse and keyboard command skills (Salen & Zimmerman, 2003, p. 317).

What is particularly interesting about core mechanics is how they relate to rules. Salen and Zimmerman (2003) present core mechanics as something that the designers *identify* and *use* (e.g. to sketch the game's interactivity), but they refrain from stating that it is something that can be directly designed. This author argues that the reason is that the players' activity can never be fully designed. Core mechanics may be directly influenced by all the rules involved in the play activity, designed or not, because they all shape what the player can do and does. This includes formal rules, as well as social rules and brute rules. Social rules include in-situ improvised rules, like those characteristics of fine tuning a well-played game.

Besides rules, both Mäyrä and Salen and Zimmerman point to shaping the core mechanics by designing "the interactivity" of the game (Salen & Zimmerman, 2003), what Mäyrä calls the "rules of interaction" (Mäyrä, 2008).

The recurring character of actions defined as core mechanics was established previously. In game studies, this repetition is considered necessary to advance in the game (game state). However, in this thesis, core mechanics are studied not as instrumental (to advance in a play activity), but as *ends*.

> […] Game designers don't just create content for players, they create *activities* for players, patterns of actions enacted by players in the course of game play (Salen & Zimmerman, 2003, p. 317).

This author considers core mechanics to lie at the core of activity-centered design. This thesis develops the concept as *embodied core mechanics*, to emphasize that they are actions worth doing, goals in themselves. This extends their instrumental value from a phenomenological perspective. Their main role is not to advance a game, but to facilitate a certain embodied experience.

A key aspect for the design of embodied core mechanics for play is the design of rules, just as in game design. However, while video games traditionally rely on "conventional interactivity to determine the key player activity" (Salen & Zimmerman, 2003, p. 327), in this thesis rules extend to include also constitutive physical rules (i.e. Montola's brute circumstances and materially embodied rules, in physical and digital artifacts) as well as formal/constitutive and regulative social rules.

Following a technology-supported approach, the key design resource to implement these rules is not only the technology, but also contextual elements, such as the space where the activity takes place, physical objects, and the players themselves.

## Concluding remarks

The last part of this chapter detailed the targeted type of movement-based activity in co-located social play, and its specific design values of "playing well together", creating a "festive context", and empowering the players to act as co-designers. The section concludes by justifying the concept of embodied core mechanics from this perspective.

The main difference between the concept of embodied core mechanics and its counterpart in game design lies in the *why* and *how* of this construct. Embodied core mechanics are embodied activities worth doing in and of themselves, irrespective of their role in the game. This draws from the embodied perspective of action presented at the beginning of this chapter, Merleau-Ponty's focusing on the role of the body as the center of our experience and action in the world, Heiddeger's phenomenology of objects and tools, and Schutz's phenomenology of social action.

This underlying philosophical stance has been made more practical (*how*) when complemented with concepts from ethnomethodology (e.g. accountability and reciprocality), social psychology and anthropology (affordances and proxemics), and somaesthetics (e.g. disruption and re-direction of attention).

# Chapter 4. Methodology

This chapter clarifies both the research tradition behind this thesis and the type of knowledge and contribution that can be expected from such work, and discusses the evaluation criteria within the field against which the contribution of this thesis should be judged.

This thesis is situated at the intersection between Interaction Design (IxD) and Human-Computer Interaction (HCI). Interaction Design is oriented towards creating and shaping interactive systems, paying special attention to its use qualities (Fällman, 2008; Löwgren, 2002). Interaction Design contributes to HCI with its goal of creating and shaping the artificial "for the better" (Fällman, 2008), but can also be considered to be a separate "design discipline" by itself, with distinctive goals, methods, tools, outcome, and resulting knowledge (Fällman, 2008).

## Design knowledge

> Design knowledge is of and about the artificial world and how to contribute to the creation and maintenance of that world. Some of it is knowledge inherent in the activity of designing, gained through engaging in and reflecting on that activity. Some of it is knowledge inherent in the artefacts of the artificial world [...], gained through using and reflecting upon the use of those artefacts. Some of it is knowledge inherent in the processes of manufacturing the artefacts, gained through making and reflecting upon the making of those artefacts. And some of each of these forms of knowledge can also be gained through instruction in them. (Cross, 2001, p. 5)

### From design science to design research and knowledge

The approach to discussing design from a scientific perspective emerged during the 20th century. In a review of the attempts to make design scientific, Cross (2001) distinguishes between three phases in this development. The first form is *scientific design*, which emerged during the first half of the 20th century with the growth of applied sciences and the move from craftsmanship to industrial design, which forged the need for more objective and rational (i.e. scientific) design methods. From this followed *design science* during the second half of the century, with its controversial attempts to systematize and rationalize design in a manner similar to natural science. Here we find attempts to develop *the* design method, as coherent and rationalized as "the scientific method was supposed to be" (Cross, 2001, p. 3). In parallel grew the *science of design*, or the systematic and rigorous studies of design to understand what design is and how designers work and think, and ultimately to help advance design practice.

There remains a call for the establishment of IxD methods that present criteria for rigor and relevance, as an implicit requirement to accept IxD methods as ways of inquiry and knowledge production in HCI (Stolterman, 2008; Zimmerman et al., 2010). Fällman and Stolterman discuss how this emerges as a "disciplinary anxiety" within the IxD discipline (Fällman & Stolterman, 2010). However, design scholars have raised serious criticisms against attempts to "scientize" design (Gaver & Bowers, 2012), especially concerning the standard approaches to judging validity (Bowers, 2012; Fällman & Stolterman, 2010; Gaver, 2012). Schön (1984) challenged the emergent positivistic approach to design, highlighting the inattention to the way designers do and know (Cross, 2001; Schön, 1984). Schön proposed a constructivist approach that embraced tacit design knowledge and reflective practice (Schön, 1984). Cross advocates a design thinking research approach that foregrounds the "designerly ways of knowing" (Cross, 2001). Koskinen et al. equate the importance of doing to thinking or discourse, which are much more accepted and valued in academia; constructing "something" can lead to discovering "things that would otherwise go unnoticed" (Koskinen, Zimmerman, Binder, Redström, & Wensveen, 2011, p. 2).

Interesting views of the relationship between design and knowledge find their roots in Frayling's classifications of design (Frayling, 1994), and have been extended by scholars in IxD and HCI (T. Binder & Redström, 2006; Fällman, 2008; Zimmerman, Forlizzi, & Evenson, 2007).

The Interaction Research Triangle (Fällman, 2008) captures well how design work in IxD can be situated at, and move within, the intersection of several typified activities. *Design practice* resembles design activities outside academia the most, where tacit knowledge, skills, and competence are key for the final outcome. There might be an explicit research question, or one that emerges during the design process. *Design exploration* is also similar to design practice in that the main goal is to design something. The main difference with the former form is the primacy of exploration, to understand possibilities, and to provoke the current state of affairs: "design becomes a statement of what is possible, what would be desirable or ideal, or just to show alternatives and examples" (Fällman, 2008, p. 7). Last, *design studies*, which resemble the most traditional academic disciplines, with the main goal of adding to a cumulative body of knowledge favored over design creation. While a design project in IxD can drift from one activity to another, it becomes important to understand in which kind of research one is currently involved. Although the methods, techniques, and tools of each activity are similar, they have different goals, produce different outcomes, and are influenced by different traditions. This creates different criteria for judging the results.

This thesis could be classified according to Fällman's triangle as design studies, given the way it is presented as academic work that builds on and adds to the body of (academic) work within a particular design domain, and attempts to advance it. However, the knowledge that shaped these contributions mainly comes from design explorations. Furthermore, the tacit expertise of the author, so characteristic of design practice, has been pivotal in designing and analyzing the design explorations. Yet unlike in design practice, the academic and research environment poses the additional requirement on the researcher (or designer) to articulate knowledge (even if tacit) if it is to be accepted as valid.

## Research through Design (RtD)

Frayling (1994) questioned the dichotomy between design (and art) and research, and between the role of the researcher and that of the artist or designer, highlighting how these are usually intertwined and often indistinguishable. Frayling differentiates instead between research *into* arts and design, research *through* arts and design, and research *for* arts and design (Frayling, 1994). Research into arts and design is historically the best-recognized form, and includes theoretical perspectives on art and design, historical research, and aesthetic or perceptual research. Research *through* arts and design involves the use of design objects and practices to develop knowledge, and includes materials research (novel treatment of materials, like colorization of metals), development work (novel technology to do "something no one has considered before" (Frayling, 1994, p. 5)), and action research (rigorous documentation of the design/art work). Research *for* arts and design involves the work prior to the design, like gathering materials, which is then embodied in the artwork or design.

Frayling's work has often been noted as the precursor to a recent approach to design research within HCI and IxD (Bardzell et al., 2015; Bowers, 2012) that is typically called *Research through Design* (RtD). This approach has been highlighted as a signature feature of the so-called third-wave HCI (Bardzell & Bardzell, 2011; Bødker, 2006; Bowers, 2012; Harrison, Art, Tatar, & Sengers, 2007; Harrison et al., 2011).

Zimmerman et al. (2007) present RtD as a form of research that grants a major role to the design process, which is typically iterative, and involves the creation of design artifacts as a way of gaining knowledge (Zimmerman et al., 2007). Their formulation is similar to Dalsgaard's (2010) use of the same concept, where the *through* foregrounds a designerly approach employed by a researcher who uses design as a manner of inquiry (Dalsgaard, 2010).

Regarding purpose, activity, and outcome, an illuminating concept is Fällman's distinction between design-oriented research, and research-oriented design (Fällman, 2003a). Both involve design and research, but in research-oriented design, the main goal is design, and research happens to support it, or as part of it. Hence, knowledge comes from the design process, and can have an important weight in it, but the ultimate goal of the activity is the final artifact. In contrast, design-oriented research sees its main product in knowledge, for which design is instrumental (Fällman, 2003a).

This thesis is clearly situated in the latter paradigm; it uses design as a mode of inquiry (like RtD), placing a strong focus not on the resulting artifact but on the knowledge gained through the process of designing. Dalsgaard argues for RtD as

> […] research that (1) is directed at improving the understanding and practice of interaction design and thus includes inquiries into the design process itself, and (2) employs the researchers involvement in design experiments as a key catalyst for knowledge generation. (Dalsgaard, 2010, p. 201)

The motivation underlying RtD is that in practice interesting design tasks are typically complex and messy, arguably too complex to be addressed with traditional scientific or engineering methods (Zimmerman et al., 2010). Complexity here refers to a special kind of problem, *design complexity*, different from its homonym in science (Stolterman, 2008). The design problem is typically under-defined, and it is also impossible to explore all possible options or to get to any "optimal" solution. These problems have been called *messy* or *wicked* (Buchanan, 1992; Rittel & Webber, 1973; Stolterman, 2008). RtD has been proposed as a valid approach of inquiry (Dalsgaard, 2010; Zimmerman et al., 2010), due to its focus on creating ways of addressing the problem and of changing the current state of affairs to a "preferred one". A final characteristic feature of RtD, which can be observed in this thesis, is that the design problem does not necessarily come prior to design solutions, but evolves, becomes apparent, and is defined and re-defined as the design process evolves (Bardzell et al., 2015; Fällman, 2003a; Schön, 1984). In Fällman's description of design-oriented research, he describes "exploring possibilities outside of the current paradigm" as a key feature (Fällman, 2003a, p. 231).

## Contributions and forms of accepted knowledge in RtD

> As a field, HCI must answer what sorts of knowledge outcomes can come from objects in (art and) design projects; if we can't, we cannot legitimize RtD as a way of doing HCI research. (Bardzell et al., 2015, p. 2094)

Design scholars in RtD tend to emphasize the key role of the actual designs produced, the "design artefacts", "design exemplars" (Zimmerman et al., 2010), or "ultimate particulars" (Stolterman & Wiberg, 2010). Some describe these as the ultimate goal of RtD activities (Fällman, 2003a), and some as the ultimate carrier of knowledge (Bardzell et al., 2015; Cross, 2001; Zimmerman et al., 2007).

> [D]esigns are seen as embodying designers' judgments about valid ways to address the possibilities and problems implicit in such situations. (Gaver, 2012, p. 937)

However, the artifact is not, and cannot be, the only outcome of an RtD design project; to be considered design-oriented research it must also produce some form of more generalized knowledge. Theory coming from RtD is of a particular type, given how RtD can uncover "[…] important relationships between phenomena in the near and speculative future and not in the present" (Zimmerman et al., 2010, p. 317).

Löwgren (2013) argues that RtD preferably generates what he and Höök call *intermediate-level knowledge*, within a continuum of scope that ranges from grand theories at one end, to the concrete design particulars at the other (Höök & Löwgren, 2012; Löwgren, 2013) (see Figure 1).

This axis of scope coarsely indicates both the level of abstraction and the applicability of a particular knowledge form (Löwgren, 2013), and so at one end we would have grand theories that would hold "in all situations and under all circumstances" (Löwgren, 2013, p. 32), and at the other a design particular, which would certainly "hold" in the context where it is created (proof by existence), but where little is known about whether the knowledge would "hold" in other contexts or instantiations. Gaver and Bowers (2012) argue that the position in this continuum does not necessarily reflect relevance to

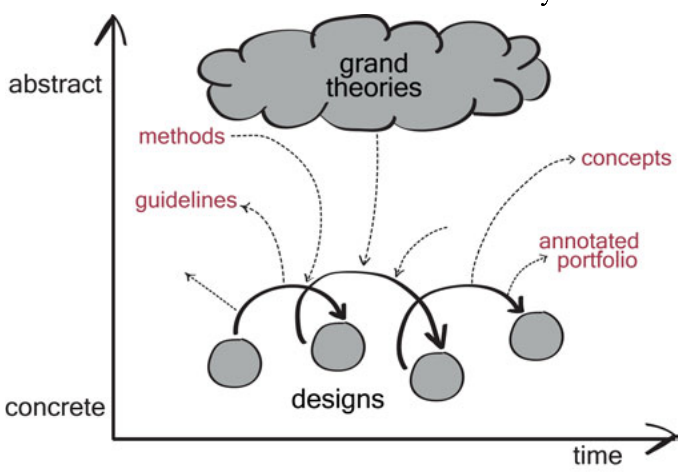


*Figure 1. Intermediate-level knowledge forms in RtD.*

design; although grand theories have explanatory power, their value in an RtD process might be limited (Gaver & Bowers, 2012; Löwgren, 2013).

Intermediate-level knowledge can be construed in various ways. Theory can help design when *translated* or *operationalized* into an intermediate-level knowledge form, which in turn can be useful in an RtD project. Löwgren describes *design guidelines* as one such form that was developed early in HCI in order to "break down" and disseminate theories that HCI borrowed from other fields (Löwgren, 2013). *Usability heuristics* form a similar intermediate-level type of knowledge that supports analysis rather than design.

> Many of these (intermediate-level forms of knowledge) rely on knowledge established in other disciplines, for example, knowledge about human experience that comes from philosophy or cognitive science. (Zimmerman et al., 2010, p. 313)

Arguably, importing and translating theories in HCI forms a valuable basis for knowledge and a common vocabulary that are generative of new intermediate-level knowledge forms (Dalsgaard, 2010; Gaver, 2012; Koskinen et al., 2011; Rogers, 2004) useful in design and research projects (Rogers, 2004).

Knowledge can also be translated, or *abstracted,* from the concrete (Höök and Löwgren, 2012), which is characteristic of RtD design processes (Zimmerman et al., 2010). Examples of intermediate-level knowledge include guiding principles, sensitizing concepts, and design implications (Zimmerman et al., 2010), manifestos and frameworks (Gaver, 2012), as well as methods and tools, design practices, experiential qualities (Löwgren, 2013), and annotated portfolios (Bowers, 2012; Gaver & Bowers, 2012; Löwgren, 2013).

Then there are a few established and well-described knowledge forms that not only reside in, but also connect both abstract theories and design particulars. For example, Zimmerman's (2009) *framing constructs* are developed at the same time from theory and the particulars. That author identifies the way a theory has been applied in different designs, which results in design patterns that encapsulates theory.

Stolterman and Wiberg (2010) present a concept-driven research approach that focuses on producing theoretical advancements manifested in concrete designs in the form of *conceptual constructs*. Their proposition is similar to *proofs of concept* in their point of departure, moving top-down from theories to the concrete. However, where proofs of concept focus on the feasibility of concepts, they embrace future scenarios and ground their reasoning (and not only their design) in theory, instead of in empirical studies. They claim this is a way of advancing intellectually and conceptually in a design-oriented field like HCI (Stolterman & Wiberg, 2010).

Löwgren and Höök's (2012) *strong concepts* come from a different departure, bottom-up, extracting the same design idea at the core of multiple design particulars and application domains related to the dynamic gestalt at the interaction level, or interactive behavior, that it triggers, and how this practice evolves over time (Höök & Löwgren, 2012). The relation these concepts have with theory comes from the vertical grounding that makes them a contribution to academic knowledge, in particular when substantiating them with theory, asking questions such as "What theories is the strong concept an illustration or concretization of? What could the relevant theories say about the strong concept that would help us provide an even more substantial knowledge contribution to other designer-researchers?" (Höök & Löwgren, 2012, p. 23:13)[11].

Finally, Dalsgaard and Dindler's (2014) *bridging concepts* are created specifically to inform both theory and design by bridging "the gap between theory and practice", and facilitating mutual enrichment and "exchange both ways between overarching theory and practice" (Dalsgaard & Dindler, 2014, p. 1637). Three constituents compose bridging concepts: "a theoretical grounding, a series of design articulations and a set of exemplars that embody the properties of the concept, reflecting the span from theory and practice" (Dalsgaard & Dindler, 2014, p. 1636).

## Criteria for evaluating RtD

As the knowledge contributions of this thesis fall within design research and not within the natural or social sciences, they cannot be judged against criteria from those disciplines (Stolterman, 2008; Zimmerman et al., 2007). The concepts presented in this thesis do not represent truths, but possible solutions (T. Binder & Redström, 2006; Zimmerman et al., 2007, 2010). They are catalysts for, and the inspiration of future possibilities (Ludvigsen, 2007; Zimmerman et al., 2010).

> […] RtD forces researchers to focus on research of the future, instead of on the present or the past. Finally, RtD provides an opportunity for the research community to engage in discourse on what the preferred state might be as an intentional outcome of the research […]. This focus on the future and the focus on concretely defining a preferred state allows researchers to become more active and intentional constructors of the world they desire. (Zimmerman et al., 2010, p. 310)

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[11] Vertical grounding also involves a grounding direction down to other exemplars, with questions like: "Is the strong concept present in other known instances?" (Höök & Löwgren, 2012, p. 23:12).

Well-established criteria in RtD related to the design outcomes are Zimmerman et al.'s process, invention, relevance, and extensibility (Zimmerman et al., 2007). *Process* refers to rigor during the design process: carefully documenting and detailing it, and clarifying and motivating design choices and selected methods. Although Zimmerman et al. recognize that replicability should not be a criterion for judging the outcome of the process, they suggest that the design process itself, in particular the methods used, be judged against this criterion. Regarding *invention*, results from a design process need to be situated within related works in the field and should advance it. *Relevance* refers to a careful articulation of the preferred state, so as to judge its impact in the world. Finally, *extensibility* refers to whether the contribution of an RtD process can be built upon, and whether it provides useful knowledge to the research community. However, the use that Zimmerman et al. make of this term resembles the traditional criteria of extensibility in sciences. Gaver notes the risk of this, from a thorough account from Philosophy of Science, foregrounding how provisional, contingent, and aspirational design theories tend to be (Gaver, 2012, p. 945).

In their proposal that knowledge contributions be articulated as strong concepts, Höök and Löwgren suggest that they should be *contestable*, *defensible*, and *substantive*. *Contestable* refers to novelty: a contribution involves propositions with which not everyone within the research community agrees yet can still be *defended*, meaning that those who disagree may accept the new proposition given solid theoretical or empirical argumentation. Finally, the contribution needs to be *substantive*: relevant for the research community to engage with, and having the potential to inspire and generate new action. The latter is related to Latour's understanding of the value of a knowledge proposal: to extend the research community's *repertoire of actions, their competencies and performances and, thus, the questions that they raise among those, scientists and non-scientists, who are put in touch with them* (Latour, 2004). This resonates with Gaver's account of design theory, in that despite being provisional, contingent, and aspirational, it can have a strong impact through being generative: *such conceptual work may nonetheless inspire thriving research programs* (Gaver, 2012, p. 945).

In the discussion chapter, we will revisit the knowledge contribution made in this thesis in the light of the criteria from Zimmerman et al. and from Höök and Löwgren, which partially overlap.

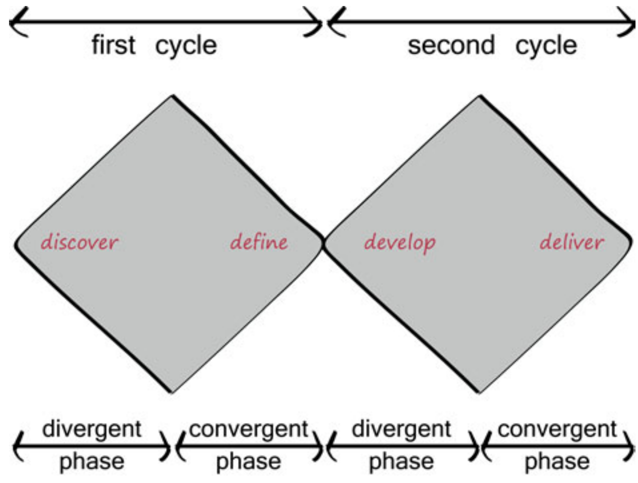


*Figure 2. Iterative design process inspired by the "Double ble diamond design process model," (n.d.)*

## Methodological considerations

This section characterizes the RtD process in this thesis, extending on the forms of knowledge produced, and two aspects of this process: a particular form of analysis used in evaluation, and the role of a first-person approach and somatic training to inspire design.

### The research cycles and forms of knowledge in this thesis

The work in this thesis follows a design-oriented research approach (Fällman, 2003a) and as such, the intended outcome is knowledge produced during the design process. The design cases in this thesis typically follow an iterative design process, with successive design instantiations, like typically happen in design practice ("Double diamond design process model," n.d.) (see Figure 2). However, as the goal is not one optimal design solution, these instantiations are seldom meant to improve or develop former designs, but are used to understand a different aspect of the design situation. Koskinen et al. (2011) highlighted how "most constructive design researchers work like the humanists and interpretive social scientists", and they contribute "to improve thinking and understanding" of practices, situations, usages, and not yet materialized possibilities, instead of focusing on making discoveries.

Figure 3 roughly sketches the phases within each cycle. Design is usually inspired by external influences (*inspiration phase*), such as external theories, related works, or a specific problem to solve (see Chapter 3). This triggers an *exploration phase*, which involves *conceptualization* and *instantiation*. In Figure 3, *instance* refers to a concrete design in use.

This relates to Koskinen et al.'s concept of *studio*, where designers engage in workshops or "knowledge environments" to test ideas in an embodied approach, "through more rich bodily, social, and playful imagination" (Koskinen et al., 2011, p. 130). Creating these studios, or *instances* as they are called in this thesis, helps participants to explore, create, and test through a common understanding of an experience and its context (Koskinen et al., 2011). Participating in a rich bodily and social activity also drives curiosity, and sense of joint accomplishment (Koskinen et al., 2011).
Such studios usually lead to re-thinking research questions and spotting design opportunities (Koskinen et al., 2011).

Yet in this thesis, this type of format of rich explorative embodied engagement that comes from doing, thinking, and creating together is carried out not only by designers, but also by end users when exploring, testing, and often modifying (hence acting as designers) design constructs on the fly.

This is related to the understanding of design constructs that underlies this thesis. First, they involve technology in use, as well as the socio-spatial elements that participate in and shape the activity (see Chapter 6). Hence, the design particular as it is traditionally understood in IxD, the interactive technology, is only *a part* of what is designed and studied. An illustrative concept that helps clarify the role of the designed technology is that of technology-supported design by Waern (2009), further explained in Chapter 3.

Second, precisely because of this particularity of design including contextual elements, concrete designs only come to life and are rendered visible in and through the *studies (instances)* in which initial design constructs are put to play.

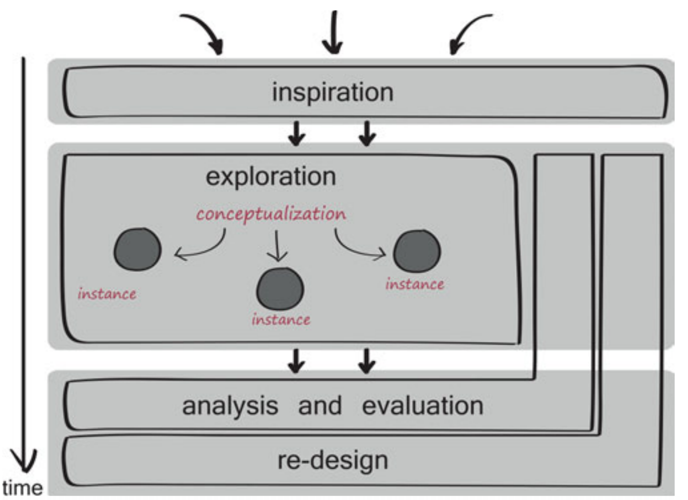


*Figure 3. One iteration design cycle.*

Finally, the open and explorative character of most studies enables participants to modify their activity as they play, thereby acting as designers.

An evaluation phase happens either in parallel with these instances or afterwards. In some studies, the researcher acts as a designer on site, changing design components on the fly, while in others, a more exhaustive analysis (involving typically video analysis) is performed. *Instances* are foregrounded as the raw material, instead of the design particulars as in, for example, annotated portfolios (Bowers, 2012; Gaver & Bowers, 2012).

Conceptualization happens not only at the end of each iteration, but also during the various phases and retrospectively during reflections on different instances that belong to the same or different projects.

Figure 1 depicts the type of design-oriented research in this thesis, in relation to the forms of knowledge produced, using a graphical representation inspired in others used by Höök during personal communications.

As with bridging concepts and strong concepts, knowledge forms presented in this thesis constitute intermediate-level knowledge, being neither general theories nor concrete instantiations.

The goal of the knowledge produced is mainly to advance design research in the field at a semi-theoretical level. This thesis also aims to influence design practice by offering an alternative design approach in a particular domain: one that is substantiated in theory, and grounded and illustrated in particulars.

Unlike Stolterman and Wiberg's (2010) conceptual constructs, research originates bottom-up, more in line with Höök and Löwgren's (2012) strong concepts. *Instances* illustrate and substantiate the more abstract concepts developed in this thesis, just as design exemplars would in a more traditional, artifact-focused, RtD endeavor.

Yet the contributions of this thesis are not strong concepts, in the sense that they neither present a single core design idea from multiple particulars, nor look at how an interactive practice evolves over time. Instead, comparably with Zimmerman's framing constructs, contributions in this thesis mainly involve the identification of important design considerations grounded in empirical data and theory.

The definition (although not the example) used in Dalsgaard and Dindler (2014) captures best the connections of the contributions in this thesis and theory and particulars. First, they are theoretically grounded. This author draws primarily on neighboring theories within Dourish's Embodied Interaction, and Shusterman's pragmatism (see details in Chapter 3). Then, theoretical and empirical insights are shaped into design articulations, or important qualities and considerations of the design constructs presented in this thesis[12]. Finally, the contributions of this thesis are explored using empirical data from design instances and design explorations, which are used to illustrate "critical" or "salient" aspects of a concept and its boundaries.

## Understanding and analyzing social and physical action

This author's understanding of important aspects of co-located physical and social experiences emerges from a situated exploration of design and play activities. An important unit of analysis is social action, which makes relevant approaches in sociology more fitting than others in other fields, like psychology (see Chapter 3). Collins, paraphrasing Goffman, highlighted how this type of analysis of social action shifts perspectives from "individuals and their actions" to "interactions and their individuals" (Collins, 2005, p. 5).

The type of data that this thesis uses to understand both the physical and social elements of play activities is qualitative, composed of first-person experiences, participant observation, and recorded video material of the studies.

The role of the designer-researcher[13] is central in all these forms of data. First, the felt experience researched in this thesis is fundamentally subjective, and in some studies this is investigated from a first-person perspective (see Chapter 3). Second, the designer-researcher has been actively involved in observations, suggesting changes in the ongoing activity, and analyzing its impact on the fly. An illustrative example of this is described in paper III, where this author was proposing changes to the play activity on the fly so that, for example, a game would better match the skills of the participants. Third, the type of analysis performed on the data has been qualitative, grounded in an interpretivist and constructivist tradition (Heron & Reason, 1997), in which the subjective influence of the researcher upon the data collection and analysis is acknowledged and embraced. Perception is in itself understood as subjective and participatory (Merleau-Ponty, 2002).

Due to the rich data collected throughout the cases, the qualitative approach to analysis has involved multiple forms of coding, memoing, and graphical representations of data and results from analysis (Lofland, Snow, Anderson, & Lofland, 2005). Coding formats have been developed through several coding stages, from "open coding" (Corbin & Strauss, 1990) or "initial coding" (Charmaz, 2006; Lofland et al., 2005) towards more fixed and conceptualized coding schemas that also are more selective. Memos go hand in hand with coding, as preliminary analytic insights at a higher abstraction level than the data and its present coding (Charmaz, 2006; Lofland et al.,

[12] Dalsgaard and Dindler use Krogh and Petersen's concept of design articulation to refer to considerations important for expressing the qualities of a concept (Dalsgaard & Dindler, 2014).
[13] In this thesis, the terms designer and researcher have been used interchangeably. The choice of words often indicates the role highlighted in a particular situation.

2005; Strauss & Corbin, 1990). These have usually been written text, and have been discussed with colleagues involved in the design or research project. Graphical representations of data, such as flow charts and diagrams, have been developed to serve a double purpose: as visual representations of coding categories and their relationships, and as an analytical tool (Lofland et al., 2005). Graphical representations have been particularly important in the work presented in this thesis, due to the ephemeral nature of the events studied.

The codings developed for analysis have been iterated in a similar manner to that in in grounded theory (Charmaz, 2006; Glaser, 1992). The conceptual knowledge proposed in this thesis is thus deeply rooted in data (Charmaz, 2006; Glaser & Strauss, 2009). However, it has not been developed in a theoretical vacuum; existing theories of social interaction, play, and embodied experience drive data categorization and interpretation. In this sense, the work relies on more constructivist and interpretivist evolutions of grounded theory (Corbin & Strauss, 1990; Strauss & Corbin, 1990).

**Video analysis**

As we established earlier, the situation, rather than the individual or an artifact, is at the core of analysis. The particular situations studied in this thesis share co-located and real-time properties with general ethnomethodological studies, as they are a here-and-now, face-to-face type of interaction. In addition, most of the studies in this thesis have focused on capturing the bodily and social engagement of participants. A persistent design goal was to facilitate the participants' use of their embodied ways of perceiving, acting, and understanding. Hence, it was important to understand the way they made use of the space, the objects around, their focus of attention, and the tools and mechanisms they used to manage their joint coordination of action.

This required a type of analysis that bears a resemblance to micro-sociological works, analyzing what happens in face-to-face social encounters in a fine-coarse and detailed way, producing so-called thick descriptions, such as conversation analysis (Atkinson & Heritage, 1984; Heritage, 2008; Liddicoat, 2007), or interaction analysis (Jordan & Henderson, 1995). This thesis makes the same basic assumption as Dourish, that users are engaged in "practical sociological reasoning", when they have to determine what other people mean and in turn determine how to act themselves (Dourish, 2001, p. 75). These "commonsense" methods allow people to make sense of situations, to "manage and organize their everyday behavior […]" (Dourish, 2001, p. 74), and "to analyze one another's conduct and arrive at judgments about personal motives and identities" (Liddicoat, 2007, p. 301). These are also the methods on which analysis in this thesis has often focused.

The approach to analysis is inspired by ethnomethodology, and in particular conversation analysis (CA), which analyzes talk-in-interaction (Schegloff, 1987) that focuses on conversation (Schegloff, 1987, p. 101). Brought forward from CA is the focus on the sequential organization of interaction, the understanding of how participants grasp a next action, and how they produce and then interpret it, as well as the concepts of turn-taking, adjacency pairs, and repair (Atkinson & Heritage, 1984, 1984; Liddicoat, 2007; Sacks, Schegloff, & Jefferson, 1974; Schegloff, 1987).

However, where CA relies on speech as the main communication channel, the work in this thesis must take many other signs and signals into account. Goodwin extended CA into "interaction analysis" by also considering bodily stances, orientations, and actions, such as direction of gaze, and by the relationship of the participants to one another (Goodwin, 1979). Interaction analysis typically involves different disciplines and methods that need to be considered together (Goodwin, 2000). The complexity makes it necessary to narrow down the data that is analyzed, as well as the degree of detail that is analyzed. Goodwin encouraged a clear central question to drive the analysis (Goodwin, 2000). For example, in the initial studies in this thesis, one aspect researched was the dominance of the technology, and in particular its screen, in guiding action. This question focused the analysis on the participants' gaze, and also on "its consequences", like how this interfered with the ongoing (physical and social) activity.

Important concepts from Goodwin are the mutual orientation of participants that characterizes face-to-face interaction, and that provide participants with an "embodied participation framework" (Goodwin, 2000, p. 1499), along with the multiple and concurrent semiotic resources, including sign phenomena, produced by verbal and non-verbal participation and by physical artifacts used in the interaction. They make use of varied resources using different mediums (that Goodwin calls semiotic fields) that are intertwined and used together by participants to understand, maintain, and produce meaning. *Contextual organizations* include those that are "oriented to at a particular moment as relevant to the organization of a particular action" (Goodwin, 2000, p. 1500). Particularly interesting is how participants rearrange contextual configurations to make sense of or act in a particular situation. Goodwin shows how the configuration of semiotic resources is key to the analysis of action (Goodwin, 2000), given that not all the resources "are relevant and in play at any particular moment"; participants therefore rearrange them as they orient to them given their relevance to the ongoing activity. An analysis focused on contextual configuration would not cover all the existing resources in a situation, but those that are at play, and being used and oriented to. This concept has been key to much of the analysis in this thesis.

In order to perform interaction analysis, we must track the activity as it unfolds, temporally. Video recordings are considered a key tool for situated interaction analysis. Although the analysis remains time-consuming and requires intensive work (Jordan & Henderson, 1995, p. 50), video recording facilitates this task; it allows detailed scrutiny, as the video material can be played repeatedly (Heath, Hindmarsh, & Luff, 2010). This feature also allows the researcher to analyze data using different angles, and even share it with colleagues and participants enabling them to complete and test their own perspectives and insights. In addition, video recordings offer a way to archive instances of interaction, for further examination or illustration of insights (Heath et al., 2010).

The video analysis carried out in this thesis notes important aspects considered in proxemics, such as relative distances, location in the space, bodily orientation, and gaze (Marquardt & Greenberg, 2015). However, the approach followed in this thesis is more hermeneutical and constructivist, and not seeking to draw clear connections between proxemics aspects and resulting intention. Instead, proxemics is treated as one aspect participants use to construct, make and maintain sense of a physical and social activity.

Moreover, the analysis carried out focuses on qualitative aspects of the interaction: rather than coding whether certain behavior happened, this author looked at how it happened. The frequent core units of analysis have been movement qualities and the strategies participants employed to accomplish joint action. All the work in this thesis has relied heavily on video analysis, which proved to generate useful and interesting insights.

### First-person perspective and somatic training

Physical engagement is a goal in itself for the activities designed in this thesis. Hence, the multidisciplinary field of somaesthetics, which foregrounds the body in aesthetic appreciation, is a theoretical grounding for the work, which also has implications for the chosen methodology. Somaesthetics proposes methods not only for understanding and articulating bodily interaction, but also for improving our somatic consciousness and sensibilities (Shusterman, 2008). In this regard, sensitizing methods within somaesthetics that have been important for this thesis include first-person explorations, and the guidance and facilitation of bodily experiences.

In particular, for some of the knowledge contributions like embodied sketching (see Chapter 7), it was fundamental to have substantial first-person understanding of movement and of embodied phenomena. A first-person orientation to inquiry was thus employed, similar to that proposed by Höök and Schiphorst (Höök, 2010; Höök et al., 2015; Schiphorst, 2011) (see Chapter 3). For developing a substantial understanding of movement, the author has undergone a process of becoming (to some extent) a somatic "connoisseur" (Schiphorst, 2011).

> [I]f one truly likes to design for movement-based interaction, one has to be or become an expert in movement, not just theoretically, by imagination or on paper, but by doing and experiencing while designing. In order to do so, we believe that designers need design tools, techniques, knowledge, awareness,

> and skills that support their search for expressive, rich behaviour. (Hummels, Overbeeke, & Klooster, 2007, p. 677)

The process started by studying methods for *talking* about movements, for which vocabulary and methods from other disciplines were borrowed: from the anatomy of movement (Calais-Germain, 2007) used in physiotherapy, and from Laban Movement Analysis (LMA) (Guest, 2005; Newlove & Dalby, 2003). Particular methods that were used early in this PhD involved labanotation (Guest, 2005; Newlove & Dalby, 2003), a coding system for transcribing and choreographing movements that has previously been proved useful for the analysis of movement-based interactive systems in HCI (Loke et al., 2005).

This author then trained to become an instructor of fitness practices, which remains an ongoing process. To this author, a long-standing engagement with several types of practical somaesthetic disciplines was insufficient. In order to transfer this knowledge into design, an understanding had to be acquired of how to facilitate and improve others' understandings of movement. Inspired by ethnographic methods (Bryman, 2012; Lofland et al., 2005), this author became immersed in several training courses for fitness instructors in various disciplines and sub-disciplines, such as AntiGravity® Fitness, BarreConcept Fitness, and Pilates. But like others in HCI that have borrowed ethnographical approaches (Ferreira, 2015), a design orientation has always pervaded in the ethnographical works towards getting insights from such an inquiry that are useful for design (Hughes, King, Rodden, & Andersen, 1994, 1995), and so the use of ethnography always had a utilitarian aim. In particular, the reason for becoming a trainer was to acquire a sense of how instructors could facilitate practitioners' understanding and performance of movement, and how they used different physical and spatial resources (e.g. fitness equipment) for doing so. However, this research journey became an autobiographical exercise, as the researcher looked into how the training changed her perception and appreciation of embodied phenomena in an instructor-based fitness activity, and her ability to transmit this knowledge to practitioners. Like many other ethnographic works, this resulted in a transformation of the researcher resulting in her "going native" (Bryman (Bryman, 2012) citing (Hobbs, 1994; Lee-Treweek, 2000)), in this case becoming the researched, since by the end of this PhD, this author will have been working as a fitness instructor (part-time) for over two years.

## Summary

This chapter has presented the research tradition behind this thesis, RtD as practiced in HCI, the resulting knowledge forms, and relevant criteria against which they can be judged. The last section has focused on presenting important methodological considerations for this thesis: first, concrete aspects of the RtD process in this thesis are unpacked, focusing on presenting the types of knowledge forms that this thesis contributes. Then, two approaches taken in the RtD process are developed: a first-person perspective that belongs to a somaesthetic tradition, and a third-person ethnomethodological perspective. Both have been important tools in the design projects in this thesis. While the first-person perspective had a more prominent generative role, inspiring design ideas and guiding in-situ participation (e.g. in studies in which this author acted as an activity facilitator, like co-designing play explorations or bodystorming sessions presented in Chapter 7), and reflection in action (e.g. in sensitizing explorations with designers), the third-person perspective was mainly used analytically.

# Chapter 5. Case Studies and Collaborations

This chapter briefly describes the empirical work that underlies the contributions in this thesis. Two design cases have been instrumental in developing the core concepts: Oriboo and PhySeEar. In addition, this thesis relies on a series of design collaborations in which this author's contribution was primarily either methodological or analytical. These have served to further anchor the concepts and to trial and refine the methodologies. Both the design cases and these other design collaborations are introduced below, together with pointers to the papers that elaborate on each case.

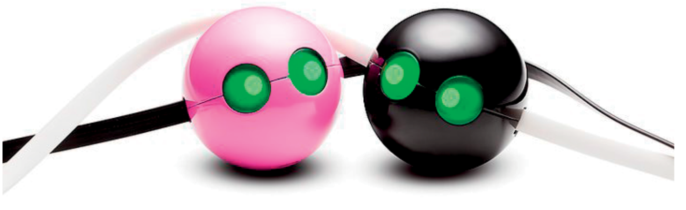

*Figure 4. Two Oriboos.*

## Design intervention 1: The Oriboo case

The Oriboo design project started as a collaboration with Jin Moen, CEO of the company Movinto Fun AB ("Movinto Fun AB", n.d.). The company was about to commercialize a movement-based game platform for children, the Oriboo ("Oriboo", n.d.), formerly called BodyBug (Moen, 2005, 2007) (see Figure 4). At the time the collaboration project was initiated, a prototype existed that supported multiple single-player games. The joint project's goal was to suggest multiplayer games for the device, because the platform's next version would include radio communication.

## The problem

The design goals for the Oriboo had already been articulated in Moen's Ph.D. thesis (Moen, 2006), in which she combined user-centered design methods with methods and theories in modern dance to design for "full-body movement as interaction modality" (Moen, 2007, p. 251). The goal was to design an interactive system that would invite participants to engage in free and "natural" movements, and hence explore new movement possibilities, their bodies, and the space around (for Moen, "natural movement" is taken to mean any free and unconstrained movement that you can do without training (Moen, 2006)).

When the collaboration started, the Oriboo had gone through a number of design iterations and studies, some of which had made it clear that the Oriboo's computational and sensing limitations were challenging Moen's de-

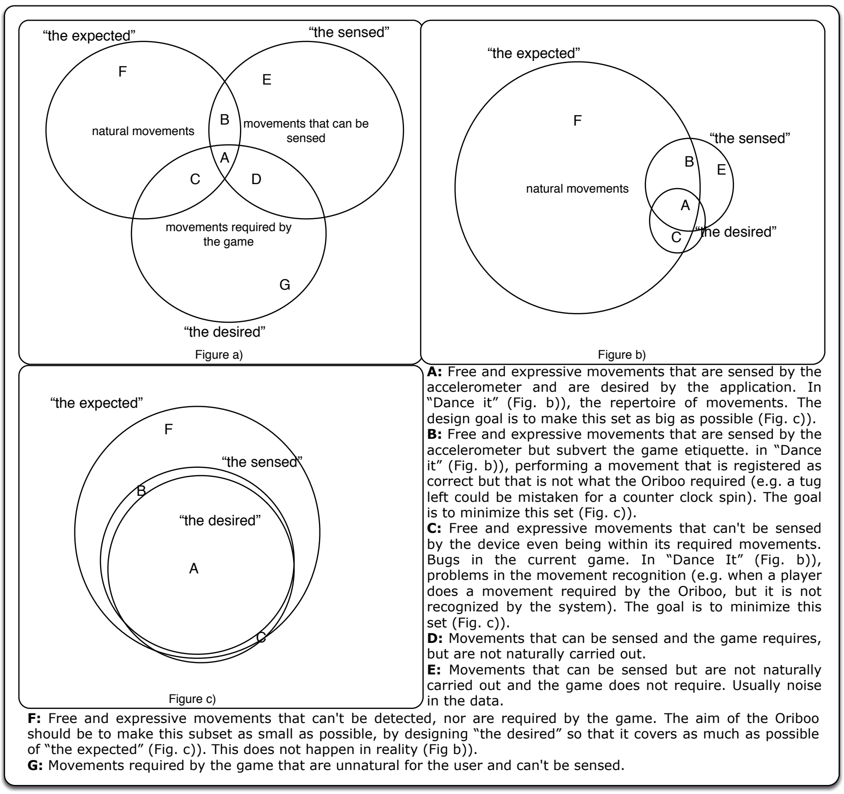


*Figure 5. Top left: Benford et al. (2005) "expected", "sensed", and "desired"; top right: as applied to the Oriboo case at the beginning of the design process; bottom: the design goal for the Oriboo case.*

*Figure 6. Artifact-focused interaction.*

sign goal (Tholander & Johansson, 2010). Only one of the implemented games, Dance it (“Oriboo Games”, n.d.), was designed to engage free and natural movements  to cover as much as possible of *the expected* category, using Benford et al.’s framework presented in Chapter 2 (see Figure 5). However, only a limited set of movements (six simple movements) was required in this game, i.e. Benford et al.’s *desired* category. The problem stemmed from the Oriboo’s sensing capabilities, i.e. *the sensed*, which could not capture the wide spectrum of natural body movements sought.

While this was a very problematic issue for the Oriboo, given its original design goal, it is a problem common to many mobile sensing platforms (Benford et al., 2005; Loke et al., 2007). In addition to limiting the movements to be included in the game design, the Oriboo’s sensing limitations added further constraints, because some movements that clearly fell within the desired space would often not register, for example due to vibrations. Players were observed to generate strategies to deal with this, typically involving constrained, artificial, and rigid postures and movements.

Tholander and Johansson also observed problems arising as a consequence of the dominant visual feedback from the Oriboo (Tholander & Johansson, 2010). They called this *artifact-focused* interaction (see Figure 6), because the players would have to focus their attention on the device’s small screen, and this was detrimental to their awareness of, connection to, and engagement with the physical and social context of play, which made for a socio-fugal player arrangement (De Kort & Ijsselsteijn, 2008) (see Chapter 3).

> We observed how they were close to bumping into each other and thus not being aware of one another, nor of the physical space around them, as expressed, *it feels a bit... inside. That one is in one’s own sphere.* (Tholander & Johansson, 2010, p. 498)

All these issues were not only detrimental to the players' experience, but also diametrically opposed to the Oriboo's original goals.

## The design process in brief

The initial design explorations for the Oriboo had already begun during this author's master's thesis project in 2010, including an exploration of the technology as design material, and of possible external stimuli that could enrich the game experience. The thesis concluded with the creation and testing of several multiplayer game designs that addressed the identified challenges.

The initial studies were carried out as explorative workshops with children, and through this author's first-person types of explorations of the device. The workshops were carried out in two phases. The first focused on simulated games using non-functional prototypes of the Oriboo (see Figure 7). These studies focused on exploring the play activity's physical and contextual aspects. This included how external stimuli, such as music and sound, could influence the participants' social interactions and movements, and how different physical arrangements of the participants influenced their behavior.

Subsequent design iterations in the second phase focused instead on a more holistic design approach, exploring how the social setting itself could function to support the execution of the play activity, and how the technology could be designed differently (see paper I). Findings from the earlier workshops were used to inspire the design of a number of potential multiplayer games that were trialed in a follow-up workshop.

*Figure 7. Children playing mirroring exercises with Oriboos that were switched off, and with non-functional Oriboo prototypes made with tennis balls.*

These imposed additional requirements on the Oriboo platform, so they were not fully implemented but simulated using Wizard of Oz (Dahlbäck, Jönsson, & Ahrenberg, 1993) techniques.

Some games explored the way that players could help sustain the activity, both by controlling compliance with constitutive rules, and by assessing movements and performance. In this way, the games were more socially sustained, and the negative impact of technological limitations was mitigated. Using this approach, this author explored alternative “sensing mechanisms” for the Oriboo that extended Benford et al.’s *sensed* category, testing in particular whether, when, and how players would accept taking over the judging task previously handled by the technology.

This in turn opened up new possibilities for *the desired*, because in games where the players judged movements, these were not limited to the few the technology could recognize (see Figure 5, c)).

Another approach was used to extend *the desired*, which involved making use of the technology’s capabilities in a different way. While previous designs targeted the recognition of movement trajectories, this author focused on recognizing movement qualities. This approach materialized in the game Make My Sound (MMS) (described in papers I and IV), in which the Oriboo emits different music in response to the player’s movement quality (see Figure 8).

The final design explorations focused on the social aspect of play, by investigating further how external (i.e. non-implemented) and socially controlled rules could influence the play activity around a single technological intervention. The technology was used as a fixed game support, and included

*Figure 8. Children dancing in a variation of the game MMS (solo mode).*

the fully functioning Oriboo device with two of its implemented games. These were used together with added social rules, and in different socio-spatial settings, to create new collaborative and competitive play situations. Following the technology-supported approach presented in Chapter 3, the goal of these studies was to focus further on *other* design resources to sustain the activity beyond solely through the technologically implemented game, thriving off the interplay between those design resources and the technology.

The author also improvised some rules on the fly, generating new games or relevant game variations, for example by tweaking the games to make them more fun, and usually by adapting the challenge the game posed (see paper III). For example, in a variation of MMS, blindfolded children had to choose and maintain one sound with their Oriboo, and navigate the room to find and join other players that sounded the same (see Figure 9). In one instance of this game, the children found their peers too quickly because they were too close together and most of them had chosen the same music. The author increased the challenge by dispersing the players more widely in the room at the beginning of the session, and by suggesting to some players that they make a specific sound. The children welcomed this increased challenge. Some new game aids for the players were tested occasionally, for example when the author provided verbal cues about the locations of some children.

In this final study, the children ultimately emerged as potential co-designers of new game variations. While participants in previous studies had been seen regulating their play when negotiating ways of playing, the play activity had mainly conformed to the designs and rules this author had designed. In the later studies, however, participants suggested new constitutive rules that not only regulated how they were playing, but also changed *what* they were playing.

*Figure 9. Children playing a variation of MMS (blindfolded).*

## Contribution to thesis

This design project contributed to all the research questions in this thesis, but primarily in their formulation. Contrasting the types of movements the Oriboo allowed and the resulting embodied experience with the initial goals behind the Oriboo's design helped formulate a "preferred state" or design goal that would permeate all the work in this thesis: supporting a play experience in which participants had fun by engaging fully physically and socially. As in HUG games (see Chapter 2), the designs would not be at the center of the children's attention, but would allow them to focus on one another and on the situated and in-the-moment activity.

Second, the technological constraints triggered the exploration of design alternatives, prompting this author to draw on design resources such as the players themselves, their social and bodily interactions, the rules of the game (which do not necessarily have to be implemented in the technology), and whatever other contextual factors were available.

In particular, post-analysis of the games played was enlightening in this process because it uncovered interesting bodily aspects for coping with the game challenge, such as bodily orientation, types of movements and movement qualities performed, and social cues expressed with the body. Likewise, it uncovered how important aspects of proxemics influenced the play activity, and how they were also leveraged by the children. For example, in a mirroring dance game, children in pairs in close F-formations (children face to face) were able to incorporate "cool moves" originated at the other end of the room by another pair (see paper I). Finally, it showed how the game challenge was treated as a practical "social problem" to be solved in collaboration. Children navigated major challenges with strategies that were improvised and negotiated fluently. For example, to cope with high-tempo music in mirroring dance games, some children "anchored" moves to specific parts of the song (e.g. when certain instruments sounded, or sections of the lyrics appeared) so that both players would recognize in advance when to perform them. Many players used facial gestures to signal agreed sections of choreography, or the direction of the next move.

The social context of play was first explored as a design resource in this project, in particular in the later Oriboo studies (i.e. rules socially controlled, and players distributed in different spatial configurations).

This project was key to shaping this author's practical understanding of how an embodied approach to technology-supported movement-based play could be implemented in a co-located socio-spatial setting. The initial and final design studies were instrumental in investigating methods of analysis and ideation, and paved the way for the emergence of the concept of *embodied core mechanics* as a basic unit of analysis.

At this point, the embryonic definition of what constituted an embodied core mechanic revolved around the idea of the relationship of socio-spatial affordances (see Chapter 3) and the children's movements and bodily orientations. In later design cases and collaborations, this definition of core mechanic embraced more clearly its relation with the design resources that sustained the play activity.

At this point, various possible game resources were probed, and then analyzed with regard to which worked and how to make an activity that the children accepted, liked, and enjoyed. For example, younger children preferred their performance to be judged by technology despite their realizing that it was less accurate than another player's judgment (see paper I).

We will revisit and change this understanding of embodied core mechanics in the light of the design cases and collaborations that follow.

Finally, this design case was pivotal in helping this author realize the potential in modifying, and letting participants modify, play activities on the fly, which underlies a particular design practice proposed in Chapter 7 (and reported in papers II, and III).

## Associated publications

The results from this project are reported in papers I, II, III, IV and VIII of this thesis. In addition to these publications, results from early explorations were presented at the Gesture, Play and Technology Symposium at the UWE Digital Cultures Research Centre at the Pervasive Media Studio, Bristol, UK in May 2010; at the Games, play, embodiment and the Wii symposium at the London Knowledge Lab; and as work in progress at the conference on Tangible Embedded and Embodied Interaction, TEI '11 (Márquez Segura, Johansson, Moen, & Waern, 2011).

The final design iteration of the Oriboo case was carried out partly as a Kids Workshop in conjunction with the ACE conference in 2012 (Márquez Segura, Moen, & Waern, 2012). A video submission of these workshops was displayed at HRI 2013 (Márquez Segura, Moen, Waern, & Onco Orduna, 2013). Finally, results from these workshops contributed to a shared chapter not included in this thesis (Chisik, Antle, Birtles, Márquez Segura, & Sylla, 2014).

## Design intervention 2: the PhySeEar case

The PhySeEar design case started as a side project to this thesis, when this author's brother, the physiotherapist at the assisting living facility of Nuestra Señora de la Soledad (NSS) in Tocina (Seville, Spain), presented an opportunity to explore the inclusion of technological interventions to improve the effectiveness, efficiency, and impact of physical rehabilitative sessions.

*Figure 10. The NAO robot.*

The project started with a technological intervention, as is typical of technology-driven processes, and with goals that might pertain to usability studies[14], for example increasing the effectiveness and efficiency of physical rehabilitative therapy. In principle, this project therefore looked far from the type of inquiry in this thesis (open, with research questions shaped at the same time as possible answers), and from its focus on play, and the general goal of designing for movements that are fun to perform. The physiotherapist's intention was to improve inpatients' accuracy in performing certain types of movements used in their rehabilitative therapy.

In this thesis, PhySeEar presented the opportunity to apply insights from the design of movement-based co-located social activities in a serious application domain prioritizing performance and achievement. During the project, however, play and playfulness emerged and drove the rest of the design process towards supporting such moments. Results in this design case showed how play and a playful attitude were not at odds with the project's initial design goals, but rather the opposite, play and playfulness being regarded as instrumental in the successful accomplishment of the rehabilitative therapy session.

## The problem

The design challenges exposed in the PhySeEar project include both the physical and the social aspects of the setting.

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[14] "Usability: the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use." ISO 9241-11 (http://www.usabilitynet.org/tools/r_international.htm)

The type of physical activity was burdensome for the participants. Most of the inpatients at NSS presented comorbidity or multiple medical conditions, with some non-specific symptoms, and secondary complications to their main diseases, which is a normal medical condition in geriatric healthcare (Hurria, 2011; Piccirillo et al., 2008; Studenski, 1999) that imposes additional challenges on the creation of physiotherapy treatment plans (Brown & Peel, 2009).

An important activity of the therapists at NSS is addressing their inpatients' functional limitations[15], because these are a major contributor to disability in the elderly (Nagi, 1991). The project focused on assisting the physiotherapist to work with age-related functional limitations such as limitations to range of motion, flexibility, strength, and endurance.

The instructed exercise sessions that the physiotherapist offered were targeted. They focused on mobility, balance, and overall fitness, in order to maintain physical abilities and independence as long as possible. They typically involved repetitions of mobility exercises. In physical rehabilitative therapy, motivation and engagement are very important for creating any substantive improvement in the inpatients' physical condition (Studenski, 1999). However, the rather repetitive nature of such rehabilitative exercises means the activities are not intrinsically motivating (Quinten, 2015), especially when the elderly experience pain (Resnick, 1999). This is aggravated in geriatric rehabilitation, where meaningful extrinsic rewards in the form of physical improvement are not as apparent, given the poor health and physical impairments suffered by some of the elderly (Brown & Peel, 2009; Horan & Clague, 1999). Yet it has been noted that older people need rehabilitation to a greater extent than do younger inpatients (Felsenthal & Garrison, 1994; Tonks, 1999).

There are social challenges related to the relationship and interaction between therapist and inpatient. When a typical training session was observed, it was noted how the physiotherapist was required to instruct, motivate, and provide feedback about performance, and the inpatient to understand and follow these instructions and feedback. The sessions therefore required joint efforts by and the coordination of the physiotherapist and impatient to

[15]Some useful definitions:
Functional limitations are "restrictions in performing fundamental physical and mental actions […]", "generic actions, recruited in many specific circumstances." (Verbrugge & Jette, 1994, p. 3).
According to the "functional limitation" framework by Nagi (1991), both functional limitations and impairments refer to function, but they differ at the level on which these manifest (Nagi, 1991). The former involves bodily systems (physiological, anatomical, mental, and emotional) and its components (e.g. tissues and organs), while the latter refers to the individual as a whole.
Disability: "is the expression of a functional limitation in a social context, that is, a limitation in performing socially defined roles and tasks." (Nagi, 1991, p. 118).

achieve success. Some inpatients attending these sessions manifested little interest in the movement performance itself, but more in the social interaction it enabled. Sometimes they used their emotional bonds with the physiotherapist to negotiate fewer exercises or repetitions. Furthermore, the physiotherapist found it difficult to communicate feedback about movement performance to the inpatients. Many were illiterate (illiteracy in Spain among people over 80 reaches 30% (De Gabriel, 1997)), and most had no previous experience of instructed fitness activities. This resulted in low proprioceptive skills, i.e. the awareness and ability to track and control the position, orientation, and motion of their body parts.

The social and instructional challenges made it difficult for the physiotherapist to communicate with the inpatients to provide feedback, corrections, and goals in ways they could understand.

## The design process and design exemplars in brief

This project went through two design iterations with associated evaluation workshops.

### First iteration

The first design prototypes were wearable devices that the inpatients would use during the rehabilitative exercise sessions (papers V and VI). They were intended to assist in upper limb rehabilitative exercises and walking exercises (see Figure 11, and Figure 12). With both systems, an explorative Wizard of Oz type of study was conducted (Dahlbäck et al., 1993) (see Figure 13, left), in which the physiotherapist controlled the outcome of the systems as if these systems were working autonomously.

Twenty-six inpatients at NSS participated in our study. There were 11 men and 15 women; all except for one aged 57 were 72-96 years old. Five inpatients suffered from Parkinson's disease, three from Alzheimer's, and two had suffered from stroke.

*Figure 11. First prototypes. Left: prototype for lower limb exercises. Center and right: prototype for upper limb exercises.*

Nine participants interacted with the lights system, eight with the sound system, and the rest with the physiotherapist without any technological intervention. The sessions were video-recorded with two cameras capturing different angles, and field notes were taken. The data were analyzed qualitatively, concentrating on where the patients placed their focus and how they engaged with the training session, the usage of the technology by the physiotherapist, and moments of joy and playfulness between the physiotherapist and the inpatients.

*Figure 12. Lower limbs prototype in use.*

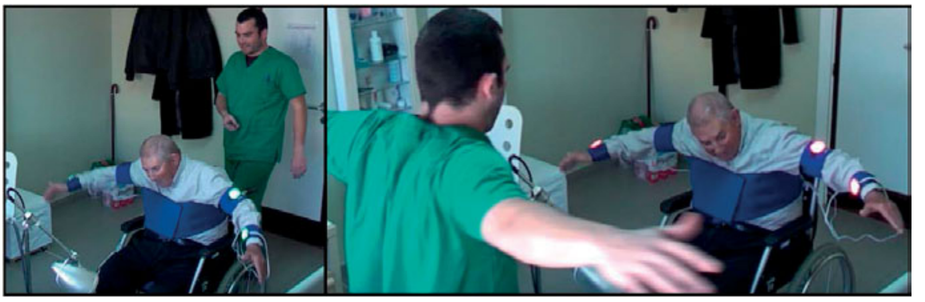

*Figure 13. Left, physiotherapist controlling the system. Right, physiotherapist modeling movements.*

*Outcome and insights*

The physiotherapist took control of the training sessions in a very interesting way. Without agreeing beforehand, he started using the technology to take the role of "bad cop", informing on the inpatients when they were performing a movement incorrectly. Meanwhile, the physiotherapist took a "good cop" role, being very understanding about the inpatients' mistakes while explaining what they were doing wrong. The inpatients seemed to enjoy the physiotherapist's siding with them "against the system" (see Figure 14).

This joint behavior had several positive effects. Patients no longer negotiated about the exercises. None of them complained about the number of repetitions, and only a few used their physical limitations as excuses. Some expressed their willingness to come back for another rehabilitative session soon, and some showed determination to continue with the exercises longer than needed.

**Second design iteration**

The key insight from the first trials concerned the many instances of playful behavior, both this author and the physiotherapist regarding them as the major reason behind the success of the trial. Subsequent design iterations were therefore directed explicitly towards supporting this playful behavior, focusing the inpatients' attention on movement performance and assessment. In particular, the re-design aimed to capitalize on the observed behavior of the physiotherapist and the inpatients siding together and fighting "the system".

For the second design iteration, the LED device was replaced by an NAO robot. A robot was selected because research on social robotics has shown that both children and adults engage with robotic toys and connect emotionally to them (Jacobsson, 2009; Turkle, Taggart, Kidd, & Dasté, 2006; Wada & Shibata, 2006). The NAO robot was also chosen due to its similarity in bodily structure and joint mobility to the human body, which was a valuable asset in presenting intelligible feedback. In particular, this author saw an opportunity for the technology to take over the modeling task performed by

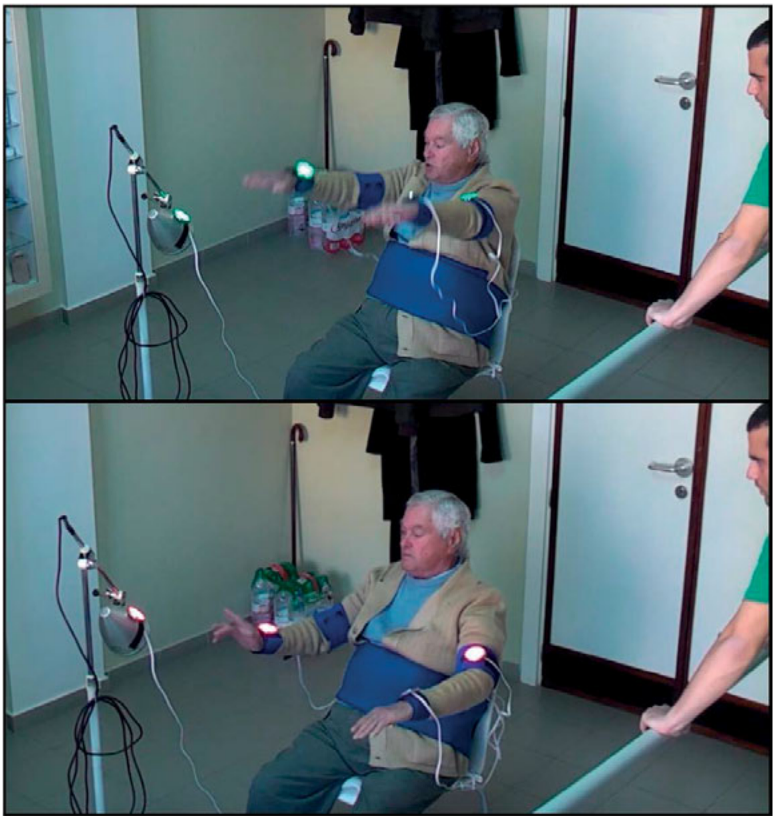

*Figure 14. Physiotherapist playing "good cop" by advising the inpatient to modify his movement just before he triggers the red lights. The inpatient complains to the system.*

the physiotherapist, in which he would use his own body to model the inpatients' movements. Furthermore, the robot could supply the inpatients with continuous visual stimuli, not only regarding the movement they needed to follow, but also showing them when necessary *how* their movements deviated qualitatively from the ideal.

With the help of the physiotherapist, the design team was able to trial this functionality by pre-programming a set of nine movements that he often used during his exercise sessions[16]. Furthermore, the most typical movement errors were implemented (see the thesis by David López Recio for details of the implementation (López Recio, 2013)). The feedback was triggered manually by the physiotherapist, either remotely or by touching the control buttons on the top of the NAO's head (see Figure 15). The NAO would then perform the correct or faulty movement variation. For comparison, the trial

[16] These were flexion/extension/abduction of the shoulder, flexion of the knee, flexion/extension/abduction of the hip, pronation/supination of the arms, and opening and closing of the hands.

also included a virtual version of the robot displayed on a screen (see Figure 16). This version was named ViNAO, and it was programmed to behave exactly like its physical counterpart. The reason for including ViNAO in the study was to investigate how important it was that the robot had a physical presence in the room.

*Outcome and insights*

The study in the second design iteration was organized as physiotherapist-inpatient sessions much as in the previous study. Thirteen elderly people participated in total, divided into three groups (see Figure 16). The first group did not use any technological aid, and interacted only with the physiotherapist. The second would interact with him assisted by the NAO robot. The third would meet the physiotherapist together with the ViNAO system. Two researchers were present during this study. The sessions were recorded using two cameras, again capturing the room from two angles. The videos were analyzed qualitatively, looking in particular at how the physiotherapist and inpatient coordinated their actions and the role of the technology in this joint activity.

The study showed that the introduction of the NAO robot changed how the physiotherapist performed the exercises. In the condition without technological intervention, he would model the movements almost continuously, complementing the modeling with verbal feedback input. In the robot condition, the research team saw less movement modeling on his part, and an increased usage of other techniques instead. In the debriefing session after the study, the physiotherapist commented that he felt liberated by the robot, and able to focus on other tasks. A particularly interesting use of the NAO robot was as a pedagogic tool. The physiotherapist would use it to explain some

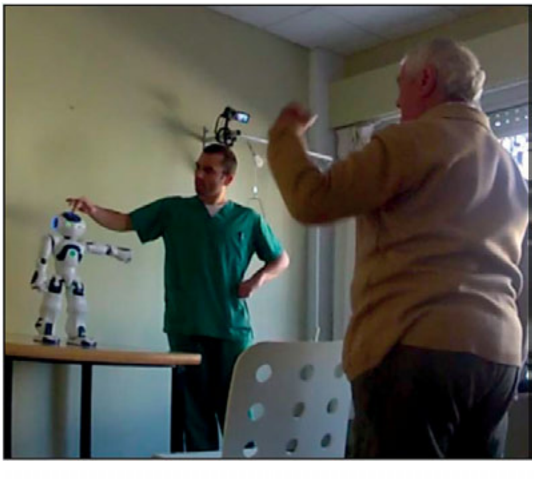

*Figure 15. Physiotherapist controlling the NAO robot by pressing buttons in its forehead.*

movements' characteristics, such as the position of a body part relative to others, or the plane of movement where a limb should be moving (see Figure 17). These types of instructions were not used at all with the virtual version of the robot, so the group concluded that the robot's physicality was instrumental in this result.

*Figure 16. Three condition groups. Top: physiotherapist alone; center: physiotherapist and ViNAO; bottom: physiotherapist and PhyNAO.*

The study supported the findings from the first iteration, in that playfulness emerged in the robot group as playful competition with and mocking of the NAO. The physiotherapist used the NAO's limitations to challenge some inpatients and set goals, such as performing some movements with a greater movement range, or faster. This seemed to amuse and motivate the inpatients, sparking off a playful competitive atmosphere, and some inpatients even "teased" the robot when performing the jerkily clumsy movements mentioned above. These were not observed in the ViNAO condition.

In line with previous findings, there were instances of the physiotherapist siding with the inpatients. This time, the physiotherapist referred to the robot when talking about incorrect or wrong movements, with utterances that "blamed" the NAO, like "The NAO is doing the movement wrong", despite the fact that the robot was correctly mimicking the inpatients' "wrong" performance (see Figure 16, bottom). The NAO became a shared plaything, referred to as "the doll" by the inpatients, and later by the physiotherapist; the ViNAO version was called "the movie" instead.

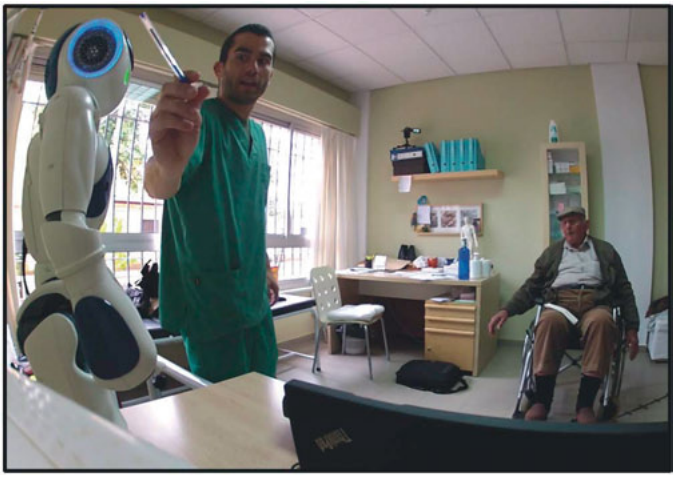

*Figure 17. Physiotherapist explaining body planes using the robot.*

Some inpatients playfully complained to it (see paper V, and VI), and some gave the robot names such as “smart-arse”, or “tattletale”, similar to what happened in the first design iteration. Some of them praised the robot’s capabilities.

## Relevance to this thesis

The PhySeEar project began as a very traditional technology-centric design HCI project, with equally traditional and utilitarian usability design goals. The purpose was to design a technology that could “solve” a very concrete and well-established design problem in a particular setting: to *improve* the rehabilitative exercise sessions in a particular assisted living facility, in terms of the inpatients’ focus, motivation, and understanding of their performance.

The final outcome of the PhySeEar design case qualifies as a success, when judged against these initial design goals. The design succeeded in improving the inpatients’ understanding of their performance, their awareness and tracking of their performance, and their focus and motivation. The design intervention therefore made the rehabilitative sessions more effective and efficient.

However, the relevance of this project to this thesis does not stem as much from *what* the designers were able to build (the artifact), but from *how* they were able to accomplish motivation, understanding, focus, and engagement.

First, it is important to observe that the initially artifact-focused design process progressively turned into an *activity-centered* design process, in which play and playfulness were harnessed both as a means to achieve the designers’ original design goals, and as a design goal in their own right.

As in the Oriboo project, it was notable here how the rules that shaped the activity and the participants' engagement with the activities were not built into the technology. In particular, a core observation in this project related to how the physiotherapist used the technology to take over the often-unwelcome critical feedback, and how this served to create a more collaborative therapy session and a sense of camaraderie between the therapist and the inpatient. This created a different type of activity, with rules that had emerged from the interaction of the physiotherapist, the inpatients, and the overall setting.

Second, this project served to highlight the crucial impact of the design decision to distribute key functions to sustain the activity between the technology and the human participants in a way that supported, complemented, and used the best from each in the joint accomplishment of the aims.

This aspect influenced this author's understanding of the concept of embodied core mechanics, in particular shifting its focus to "moments" when things worked particularly well; when participants, technology, and space worked simultaneously in a close relationship, sustaining the activity's *dynamic gestalt* (Löwgren & Stolterman, 2004). Likewise, exploring moments when this gestalt was disrupted, or simply did not emerge, uncovered problems in the synchronization and fitting together of the activity's components, actors, and design resources.

The locus of analysis was therefore placed on these moments, and on looking at the foundation and support that shaped them; in particular how the participants and the technology were involved in and sustained the activity, how they were distributed in the space, and the rules that participants were following, transgressing, or creating (see paper X).

The PhySeEar project was fundamental in the realization of the impact that small changes in the distribution of the roles and functions among those that sustained the activity had on the embodied core mechanic and, as a result, on the experience of the activity.

This realization refocused the project's design goal after the first explorations to find ways to support embodied core mechanics that worked particularly well to influence the overall experience of the rehabilitative sessions. The design team also explored the use of an anthropomorphized form to increase the playful antagonism with "the system".

What should be noted from this is that in the PhySeEar case, great emphasis was placed on the design's *social* aspects, in particular on how the changes in task distribution enabled a shift in the character of the activity, from serious to playful, and from less to more efficient. However, these changes went very much hand in hand with the physical setup, such as how the physiotherapist preferred to manage the technology in a way that let him keep his attention in a space zone of common focus and action.

Finally, this project contributed methodologically to understanding the potential of the participants in an activity to act as co-designers, when owning their activity and appropriating it to suit their aims. This aspect becomes relevant in Chapter 7.

### Associated publications

Initial observations from the study in the first design iteration were reported in paper VI. The second design iteration was demonstrated at the conference on Human-Robot Interaction HRI 2013 (paper VII). Initial observations from the second design iteration were reported in the poster session at that conference (López Recio, Márquez Segura, Márquez Segura, & Waern, 2013). Insights related to the PhySeEar project were also presented at the conference Games for Health Europe, 2015 (http://www.gamesforhealtheurope.org/). These insights have been extended and discussed in a paper V, which presents design for play and playfulness as an alternative to gamification approaches in healthcare.

Insights from PhySeEar have contributed to a long paper submitted to ToCHI (paper X). In that paper, the authors present a four-faceted model of play engagement with a designed activity structure or frame (in particular, games that are technology-supported, but also activities that include designed goals, resources, conflicts (e.g. obstacles), and rules, game mechanics, and allowed procedures (Salen & Zimmerman, 2003).

## Design collaborations

The final form of empirical underpinning of this thesis comes from this author's contributions to a range of design or research projects carried out in collaboration with other research groups. This author has been involved primarily as a facilitator in design and evaluation activities in these projects, and the results contribute primarily to the insights reported in both Chapter 6 and Chapter 7.

### The NYU Poly collaboration: the Yamove! case

Over several months (November 2011, December 2011, and April 2012), this author joined Katherine Isbister's former research group, the Game Innovation Lab (GIL[17]) at NYUPoly (NY, USA), and helped the Interaction Design team that was then iterating a dance battle game app, Yamove![18] (see Figure 18) .

[17] http://cite.poly.edu/
[18] http://game.engineering.nyu.edu/yamove/

*Figure 18. Two participants playing Yamove!*

The NYU Polytechnic game lab was a multidisciplinary team strongly influenced by the indie game development culture, and enabled this author to become involved in rapid design iteration cycles, with continued contact with local and external players in all sorts of studies, ranging from semi-controlled explorations in the lab to very much "in-the-wild" playtestings. Besides offering the obvious didactic value of immersion in such a stimulating environment, the group achieved a large, varied, and rich corpus of data within their application domain. While at GIL, this author participated in their design sessions, and helped them design and conduct several playtesting sessions. The collaboration continued subsequently, and this author was in charge of analyzing data from the studies during in-situ collaboration, as well as from previous studies.

That collaboration has contributed to this thesis in several ways. First, the project shares the elements of co-located social play as key components and uses dance as an engagement mode, and is in this sense very similar to the Oriboo case. Insights learnt during the Oriboo case were thus grounded, extended, and verified through this collaboration. However, the Yamove! collaboration also brought in a new element to consider in the design process: the audience, extending on the social context, and providing yet another design resource to be considered. This enriched this thesis with insights into how to design for social engagement, in particular to elicit participation.

That collaboration has extended over a large part of this PhD[19], presenting this author with the opportunity not only to learn from, but also to expose, her own contributions, providing an important external "reality check". In this thesis, that project has been used to substantiate the concepts, strategies,

[19] The collaboration started at the very beginning of this PhD, when the design team at NYUPoly was in the middle of its design process. The data analysis and write-up has continued until the very end of this thesis (the final publication is still under review).

and considerations related to the contribution of embodied core mechanics (see Chapter 6).

In particular, the Yamove! case study functions as a proof of concept for the values and strategies proposed by the design approach pioneered primarily during the Oriboo case. The researchers and designers involved had initially focused on usability-related goals, trying to improve an existing mobile app, with the design goals of encouraging and enhancing social interaction. While fine-tuning the app in several playtests and design iterations, the group found that their traditional UX approach was not helping them to attain their goals, and they progressively turned towards a design approach inspired by indie game methodologies, which was very much in line with the technology-supported approach taken during the Oriboo case studies (see paper IV).

This change of approach was reflected in the subsequent designs, and had a large impact on the experience of the game. This was apparent when this author conducted a thorough analysis of the recorded video material covering the multiple playtests that documented the evolution of the designed app.

The concept of embodied core mechanics, which started to develop in the PhySeEar project, consolidated here as a collective endeavor of "activity supports" (some of them previously referred to as "design resources") that together helped sustain an interesting interaction gestalt, one that is deeply rooted in, and makes the most of, a social and physical activity.

The concept of embodied core mechanics was used here primarily as an analytical tool serving to highlight the design goals and the influence of various design interventions.

### Papers associated and included

The results from that collaboration are reported in papers IV and VIII. Paper VIII is a book chapter written jointly with Isbister that focuses on important considerations for the design and evaluation of movement-based co-located social play, illustrated using the Oriboo project and the Yamove! case. Paper IV is a journal paper that reports findings from the Yamove! design process. The paper reflects important conceptual and methodological contributions in this thesis.

In addition, the final Yamove! game was featured in the NYU Game Center's No Quarter exhibition, which was commented in game cultural critics (Narcisse, 2012). The game was an IndieCade finalist[20], and Isbister presented insights learnt during the design process in a keynote speech at MobileHCI '2012 (Isbister, 2012).

[20] IndieCade is the premier peer-reviewed independent games venue in the USA (http://www.indiecade.com/).

## Exploring embodied core mechanics based on hanging

From January to March 2014, this author had the opportunity to visit Mueller's group, the Exertion Games Lab (XGL[21]) at RMIT (Melbourne, Australia). This group was involved with designing and studying exertion games, i.e. computing technology games that promote physical activity resulting in physical fatigue, hence the term "exertion" (Mueller, Gibbs, & Vetere, 2008).

This author contributed to the lab's research agenda by exploring interesting experiential qualities and opportunities for design related to the concept of *hanging*, on which the group had been working, and which had materialized in an exertion game, *hanging off a bar* (Mueller et al., 2012).

The author performed several workshops during and after the collaboration that were instrumental in articulating the design practices presented under the overarching name of *embodied sketching* in Chapter 7.

The onsite workshop included in this thesis is used to substantiate and illustrate an instantiation of embodied sketching for bodystorming ideation activities (bodystorming for brevity). In this activity, designers and researchers generate game ideas by physically engaging with play actions that involve a repertoire of game elements comprising, and often represented by, play artifacts brought to the design activity (see Figure 19). For this particular workshop, the author included the TRX[22], a piece of equipment for fitness suspension training that is used as a probe for creating design ideas using the core mechanic of hanging.

This design activity appropriates previous embodied ideation methods for the concrete application domain of this thesis. Although methodological

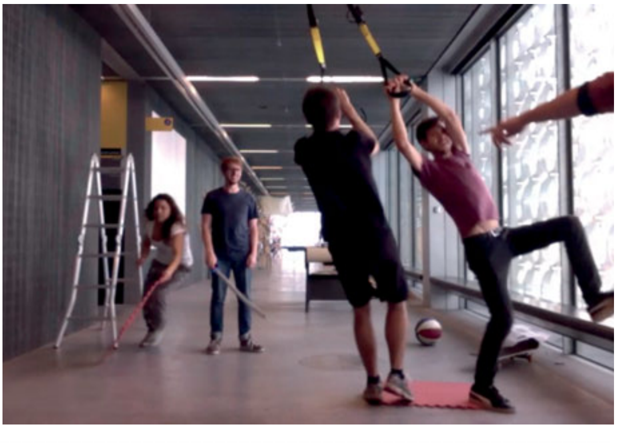

*Figure 19. Designers bodystorming to generate game ideas based on hanging.*

[21] http://exertiongameslab.org/
[22] https://www.trxtraining.com/

details will be covered later in this thesis (and in papers II and IX), a few basic features are advanced here: the use of movement and play as both a design goal and a design method; a very physical and hands-on creative process, involving the sketching of possible game ideas by playing them out; and a regulation of participation following turn-taking and building upon previous ideas until "exhaustion"[23].

A qualitative analysis of this session shows interesting relationships between the design objects that participants use to sustain the activity, their rules and goal creation, and the embodied core mechanic that emerge. These relationships are unveiled as the activity unfolds, and are leveraged by the participants for their creative process.

Results from this design activity include not only a collection of sketches of interesting embodied core mechanics that could become game designs, but also interesting insights into the generative potential of embodied core mechanics used in this form of bodystorming. While the concept of embodied core mechanics was previously used mainly as an analytical tool, here it showed the potential to be used generatively, too. While previous notions of embodied core mechanics assumed the necessity of a thorough post-analysis to unveil important relational aspects of the activity's supports or design resources and the type of activity that these sustained, this case presented a phenomenological view of such analysis, happening together and as part of the participants' active engagement with the activity.

### Follow-up sensitizing workshops

Two follow-up workshops were organized after this collaboration to extend insights into interesting experiential qualities related to the core mechanic of hanging: one with fellow researchers and designers, and another with students on the Embodied Interaction master's course, held as part of the Human-Computer Interaction master's program at the Department of Informatics and Media, Uppsala University.

These workshops were instrumental in the articulation of another type of embodied sketching practice presented in Chapter 7: *sensitizing designers* (see Figure 20). The result was a collection of interesting experiential qualities related to physical activities in which the player is partially or totally suspended by means of an external piece of equipment, onto which the participant holds.

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[23] i.e. when the designers considered the idea was "done with", either because it had been polished until it "worked" or, because it had reached a dead end and was therefore discarded.

*Figure 20. Sensitizing workshop.*

Students on the Embodied Interaction course reflected on this design activity, comparing it with others they had engaged with, such as classic brainstormings, participant observations, and interviews. Here is one such reflection:

> The most beneficial session among all the sessions we've had was the sensitizing workshop session […]. The workshop allowed us to quickly discover new problems and design opportunities by letting us feel that actual activity. This was very different from the observations we had in the beginning, because I think it's hard to spot design opportunities by simply observing the activity.

**Papers associated and included**

Results from the design exploration during this collaboration and the follow-up workshop have been reported in paper II. Further methodological details and results from the bodystorming activity during this collaboration have been reported in paper IX.

## The Move:ie case

The final collaboration included in this thesis was with a fellow Ph.D. student, Asreen Rostami, at the Department of Computer and System Sciences (DSV) at Stockholm University (SU), who was working with a theatre director, Rebecca Forsberg. She had created a movie for children, "Liv", and was examining novel ways for children to interact with the movie in a richly physical way (see Figure 21).

This collaboration presented another opportunity to work with an embodied sketching type of design exploration, this time in the domain of interactive performances that involved physical and social engagement. In particular, it worked to expose and examine the bodystorming type of design exploration used in the previous collaboration in a slightly different domain, where play was not an explicit design goal (although neither was it avoided) but movement was. Nevertheless, both movements and play are used as a method in a way similar to previously. Participation is also regulated with turn-taking, and participants are encouraged to take a very hands-on approach to ideation, using probes and enactment for generating and sharing their ideas.

The design activity organized was described by the colleague at SU as “generative”, given how it was a process *where the first idea presented was used as a base upon which all the other participants’ ideas were projected on, and built from* (excerpt from a report written by colleagues). This was contrasted with a parallel ideation process in another group during the same ideation workshop, which was described as a more *reductive process* in which ideas were first shared and deconstructed before converging into combined ideas.

This observation supported in part those from the previous collaboration, in the way direct engagement and enactment revealed opportunities for design that were probed in the moment, revealing in turn new design opportunities.

**Papers associated and included**

Results from the bodystorming workshop in this collaboration are reported in paper IX, in contrast to those from the previous bodystorming ideation activity in the former collaboration. The paper compares methodological aspects and outcomes from both activities.

*Figure 21. Scene from the movie LIV*

# Chapter 6. Embodied Core Mechanics

This chapter approaches mainly the first sub-question, regarding *what* we can design with to support and foreground the physical and social engagement in the play activity in the domain of technology-supported co-located physical and social play. In illustrating important elements and aspects of design that have emerged as important in the works in this thesis, this chapter also deals with *how* these are important. Further methodological considerations will be discussed in Chapter 7.

The previous chapter described how the notion of embodied core mechanics evolved through various projects and collaborations, incorporating a wide range of design resources (often also called activity supports), such as the technology, the people present, and the activity's physical and spatial context including physical objects. Less tangible are design resources like the rules and goals designed for the activity, and ambient resources of sound and light.

In the articles and in this thesis, they are called either design resources or activity supports. Both terms indicate that they are somehow designed not only to fit, but also to sustain the activity. In some design studies, the role of the designer is merely to arrange their position, which is why "design resource" is slightly too strong a term in these cases. Nevertheless, each element provides support for the activity, and all work together to sustain it.

## Defining embodied core mechanics

Embodied core mechanics refer to desirable and repeatable embodied phenomena during a play activity that involve a rich use and incorporation of the elements present in the scene (called design resources or activity supports). These are the digital and physical artifacts in the activity, and the people participating. An important aspect of how they sustain the activity involves not just their presence, but also their participative status. It is therefore important to consider their roles in the activity (shaped by the activity's goals and rules) and their spatial configuration.

The intertwining of the physical and social aspects of an embodied phenomenon pointed out by Dourish is central here (Dourish, 2001) as the concept's design focus. Embodied core mechanics emerge as "physically realized and socially situated phenomena" (Dourish, 2001, p. 115), in which small changes in the physical and social context would influence the way that participants participate and act. In particular, the design can influence bodily performance and skills, the situational responses, and the social understanding of the activity; these are essential aspects of the understanding of the concept of embodiment in Merleau-Ponty's work as presented in Dourish's book[24] (Dourish, 2001).

As has been pointed out previously, the word "embodied" has been abused, and often means no more than a "lexical band-aid" (Sheets-Johnstone as cited by Höök et al. (2016)), because every action is in fact embodied, and this word adds little in principle to what follows (e.g. "embodied mind", "embodied agent" (Höök et al., 2016)).

By using "embodied" in embodied core mechanics, this author does not mean that there are disembodied core mechanics, but that the core mechanics are designed using a particular design approach: one that considers how, and endeavors, to make them "physically realized" and "socially situated" (Dourish, 2001, p. 115).

More simply, while the concept implies no particular aesthetics, this author's goal has often been to design embodied core mechanics where the physical and social aspects of the full situation work together, all components are engaged and play a role, and participants are playfully engaged.

As mentioned previously in this thesis, many of these resources are not designed directly by the designer, but just "arranged", or "placed", or "given a role". This positions the designer as a person who crafts the experience with designs and with contextual elements.

The idea of the designer as composer and orchestrater of a designed situation is not new. It is for example at the core of Benford et al.'s (2009) idea of designing trajectories of experience for participants in interactive installations, pervasive games, and any experience that involves complex structures of physical and digital artifacts and people. Benford et al. (2009, p. 709), liken people's trajectories to "user experiences" and "journeys through hybrid structures, punctuated by transitions, and in which interactivity and collaboration are orchestrated".

Löwgren and Stolterman (2004, pp. 53–54) talk about designing the *dynamic gestalt*, i.e. "the emergent dynamic whole, something changing over time", and designing is liken to composing, to "putting things together".

> Composition is all about trying to bring things together and to create a coherent gestalt of a possible design (Löwgren & Stolterman, 2004, p. 91).

[24] Dourish highlights three aspects of Merleau-Ponty's understanding of "embodiment": first, the "physical embodiment" or physical aspects of actors; second, the "bodily skills and situational responses" that we develop; and third, the "social skills" and "understanding that we responsively gain from the cultural world in which we are embedded" (Dourish, 2001, p. 115).

## Design resources to support embodied core mechanics

This thesis advocates a technology-supported approach to design (Waern, 2009), considering that the activity designed is not entirely *sustained* by the technology, which only helps to *support* it. This implies that *support* and *sustain* are similar concepts, but the latter has a more absolute character.

In many of the works mentioned in this thesis, the goal has been to sustain a particular activity by underpinning it with multiple "supports", i.e. the so-called design resources or activity supports: the physical artifacts, the players or participants, and their spatial configuration.

Activities designed in this thesis are therefore technology-supported, as well as socially and spatially supported. These concepts emerge as counterparts, arising from the question: if the technology only does part of the job, what makes the design work as a whole? They all do; all contribute to sustaining the activity designed.

Three key design resources will be examined below, foregrounding considerations that have emerged as particularly important in the design and study of embodied core mechanics. For each of them, examples from the cases will be used to clarify the consideration, and some strategies for developing these aspects will be suggested.

## Technology

This thesis foregrounds a design approach that is activity-centered, in contrast to technology-centered approaches. However, a design focus on the technology and a design focus on the activity are not mutually exclusive. The role of the technology as enabler of the activity is fully recognized and embraced in this thesis, and as such the technology is considered a key design resource. In fact, it is one over which the designer has more control given that games, rules, and interactivity can be implemented in the technology. Participants can always appropriate their use, and generate novel ways of dealing with the technology, but the design as implemented means a "fixed" activity support.

### Technology to disrupt

The background material in this thesis has described the use of technology to disrupt the normal locus of attention. While many works within somaesthetics focus on bringing the attention inwards, in this thesis the locus of attention is typically outwards, towards the physical and social world.

For example, in the PhySeEar project, the NAO is seen focusing the inpatients' attention. While this focusing on external stimuli has implications from proprioceptive and even interoceptive perspectives (the inpatients' focus typically resulted in more accurate performance and deeper physical engagement, which probably resulted in sensations of muscle fatigue), the design targets this third-person type of attention.

The technology was also used to *defamiliarize* (Wilde, 2008; Wilde et al., 2011), and presented an opportunity to *make the strange* (Loke & Robertson, 2013). In particular, the technology has been used to extend the concrete kinesphere. For example, in the PhySeEar project, the NAO's range and fluidity of movements was questioned by several inpatients, who made an effort to "beat" him and reach farther, and move more smoothly.

In early explorations during the Oriboo case, this author used switched-off devices, and mockups made from tennis balls, to understand how the device's form factor influenced the children's movements. It was observed how small dancing exercises with these artifacts extended the children's concrete kinesphere, compared with the same exercises without the devices. See for example in Figure 7 (Chapter 5) how they explored the space around them by moving the device and themselves to lower positions.

Different ways of holding the device also inspired them to invent new movements, such as treating it as a lasso (see Figure 8, in Chapter 5).

In Yamove! the score of "diversity" implemented in the technology was designed by Isbister's team to encourage the players to extend their repertoire of movements.

**First-person experiential explorations**

This author found it very useful to engage in first-person hands-on explorations of the technological capabilities, to move past the technological limitations and understand possible design opportunities. This is very much in line with the materiality move in HCI, which encourages exploring the design material early in the design process (Belenguer, Lundén, Laaksolhati, & Sundström, 2012; Sundström et al., 2011).

In the Oriboo case, there was already empirical evidence of the technology's limitations (Tholander & Johansson, 2010), which was consistent with known technical limitations from an engineering perspective. It was not possible to measure the trajectories of movements with full degrees of freedom. However, design opportunities emerged when this author danced with Oriboo. These explorations typically involved this author dancing with the device in usual and unusual ways, exploring the space of movements encouraged by holding the device in the stipulated as well as those inspired by unusual ways. This author explored what movements felt good to perform (using Benford et al.'s (2005) taxonomy, those within *the expected*), and the experience resulting from performing the movements prescribed by implemented games (Benford et al.'s (2005) *desired* category). Reflecting on the movement qualities together with technical insights into what the technology was capable of recognizing (Benford et al.'s (2005) *sensed* category), this author generated a design opportunity involving a different type of movement sensing, focused on recognizing movement qualities instead of trajectories of movement.

### Using material and immaterial properties

Immaterial properties of the technology were also used as a design resource to shape and disrupt behavior.

In the Oriboo case, instead of visual means that fixed attention on the device to the detriment of performance and awareness of the surroundings (Tholander & Johansson, 2010), sound was used to guide and provide feedback. This allowed the players to engage in expressive and performative movements towards their peers, extending their movement repertoire with creative moves. This was seen in the game "Make My Sound" (paper I), where participants were told to "sound" (i.e. make their Oriboo sound by moving it in particular ways) like somebody else in the group. When the researchers asked the children how they had managed to get the "right sound", their replies showed a variety of sensorial strategies, none of which involved visual attention fixed on the device: "I listened to the music"; "I looked at the others"; "I just shacked it!" (paper I).

In other games created for the Oriboo, a mix of visual and audio feedback was designed together with the rules of the game. When children were expected to move freely and expressively, audio feedback was provided. When they were still and focused on one another, visual stimuli from the Oriboo were implemented (see the game "The Blind Mirror" in paper I).

In Yamove! Isbister's design team decided to include the role of a Master of Ceremonies (MC) to call movements the players would have to perform, as well as to provide feedback (see paper IV). This helped the players focus on their performance while having awareness of their progression, in contrast to earlier implementations of Yamove! where this information was given visually through a display that the players checked frequently, to the detriment of their involvement in the performance (see more details below).

## Participants

This author proposes that activities can be, and typically are, supported by those involved in the activity. This has been explored in this thesis by telling people what to do: setting prescriptive rules for behavior to support the ongoing activity. This means that in a way similar to how the technology is in charge of sustaining certain constitutive aspects of the activity, so are the participants.

This aspect is described in the included publications as prescribing a "role distribution" between participants and technology, given how functions, processes, and rules were divided among them.

**Considering social conventions and dynamics**

It is important to develop a sense for distinguishing the different parties that will witness or engage in an activity, and the social setting where the activity will take place. Understanding the social conventions and agreements embedded in that particular context, and the (cap)abilities of that or those involved, was instrumental in the design cases included in this thesis.

In the Oriboo games, this author explored a range of modes in which participants could take over assessment. This study uncovered a certain resistance from the younger participants to letting them judge the outcome of the games in the most competitive settings. However, they were open to assess movement quality in more explorative settings (see paper I).

In the PhySeEar project, the design team observed which role the physiotherapist desired to give to the technology, which influenced design decisions with regards to the type and function of the technology introduced in subsequent interventions.

Yamove! was meant to be played in front of an audience, and the design team realized that this audience could be used to take over some of the functions causing difficulties for the technology, for example assessing performance qualities such as creativity or expressivity. In later design stages, the choice of functionalities that were designed to be socially controlled was influenced by social conventions around the theme of the game. For example, the design team included the MC who would call some moves (see paper IV), and later a DJ who would adapt the music to the general vibe of the situations.

**Participants as support for and owners of the activity**

Certain activity supports can be designed before players are involved: from the rules of the activity, to the artifacts and technology used, as well as certain spatial features, like the arrangement of the furniture and the space. The role of the participants can also be designed as mentioned above.

However, an embodied core mechanic emerges only when it is lived and played by the participants. This means the players have the final say in shaping the embodied core mechanics.

In this thesis, proposed designs have often been changed and transformed by participants through their active play engagement. This transformative power of play has been used as an important design strategy, to further develop designs in subsequent phases of the design process. Emergent play behavior, transgressions, and creative variations of designed structures have been embraced and used in subsequent design iterations (papers V, VI, and X).

For example, children at our earlier Oriboo explorations started using strategies to cope with certain design game challenges (e.g. the use of turn-taking for challenging mirroring exercises). These were influential in later game designs (turn-taking was implemented in the game “The Blind Mirror”; see papers I and III).

In the PhySeEar case, interesting playful behavior and social dynamics were identified, and further supported in subsequent design iterations. In particular, the playful antagonism with the technology was furthered by including the anthropomorphic robot assistant (see papers V, and X).

This aspect of the players as not only testers, but also co-designers, will be examined in more detail in the next chapter.

## Space

In Chapter 3, the importance of the social and spatial settings in influencing the play experience was established. A classic way of regulating social participation is by designing player interaction patterns (Avedon, 1971; Fullerton, 2008). Previous arrays of player pattern forms for social play have been developed with a focus on pure technology-sustained play (Bekker et al., 2010), but these can be extended take into account configurations that do not happen in front of a screen (paper VIII) (see Figure 22).

An example of the importance of the arrangement of design resources comes from a failure case of the faulty mode of the ViNAO design in the PhySeEar project. Earlier it was noted how the physiotherapist had to turn his back on the inpatients in order to trigger specific behaviors of the virtual robot. By contrast, the physical robot had these controls on its head, which allowed the physiotherapist to trigger them while his body was oriented towards the space of the activity, the o-space of interaction with the inpatient (see Chapter 3).

With regards to the spatial configuration, this author’s designs have involved people’s bodily orientations in space in ways that support or hinder awareness of the ongoing activity, the monitoring of their actions and their subsequent effects in the activity (Reeves et al., 2005), and the communication and coordination of joint action. The spatial configuration considered in this thesis extends previous work in that it includes design strategies other than the orientation towards technology.

### Socio-Spatial Configurations to Regulate Attention

As discussed in Chapter 5, the artifact-focused interaction was a major concern in the Oriboo case. This issue was accentuated in multiplayer settings. In Reeves et al.’s (2005) terminology, the Oriboo interface can often be suspenseful, since players can see what others do, but it is difficult to see how this affects the implemented game. The result was that players would focus

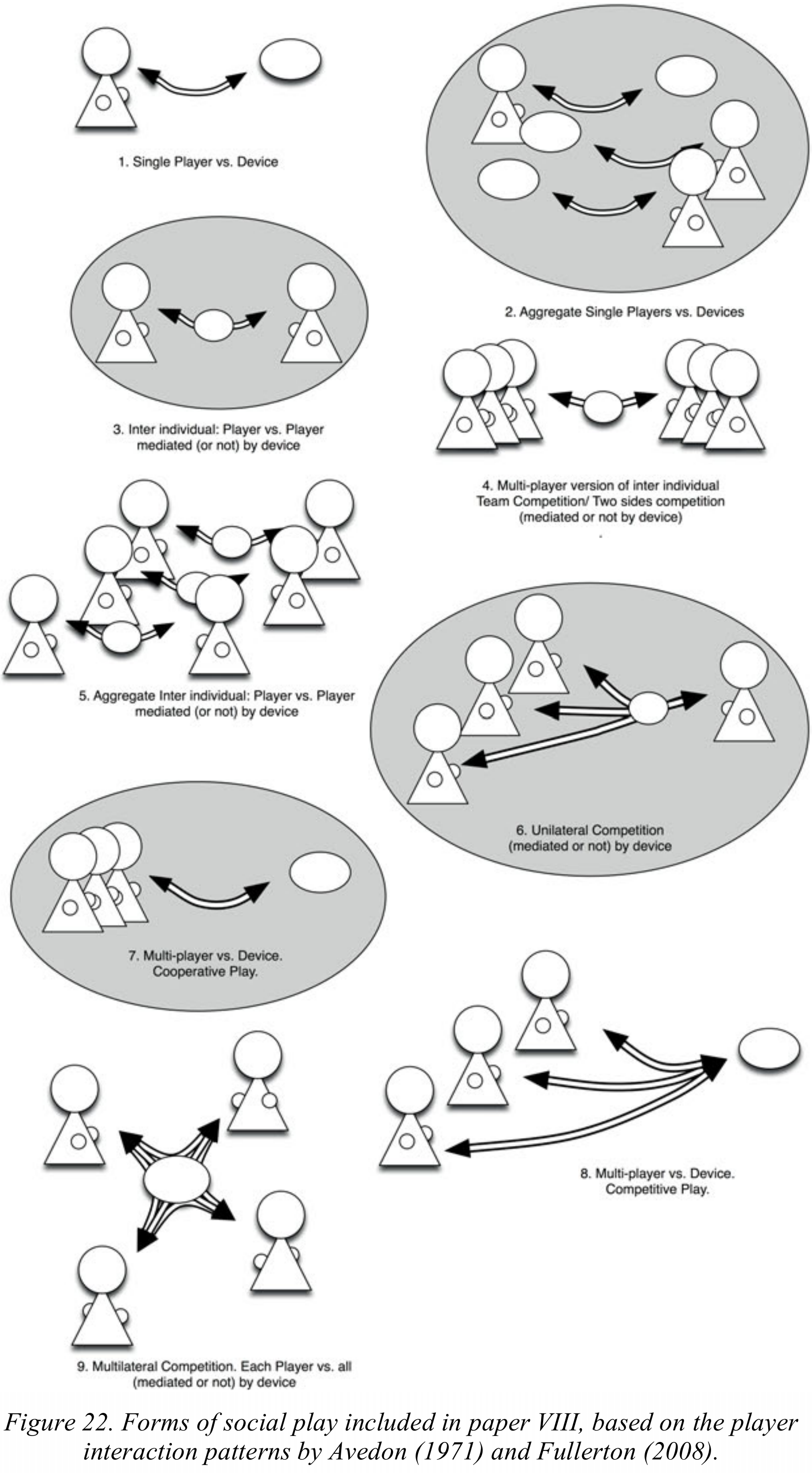


*Figure 22. Forms of social play included in paper VIII, based on the player interaction patterns by Avedon (1971) and Fullerton (2008).*

entirely on the device, and other participants would not know what was going on.

A way this author dealt with artifact-focused interaction involved designing activity supports that required participants to spread their attention to different points in space – to other artifacts or to other participants. For example, in the game “The Blind Mirror” mentioned above (see paper I), the Oriboo outputs relevant information (using its LED eyes) when assigning roles to the children. In this game, the players are placed in a circle, where they can all see the eyes of all the Oriboos, as well as the other players' movements. The physical configuration of the players was an important factor in making the game interface on the Oriboo expressive, rather than suspenseful.

*Figure 23. Inpatient with attention focused on the light feedback.*

Artifact-focused dominance was also sometimes sought. For example, in the PhySeEar case, one of the project's goals was to bring the attention of the inpatients back to their exercises; having their eyes focused on a visual representation of their movement assessment was therefore useful (see Figure 23). Due to the type of movements – non-expressive, simple, and repetitive — artifact-focused attention was not impacting the movements negatively.

Intended artifact-focused interaction was also used in one of the games designed for the Oriboo. A multiplayer version of an original Oriboo game required children to share one Oriboo, which guided them by calling in different movements (see in paper III the collaborative version of the game "Dance it"). This required that the Oriboo be maneuvered and handed over in such a way that the display was always visible to the right player. This game variant used the screen-based feedback as a designed obstacle, to make the activity challenging and fun.

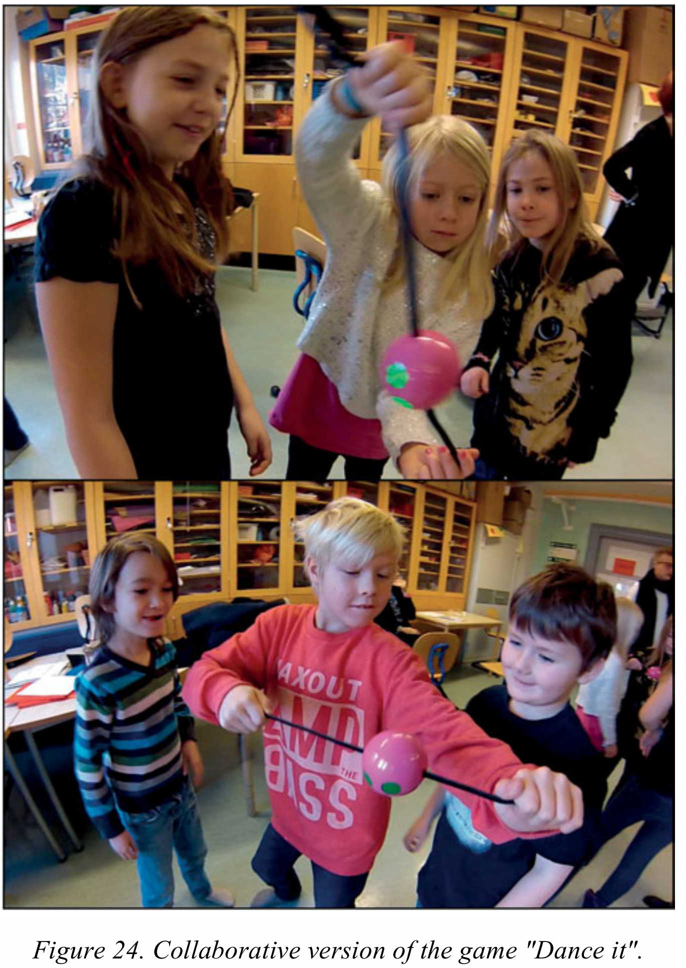

*Figure 24. Collaborative version of the game "Dance it". Using artifact-focused interaction to set a game challenge.*

**Shared frames of reference**

Some examples in the previous strategies have already indicated that a shared frame of references is key for coordinated action. A particularly clear example emerged in the Yamove! case. An early version of the game was playtested in an event called “F*%k the screen”. In line with the theme of the event, the Yamove! team moved all feedback to the individual devices that participants would use. This turned out to be problematic for managing the attention of both the players and the audience. The players were too focused on their individual devices to the detriment of their movement performance and their synchronization, similarly to the artifact-focused interaction in the Oriboo game “Dance it”. Furthermore, the activity was not intelligible for the audience. Given that the designers were interested in addressing an audience, allowing them not only to spectate but also to enter the game themselves, they decided to include a big screen in further design iterations (see paper IV).

It took several design iterations for Isbister’s group to settle on the precise position of this screen, and on the information it would display. Ultimately, the designers opted for having all the players in one team side-by-side, facing the other team (in a dance-battle set up). The screen would be placed on one side of the field. The big screen made this system an expressive one in Reeves et al.’s (2005) terminology, since the audience was able both to see what players did, and monitor the effects on the game state. The players relied less on screen feedback, but used the screen towards the end to check their final scores (during the game, the players received feedback from the MC).

A final observation about the importance of artfully managing shared frames of reference comes from PhySeEar. The Wizard of Oz setting used in this setup meant that the inpatients had to deal with a *magical* interface in Reeves et al.’s (2005), in the sense that while they could see what the artifact did, they were not aware of the fact that it was manipulated by the physiotherapist. This was key for the emergent playful behavior we observed, and further emphasized in the subsequent design iterations.

## Concluding remarks

The considerations above have helped this author to identify and analyze desirable embodied core mechanics. However, the same mechanics may be supported in several different ways, through a combination of physical, social, and technical resources. It remains to discuss how to find a suitable combination of resources. Many technology-driven approaches start from the capabilities of the technology, and then think about how to make an activity that can use what the technology can do. Designing for embodied core mechanics differs from a pure technology-driven approach by focusing on all the available design resources – not only the technology – to support the activity, and by thinking primarily about interesting in-the-moment activities to support.

A useful strategy to advance from the identification of an embodied core mechanic towards the design of the activity supports involves first identifying possible formal elements that could frame and support the activity. Similarly to ordinary game design, this can include goals, rules, means, and obstacles.

For example, in the Oriboo design case, a particularly interesting embodied core mechanic was that of having participants mirror one another, being able to move in any possible way, expressing themselves and performing movements of their choice. To make the activity into a game challenge an obstacle may be added, such as having to memorize and recall one another's movements.

The embodied core mechanic of mirroring can be combined with the game *challenge* or *goal* of memorizing and recalling. Game *obstacles* can be incorporated to make the game more fun, such as time pressure and performance accuracy. Once the idea has been developed this far, the role of technology can be decided depending on not only what is technically feasible, but also what kind of technology support will function best from a social perspective. In the game "The Blind Mirror" (see paper I), the technology paced the game, assigned time slots for the performance of movements, and assigned "randomly" (faked) roles for the players. The judgment of movement was designed to be socially controlled, to allow free expressive movements. However, younger children showed reluctance to accept socially controlled outcomes (see paper I).

## Summary

This chapter has focused on the concept of embodied core mechanics, and presented core design considerations and strategies addressing them. At the core of this chapter lies the idea that the design targets the player *activity*, and that this activity is shaped by multiple elements, many of which can be designed.

Embodied core mechanics refer to desirable and repeatable actions that involve players making use of a wide variety of activity supports in their play: technological, social, physical, and spatial. Ideally, these resources are tightly knit together, sustaining a playful and rich physical and social activity.

Focusing on embodied core mechanics and their supports has proven useful in addressing overly artifact-focused interaction styles, making players more aware of and participative in the ongoing activity, which is a design value that pervades this thesis. The approach is also useful when dealing with technological limitations.

However, the approach presents new challenges. A major challenge is the fine-tuning of the elements involved in the activity, their tasks, and their role in sustaining and making the activity "work". For much of the work in this PhD, this analysis has been possible retrospectively, once a designed activity has been played out. Its details emerge only after a thorough video analysis, used to uncover the issues and advantages of particular arrangements of the functions and elements involved.

The concepts and considerations covered in this chapter were therefore initially only used as lenses through which a designed activity was analyzed. While this analysis was used to inform subsequent design iterations, this creates a rather heavyweight design process. The next chapter examines ways with which the concept of embodied core mechanics can be taken as generative as well as evaluative, allowing them to be considered in the design process much earlier.

# Chapter 7. Embodied Sketching

Chapter 6 mainly dealt with the question of *what* can be designed in the space of movement-based co-located social play with the aim of sustaining rich physical and social experiences. The concept of embodied core mechanics presented a useful framing for such design processes, used both as a design goal and as an evaluative analytical tool. This chapter will explore whether this concept could also be used in a generative way, and hence answers the second sub-question of this thesis: *How to understand and consider relevant aspects of the physical and social play activity, and explore and generate design ideas.*

In the following, embodied sketching will first be introduced as an appropriation of embodied ideation methods, then several forms of embodied sketching will be described that illustrate how the design practice can be adapted to the particular challenges and the state of the design project where it is performed. Based on this, a set of common principles for embodied sketching practices will be discussed in relation to previous ideation methods. The chapter concludes by reflecting on an important aspect of embodied core mechanics and embodied sketching: their ephemerality.

## Inspiration from ideation methods

A plethora of methods supports ideation (Biskjaer, Dalsgaard, & Halskov, 2010; Bødker, Nielsen, & Petersen, 2000; Gray, Brown, & Macanufo, 2010; Osborn & Bristol, 1979); some have emerged as best practice in design, and some are imported from other disciplines and domains. This thesis operates in the design domain of embodied interaction, so those that address the situated and lived experience of the designers are most relevant. In this regard, design has drawn from techniques in arts and theatre, in particular from improvisational theatre (Blomkvist, Åberg, & Holmlid, 2012; Brandt & Grunnet, 2000; Buchenau & Suri, 2000). Many of these have exploited dramatization, enactment, and role playing as key practices in design ideation. Some of them refer to *bodystorming* as a form of performance and improvisation, used together with *repping* or "re-enacting everyday people's performances" to experience "data in embodied ways" (Burns, Dishman, Johnson, & Verplank, 1995). Other forms of bodystorming refer to situated or immersive brainstorming, conducted "in the wild", or in a similar or replicated environment for which designers design (Oulasvirta, Kurvinen, & Kankainen, 2003; Schleicher, Jones, & Kachur, 2010). In any form, bodystorming brings about empathy for the end user, and some sort of "immediate feedback" for the ideas discussed (Martin, Hanington, & Hanington, 2012; Oulasvirta et al., 2003).

These ideation methods have in common that they use situated action as a way to deepen an understanding of the design domain and the design situation at hand, as well as to communicate and share this understanding. Buchenau and Suri (2000) articulate these three aspects with their *experience prototyping*, an umbrella term for a form of prototyping that allows one "to gain first-hand appreciation of existing or future conditions through active engagement with prototypes" (Buchenau & Suri, 2000, p. 424).

Experiencing is at the core of this ideation practice, for which they use "whatever representations are needed to successfully (re)live or convey an experience with a product, space or system" (Buchenau & Suri, 2000, p. 424). The example cases those authors present to illustrate experience prototyping are diverse, including among others storyboards, scenarios, sketches, and videos. They also suggest making use of props and artifacts, prototypes, and realistic or staged environments as needed, as well as of enactment techniques like role-playing. The representation they use is what they call the experience prototype.

## Defining embodied sketching

Inspired by existing embodied design methods in HCI and IxD, in particular by bodystorming and experience prototyping, as well as by pragmatic somaesthetics, this author proposes that when the idea of embodied core mechanics is combined with such design practices, it can become generative. In paper II, this combination has been grouped under the umbrella term *embodied sketching*.

Embodied sketching is a characterization of design practices in the domain of movement-based co-located social play that leverage important aspects in the embodied experience, in particular the way we use and rely on resources in the physical and social world around us to act and think. The purpose is to support the exploration of, and the design for, particularly interesting physical and social activities in the form of embodied core mechanics. The "embodied" highlights that this is a bodily grounded and socially embedded practice, while the "sketching" emphasizes the provisional, exploratory, and early status of the ideas generated.

Embodied sketching is characterized by: 1) engaging with simple actions[25] and activities that are essential for, or constituents of, the embodied activity being designed for; and/or 2) putting together and testing how different design resources or activity supports (technical, physical, social, and spatial elements) blend together, and support and give rise to embodied core mechanics, and in turn organize these into play activities.

## Three instantiations of embodied sketching

Three forms of embodied sketching have been explored in this thesis, each carried out with a different purpose: 1) *bodystorming*, used to brainstorm design ideas with peer designers and researchers; 2) *participatory embodied sketching,* a co-creation design practice involving end users to brainstorm and test design ideas; and 3) *sensitizing designers*, used to explore important aspects of the felt experience that the design team wants to support.

The first two are particularly useful for generating and testing possible embodied core mechanics, while the third is valuable for accessing and uncovering relevant aspects of the felt experience of a novel embodied phenomenon. They all help during the early ideation phases of a design project within this thesis' design domain. Finally, they share a playful orientation that supports creativity.

### Embodied sketching for bodystorming

The appropriation of bodystorming techniques in this thesis takes from classic brainstorming methods the basic idea of a group of co-located designers thinking together, and generating design ideas. The co-located nature of traditional brainstorming enables ideas that emerge to inspire, and be inspired in, other ideas. The outcome is then the result of a collaborative creative venture.

Classic brainstorming rules (Osborn & Bristol, 1979) are maintained, such as turn-taking, building on co-participants' ideas, fast-paced ideation with a focus on quantity, creating rather than criticizing, and not overthinking feasibility issues. The main difference between classic brainstorming techniques and the form of bodystorming proposed in this thesis relates to the types of creative activities with which designers engage. In this appropriation of bodystorming, designers co-design by physically engaging with the ideas, i.e. playing (with) the ideas. These are presented and explained physically to others, sometimes by the proponent, or sometimes in collaboration with the other designers, who are guided by the idea's proponent.

[25] Since the goal is to sketch embodied core mechanics, the focus here is on trying out several simple actions or set of actions that can inspire and form part of embodied core mechanics.

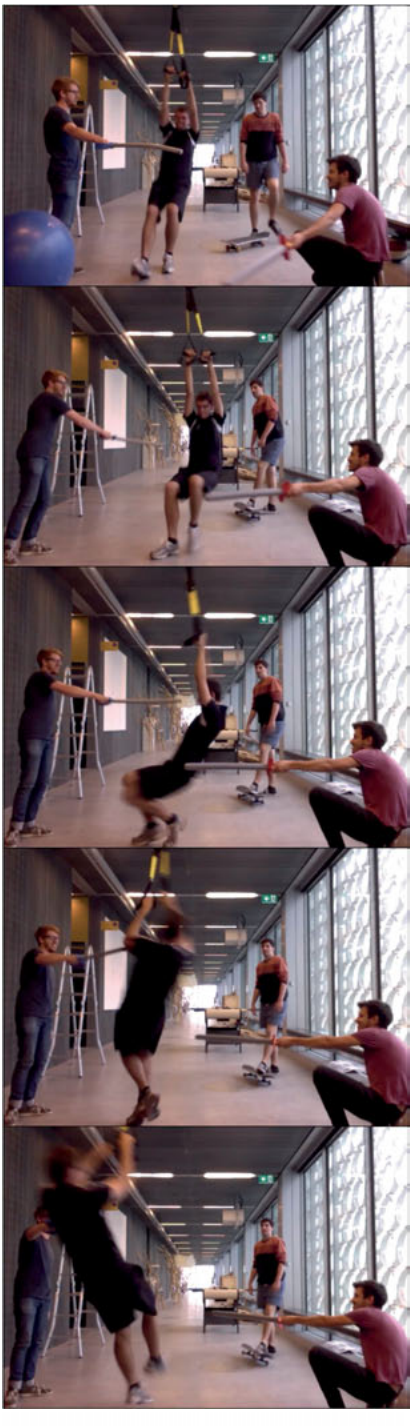

*Figure 25. Designers bodystorming. Here they sketch an embodied core mechanic called "lasers".*

The purpose of the embodied sketching version of bodystorming is to support designers in the creation of embodied core mechanics from scratch. The goal is to explore practically the relationship between formal elements (like rules and goals), objects, people, and the space where the activity takes place.

Embodied core mechanics emerge during bodystorming as *embodied sketches*. These are ephemeral instances of activity that emerge when designers piece together such elements on the fly. This should not be read as the designers arranging activity elements *first*, with embodied core mechanics then emerging. Often, designers just engage with an activity, and this activity is supported by rules invented on the fly, objects, the space, and other people around. The identification of these as embodied core mechanics happens in an analytical phase, which may happen afterwards, when revisiting documentation.

Two main bodystorming workshops (part of two collaborations introduced in Chapter 5) are analyzed in this thesis: HangXRT to create the exertion game (papers II and IX); and Move:ie on interactions with movies (paper IX).

### Characteristics of bodystorming

The approach in both bodystorming sessions was the same, using turn-taking to regulate social engagement and support collaborative co-ideation, emphasizing the role of physical engagement in a "show, don't tell" manner, and the incorporation of artifacts and the space as resources for design ideation. In both cases, ideas emerged in a very hands-on way, with participants engaging physically and socially, and focusing on building ideas together.

*Artifacts, simulated technology, and actions*

Artifacts were important ideation drivers, but used differently, in both bodystorming sessions.

In the HangXRT workshop, the affordances of the artifacts inspired game ideas, incorporating them directly as obstacles, resources, or indicators of some sort. For example, Styrofoam swords were used as lasers (obstacles) the players had to avoid (see Figure 25); mats were used as targets. Artifacts were evocative resources in action, because acting with them inspired new usages and game artifacts. As participants moved, and moved and used objects, new affordances emerged and this in turn triggered new ideas.

Whenever an imagined functionality was not entirely covered by the physical object present in the workshop, the participants would use make-believe to animate the object. In the example of the laser idea, the designers would hold the swords but simulate their beam of light, their sound, and their trajectory (see Figure 25).

This helped designers foresee design issues. For example, when playing the game "hitting dots" (see paper IX), two designers were simulating the automatic appearance of dots (mats) on the floor. They started discussing possible rules for their appearance, which led to a game variant in which the dots appeared in the 3D space. This in turn led to a brief discussion about which technology would support this.

In the Move:ie case, the objects had a very different function. Primarily, they served as a physical anchor helping participants project abstract concepts,

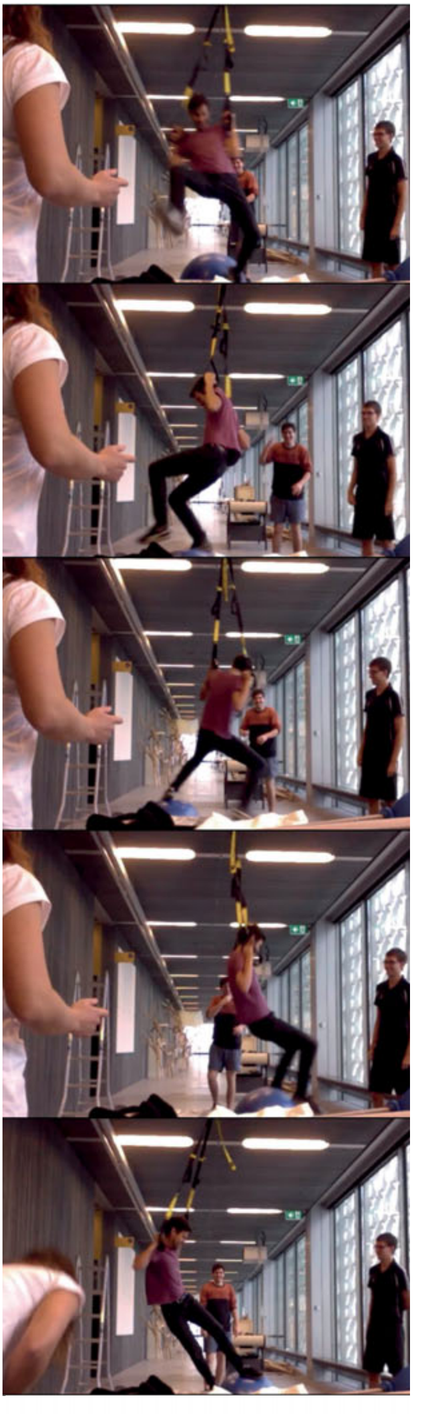

*Figure 26. Designers bodystorming. Here they sketch an embodied core mechanic called "standing on a ball".*

making them more concrete. This helped them visualize them, fiddle with them, and simulate activities around them, which highlighted issues, uncovered interesting qualities, and inspired new ideas. Furthermore, artifacts were key resources for sharing ideas within the group and for documenting and packaging ideas. On one occasion, one of the designers built some sort of handheld device, which was used to illustrate its imagined use in the game idea being described.

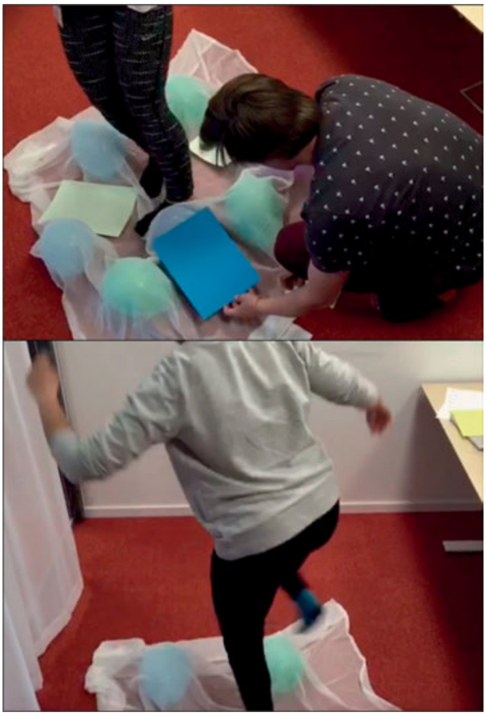

*Figure 27. Designers bodystorming how to "unlock" a treasure that a reactive surface holds. Top: by moving features of the interface so that "they match" (see blue balloon and blue paper). Bottom: by dancing around the treasure.*

The difference between the two bodystorming workshops in relation to the artifact lies in how in the HangXRT case, objects are *actual* activity supports, whereas they are *imagined* as activity supports in the Move:ie case.

This is related to the concepts of perception, projection, and imagination (Kirsh, 2013). Having a physical object on which to project imagined ideas facilitates thinking about these ideas. However, this is different from actually perceiving and experiencing how these ideas materialize when enacted.

For example, in the HangXRT case, the big ball was used for standing on, and introduced the challenge of balancing while holding the TRX equipment. The ball allowed the designers to experience this challenge and think of, suggest, and try (together) ways of using it for game ideas (See Figure 26). By contrast, in the Move:ie case, designers used a curtain to simulate a reactive surface. The designers imagined a complex function for this surface: it would enclose a "treasure", which would only be released by moving in certain ways (see Figure 27). This complex functionality could only be coarsely represented and not fully experienced, and had a gestural character. We liken these to Bekker et al.'s (1995) kinetic gestures[26], spatial gestures,

[26] Gestures "mainly used to mimic how users would interact with the product" (Bekker, Olson, & Olson, 1995, p. 162)

and pointing gestures used in design activities, albeit gestures in Move:ie typically involved the full body and also available artifacts.

In both cases, embodied sketches allowed participants to move from "seeing as"[27] to "seeing that"[28], characteristic of the process of sketching (Goldschmidt, 1991).

However, suggestions in the Move:ie case would typically involve other ways of implementing something, i.e. other "seeing as" (introducing other complex functions), and less in line with "seeing that" in response to how something was enacted.

This also talks about the type of generativeness of actions in both cases. In the HangXRT case, there were many more instances when a particular action triggered many chained reactions and ideas, which fine-tuned the original, as a result of "seeing that" of that originally enacted. In the Move:ie case, variations of ideas appeared less like the polishing of an initial idea, and more like possible alternative designs.

This speaks of the *sequential implicativeness* and the *conditional relevance*[29] of an original action to a *next* action. Similarly to what happens in a conversation when participants take turns, in the HangXRT case some actions and suggestions acted as a *summons* or *attention-getting devices*, producing "the first part of a two part sequence" (Schegloff, 1968, p. 1080), which produced a response from the rest of the group. In the Move:ie case, suggestions and actions appeared more as "separate units", instead of a "sequenced pair of items" (Schegloff, 1968, p. 1083).

*Analysis method*

The two bodystorming workshops were analyzed using a fine-grained interaction analysis. The collected film material was coded as sequences of actions, with the type of participation and contribution of each participant being noted, as well as the distribution of artifacts and participants in the space.

However, partially due to the differences discussed above related to actions and objects in the workshop, the HangXRT case was easier to code and represent graphically (see Figure 28). Furthermore, most of what was coded was observable: actions that made use of certain arrangement of activity supports, each with a clear role creating a clear sketch of the embodied core mechanic.

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[27] There is no one-to-one correspondence between objects in the workshop and objects as imagined (e.g. swords as lasers in the HangXRT case, the curtain as a reactive interface in the Move:ie case).

[28] Design thinking related to "the entity that is being designed", i.e. what objects represent (Goldschmidt, 1991, p. 131).

[29] Action-suggestion or suggestion-action are "chained" (Silverman, 1998); they come in *immediate juxtaposition* (one after the other) and have *discriminative relation* (the first part is relevant to the response or the second part) (Schegloff & Sacks, 1973). In a summon-answer sequence (SA), "A is conditionally relevant on the occurrence of S" (Schegloff, 1968, p. 1084).

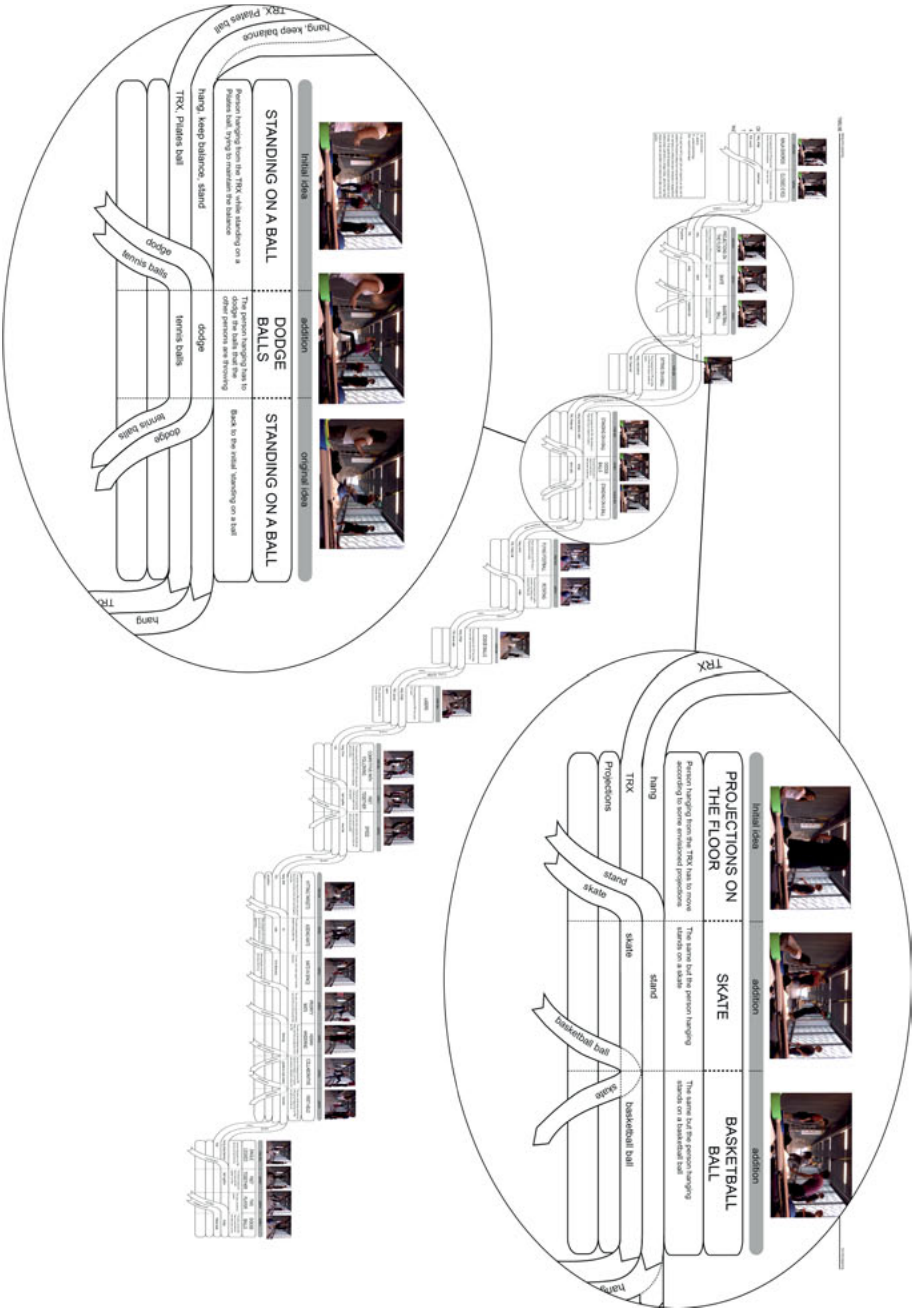


*Figure 28. Bodystorming Braid: a representation of the different embodied sketches as they emerged, highlighting how different design resources or activity supports change.*

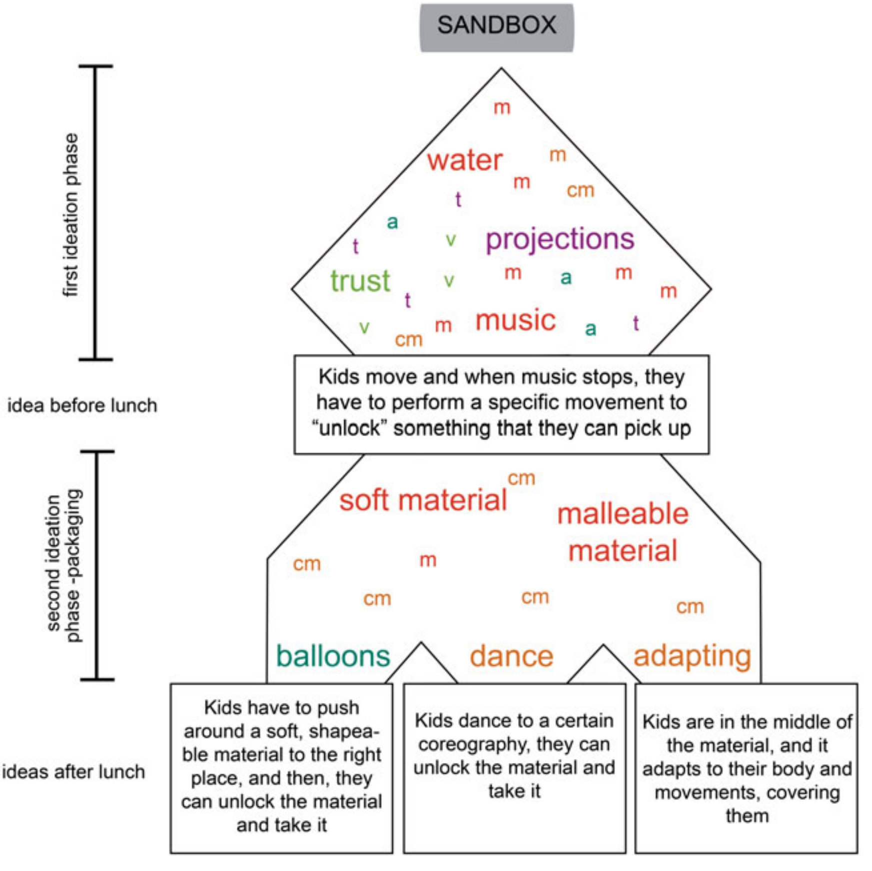


*Figure 29. Representation of the type of ideas discussed, and how the ideation activity diverged and converged at different stages.*

Documentation of this workshop included excerpts of interaction analysis (paper IX), and what was called the Bodystorming Braid (see Figure 28), which was rendered in the form of printed chronological documentation, and an annotated video (paper IX). Both forms show game elements that support each embodied core mechanic.

The design activity in Move:ie was more difficult to represent, because ideas were often just discussed, and did not materialize in observable actions. When enacted, the embodied core mechanics would only be vaguely represented by the activity.

The designers would complement the enactment with explanations of how the activity would be supported by different means, which were either not physically represented at all, or represented by objects very different from the envisioned resource.

Here, ideas were visualized in a more coarse-grained chronological representation. Inspired by the Double Diamond design model ("Double diamond design process model", n.d.), the research team created two visualizations. One focused on showing the divergence and convergence ideation phases in the workshop (see Figure 29), giving a sense of the types of ideas discussed (whether they are concepts, artifacts, materials, etc.). The second represented graphically each idea discussed, to allow the reader to understand the evolution of the group's design thinking (see Figure 30).

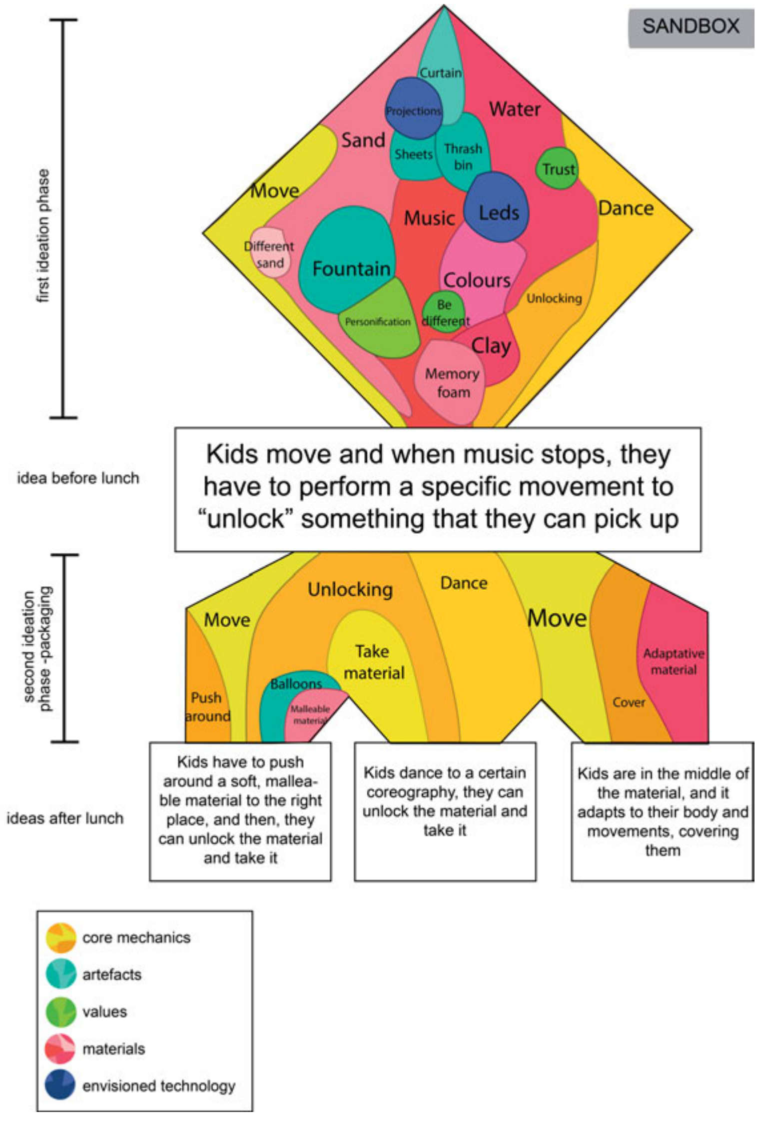


*Figure 30. Representation of the ideas discussed, focusing on how these ideas lingered and influenced the ideation process.*

*Play as a method*

In both workshops, this author has tried to infuse a playful mindset, and create contextual play boundaries (Sicart, 2014) to frame the play activity. The goal was to lower social distance, letting designers be physically closer than social norms usually prescribe, lowering the barrier for physical intimacy, and lowering movement and body self-consciousness.

Chapter 3 introduced ways to infuse a playful atmosphere and encourage play activities. In these workshops, the research team used a demarcated play area, and playthings and play equipment. These can stimulate divergent thinking, which can impact creativity in a positive manner (Susa & Benedict, 1994).

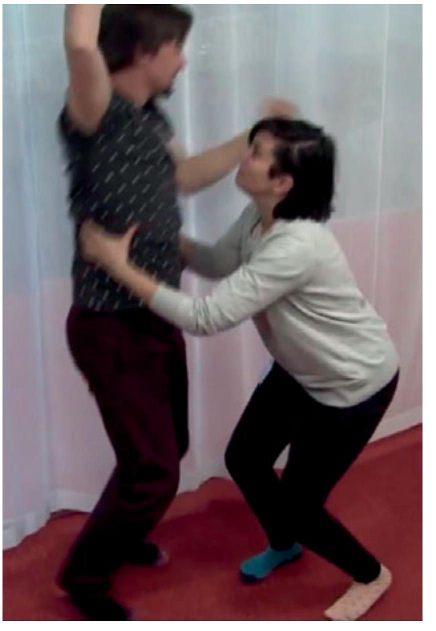

*Figure 31. A designer (right) act as a child who is "lifting" an intelligent agent (left).*

This proved to be enough for the HangXRT designers to engage in physical play. The designers who participated in this workshop were accustomed to participating in play activities and actively engaging with play artifacts and prototypes.

However, in the Move:ie case, most of the participants were not game or play designers. In addition, play was not an explicit design goal. These conditions made it important to find other ways to imprint a playful mindset conducive to creativity. The approach taken was to organize a warm-up session, focused on working with movement, proximity, and social play.

According to the participants, the warm-up session was important for breaking those social and physical barriers. This was needed because enacting the ideas for embodied core mechanics would often require close and intimate bodily orientations and physical contact. An example is shown in Figure 31, when a designer is dancing around and "lifting" the mood of an intelligent agent, by physically lifting it, and in Figure 32, where designers are simulating a reactive surface that wraps participants around. The warm-up seemed to help infuse a playful atmosphere, create more comfort with one's body, and generate a spirited mood.

*Figure 32. Two designers (top and right of the picture) are simulating a reactive surface that adapts to a user's (left of the picture) movements by embracing her.*

The atmosphere persisted over the design activity. In particular, the physical and emotional after-effects of the warm-up are linked to what Sheets-Johnstone calls the residual spin-off of movement, which awakes "feelings of aliveness, aliveness in a personal and existentially vibrant sense quite apart from an energized readiness to resume everyday activities" (Sheets-Johnstone, 2010, p. 2). The playful mindset can be linked to the after-effects described by Huizinga that happen after playing, related to a residual bond with the play activity, that make the player feel related and connected to it after having played (Huizinga, 1955).

## Participatory embodied sketching

Embodied sketching can also be performed once some design constructs are in place. These are exposed to the users, who are encouraged to follow or explore new uses and play activities. The "participatory" term here highlights how embodied sketching serves not only to elicit feedback on the existing concepts, but also to generate new ideas together with users.

This form of embodied sketching has two aims. One is to test embodied core mechanics that are assembled into more complete designs, in the form of games or structured activities (see Figure 33). The second is to generate new design ideas, based what happens when end users create and shape their play activity. This is touched upon in articles I and II, and elaborated in paper III.

The studies reported in article I present a less developed version of participatory embodied sketching[30]. This type of embodied sketching included the design of simple play activities that made use of different resources and different socio-spatial arrangements, which were presented to the children as small "games". During the workshop, designers did not change or modify these games. The role of the designer was mostly that of a field researcher, taking notes of interesting phenomena. Insights from this workshop influenced the next design iteration, in which the games were fully or partially implemented using the Oriboo.

*Figure 33. Children playing a competitive-collaborative variation of the game "Dance it".*

In its more developed form, participatory embodied sketching was first used during the PhySeEar design process, and became fully articulated at the end of the Oriboo design process during the last studies with children (paper III). It was only when this author revisited the findings from PhySeEar, in the light of the final observations of the Oriboo studies, that the creative involvement of the physiotherapist and the inpatients was understood as a way of owning and co-creating their joint activity. With this in mind, the author also revisited the original Oriboo studies, finding instances of children's co-creation there too, albeit more constrained – an observation related to how flexible the game activity seemed to the participants at the end of this section.

### Characteristics of participatory embodied sketching

In participatory embodied sketching, designers and end users are *thinking and designing together while playing.* A play activity is suggested, compris-

[30] In paper II, these are called bodystorming. This paper was written prior to the development of the different instantiations of embodied sketching.

ing different embodied core mechanics. Yet participants are allowed and encouraged to play their way, generating new embodied core mechanics or changing prescribed ones.

*End users as designers*

The roles of the participants as active *makers* and *changers* of their play activity were obvious in the final Oriboo workshops. In all four participating schools, many creative variations from the children emerged in an apparently effortless manner (paper III). For example, in one of the schools in Nepal the children became tremendously engrossed in and thrilled by very simple implemented games (see Figure 34), to which they found plenty of novel ways of adding and involving the social context around them. They would show off their scores to the designers and fellow players, or turn single-player play configurations into multi-player variations. In Seville, children approached the researchers with the explicit question of whether they were allowed to modify the suggested games. In Stockholm, the children modified the players' arrangement in the room and how they would hold the Oriboo to enable sharing.

In the PhySeEar case, the way in which the physiotherapist was siding with the inpatients to "fight the system" was unplanned and unexpected (papers V, VI, and X). This new role emerged from an opportunity window provided by the technology when it took over from the physiotherapist some of the work of assessing movements. The inpatients also modified the planned activity by extending the length of the sessions and adding exercise repetitions "to punish" and rebel against the system.

*Designers designing on the fly*

A common feature of all instances of embodied sketching is the role of the researcher as an on-the-spot designer. This became crucial in one of the Nepal school workshops when children became engrossed in the simple implemented games. This author found that the atmosphere was too vibrant, and the children were too excited to move on to another instructed activity. The research team was experiencing language barrier issues, and this author

*Figure 34. Children engaged in sensorimotor play, engrossed with the interactivity of the technology.*

deemed that the planned game variations were too complex to be instructed. The children were therefore allowed to improvise their own games and play with the implemented Oriboo games. In the other schools, the planned game variations were played, but modified on the fly to increase or decrease the challenge and to balance the game with the children's skills and expectations (paper III).

In the PhySeEar case, the researchers onsite observed that the triggering of the ViNAO's faulty movements was presenting a problem for the physiotherapist, because he had to turn his back on the inpatients. One of the researchers therefore took care of the triggering mechanism for the physiotherapist, adding an activity support that allowed the physiotherapist to orient towards the action at all times.

*An activity structure in place for participants to own and engage with*

In Chapter 3, play was discussed as something that can only be partially designed. Using a structural understanding of play, the designer creates a play structure that is presented to participants for them to engage with. Only when this happens does play takes place.

The participatory design workshops have in common that a designed play structure was already in place, with rules and goals and several embodied core mechanics. Observations across the different cases in this thesis show that the players' understanding of the activity structure and their perception of ownership were key for their appropriation of such structure (see paper III). In instances when the play activity was presented as open and explorative and when the structure was subjected to changes and modifications by the researcher onsite, participants were keen to engage in creative modifications and transgressions. This was particularly visible in the final Oriboo workshops, where the researchers would be seen changing the activity on the fly. This made apparent not only the existence of an activity structure, but also that it was a flexible one, which seemed to invite participants to engage creatively in modifying the ongoing activity and thus become co-designers.

## Sensitizing designers

The last version of embodied sketching is focused on *sensitizing designers*, a practical somaesthetic activity that facilitates the designers' building up their sensibilities towards embodied phenomena. Sensitizing explorations promote access to embodied experiences, through designers' physical engagement with embodied phenomena that are important for building certain embodied core mechanics. Such activity is then followed up by a design ideation activity. The practical somaesthetic experience prior to ideation allows participants to access elusive embodied phenomena, further their understanding of them, and be able to articulate to and share their felt experience with peers. The close link between the sensitizing experience and how this enables new design ideas motivates a view of sensitizing designers as a form of embodied sketching.

This author's first sensitizing experience was informal, at an early stage of the Oriboo project. These are illustrated in the section "First-person experiential explorations" in Chapter 6. As shown in that example, sensitizing exercises can have an important effect on the direction of a design project. The experiences from the exploration of hanging show that ideation may also come in the form of a deeper understanding of the somaesthetic experience of an embodied core mechanic.

Hanging was previously explored during the bodystorming workshop with colleagues from RMIT, but the felt experience remained underexplored (paper II), which changed once researchers dedicated time to deeply engaging with the particular core mechanic they wanted to design for. The required third-person perspective in the bodystorming workshop (keeping an eye on what peers are doing and suggesting, and how that affects one's own movements and activity, the handling of various artifacts, and the goal of creating new ideas for embodied core mechanics) does not allow attention to focus on subtle and elusive details of the felt experience. Neither are the enthusiasm and thrill that the participants showed supportive of the careful somatic discrimination (Shusterman, 2008) that the sensitizing explorations foreground. Shusterman commented how "[s]ensory appreciation is typically dulled when blasted with extreme sensations" (Shusterman, 2008, p. 37). Likewise, Schiphorst suggests that "[s]low motion enables the body to shift its attention to an immersive state in relation to its environment, where attention is intensified, and sensory details are sharpened" (Schiphorst, 2007, p. 10).

This form of embodied sketching is covered in paper II (third case example), with a sensitizing designer's exploration performed with colleagues to complement the insights from the bodystorming session in the HangXRT case. A group of fellow researchers shared a practical somaesthetic practice around the concept of hanging: AntiGravity® Yoga. A precursor of this form involving only one designer was carried out early in the Oriboo design process, and the method has also been used in teaching embodied interaction to master's-level students.

### Characteristics of sensitizing explorations

In a sensitizing exploration, designers engage with a practical somaesthetic activity that includes either embodied core mechanics that will be designed for later, or just similar or related embodied phenomena. The goal of the activity is that participants engage in a first-person experience, which typically requires somatic facilitation (Schiphorst, 2011). In this thesis, this has been provided by this author (see Figure 35). Experiences are articulated after the practical somaesthetic activity in the form of a discussion, in which the facilitator intervenes with prompting questions to guide the participants' attention when necessary. This is a usual practice for somaesthetic facilitators (Höök et al., 2016; Shusterman, 2008). Notes are taken on Post-its that participants later further discuss, classify, and cluster.

*Figure 35. Sensitizing exploration. Top: designers engaged in several poses involving hanging and suspension of one's weight. Bottom: designers discussing the experience.*

*Second-person experience*

A characteristic of this form of embodied sketching is the separation of idea articulation from the actual doing. In the sensitizing designer version of embodied sketching, a practical somaesthetic activity takes place *before* a discussion, or a brainstorming (or bodystorming) session. This contrasts with the other forms of embodied sketching, where participants create as they play.

In other embodied sketching, the focus was mostly on the everyday awareness or third-person perspective, with designers acting and articulating their suggestions with actions. However, the aesthetics of the embodied core mechanics involved, and how they feel, remained obscure. As the excerpts from Shusterman and Schiphorst above suggest, focusing on somaesthetic activity supports a stronger focus on the first-person perspective, even though the activity is also social. A participant in the sensitizing workshop presented here reflected on this:

> It was a closed and personal experience, even though it was done in a group […].

Other embodied sketching practices succeed in showing the participants' orientation towards and preference for physical and technical resources for action, as well as interesting uses of them, such as when observing how participants generate new uses for artifacts, or how they favor some over others. This aspect can also be further explored during a sensitizing exploration, when activity is designed around the usage of a particularly interesting object. The workshop presented here revolves around a particular piece of equipment for hanging, a hammock, and the somaesthetic experience facilitated by this object. Participants' reflections involve the object *as perceived and experienced* by them, instead of as *used* for them or *as presented to* others. While the former is an instrumental approach, the latter foregrounds a more phenomenological one.

This phenomenological approach, attentive to objects in the world as experienced by the self, is what Schiphorst calls a second-person perspective (Schiphorst, 2011). This perspective is difficult to achieve, because it requires disruption from our everyday third-person perspective, a reconnection with our first-person awareness, and from there towards the world where we act (Schiphorst, 2011). This requires bodily engagement, and attentive focus for somatic discrimination. This is challenging, and benefits from somatic facilitation from an activity guide or instructor, whom Schiphorst calls a somatic *connoisseur* (Schiphorst, 2011). In the workshop presented here, the facilitation mainly involved helping the participants engage with the activity in specific ways, providing breathing cues, indications about how to move and use the hammock, and prompting somatic questions to raise awareness.

*Articulating and sharing*

An in-situ type of brainstorming comes after the practical somatic activity. Both activities are considered part of the design exploration, and the practical somatic activity is key for the articulation and sharing of the subjective felt experience. Articulation helps designers develop a more accessible understanding of an embodied phenomenon, and establishes a common experience within the group. It provides them with a shared vocabulary and establishes common moments and events that they can refer to.

In paper II, the results of the discussions held after the practical somatic experience are presented. They illustrate how themes emerged, and how designers were able to discuss and access one another's subjective experience. It is also apparent that shared moments can be experienced differently: there are opposed comments on the same events.

However, this author and some colleagues participating in this sensitizing workshop thought that the representations of the themes into categories fell short for illustrating important aspects of their aesthetic experience. This author and other fellow-researcher are currently exploring how to package and portray these experiences in ways that are more truthful to the richness of the subjective individual and collective experiences (paper XI). This remains as future work.

Sensitizing embodied sketching remains as a way of furthering designers' understanding of important subjective, experiential, and aesthetic qualities related to a particular aspect of an embodied core mechanic, in this case, one that involves hanging or being partially suspended. In paper II, sensitizing designers is presented as design activity that combines well with bodystorming activities.

*Moving and making strange*

The positive physical and emotional after-effects of engaging with movement (Sheets-Johnstone, 2010) have been commented on previously. A participant in our sensitizing workshop (reported in paper II) reflected on this:

> The weirdest thing was the experience afterwards, when I felt a strong desire to get back into the hammock even though working with the hammock sometimes was uncomfortable or even hurt. This experience reminds me a bit of dancing and horseback riding.

To support the subsequent ideation, it is useful to disrupt the ordinary embodied experience, similarly to when the children in the initial Oriboo workshops were instructed to dance with the Oriboo, which changed the way they moved. Another option is to engage with unusual activities or actions, such as hanging upside down to explore the felt experience of hanging. This is related to phenomenologist Sheets-Johnstone's concept of making the strange out of the ordinary (Sheets-Johnstone, 2010), used also in Wilde's concept of *defamiliarization* (Wilde, 2008; Wilde et al., 2011), and Loke and Robertson's concept and method of *making the strange* (Loke & Robertson, 2013).

## Characterizing embodied sketching

This chapter has presented three forms of embodied sketching, all supporting the design ideation of embodied core mechanics.

These methods take inspiration from previous ideation methods in IxD and HCI, the most important of which are brainstorming, bodystorming methods, other sensitizing methods in HCI (some of which are presented in Chapter 2 and Chapter 3), and experience prototyping.

In particular, some aspects of the characterization of experience prototyping could also describe embodied sketching: they both focus on understanding important experiential aspects of a technology-mediated (or -supported or -sustained) experience, and on exploring design ideas. However, the understanding and use of "the prototype" are different. The prototype's users and designers dealt with in this thesis (i.e. the embodied core mechanics as they are sketched by the participants) are ephemeral, emerging only as they are lived by the participants, and supported by various design resources or activity supports, including the participants themselves. The concept of ephemerality will be returned to in this chapter's conclusion.

Below, five characterizing principles of embodied sketching are discussed, and contrasted with previous works (also in papers II, and IX).

### Five characterizing principles

**I An activity-centered embodied approach to ideation**

In line with previous work on embodied ideation methods, embodied sketching leverages the situated physical, social, and cultural setting for the design of interactive systems.

However, embodied sketching is meant for *designing for* physical and social activities *by doing* physical and social activities. Although some examples center around designing for a particular activity or experience (e.g. experience prototyping (Buchenau & Suri, 2000) and service walkthrough (Blomkvist, 2014; Blomkvist et al., 2012)), most of the ideation methods referred to in this chapter are typically artifact- or technology-centered, in the sense that ideation revolves around thinking about, designing, prototyping, and testing a concrete design (Arvola & Artman, 2007; Bekker et al., 1995; Blomkvist & Arvola, 2014; Brandt & Grunnet, 2000; Buchenau & Suri, 2000; Djajadiningrat et al., 2000).

Designing embodied core mechanics means designing a whole activity with several digital and non-digital design resources that support the activity.

Where previous methods mostly emphasize early prototype testing (e.g. Oulasvirta et al. (2003) and some examples of experience prototyping (Buchenau & Suri, 2000)), embodied sketching is focused on idea generation and idea exploration. It presents a way to explore, engage with, and design activities that foreground our embodied ways of being, perceiving, and doing.

**II Use complete setting as a design resource**

Another important characteristic unique to embodied sketching is the use of contextual elements as design resources or activity supports. In contrast, previous methods use context as a backdrop for inspiration or against which to evaluate design ideas. An example of this is the proposed "in situ" practice for the *bodystorming* discussed in Schleicher et al. (2010) and Oulasvirta et al. (2003), where designers would situate themselves in a particular context (Schleicher et al., 2010). A classic example would be sitting in a cafe, while brainstorming to design a food-ordering system for a cafe. In Schleicher et al.'s (2010) *strong prototyping*, and in some cases of experience prototyping (e.g. the example of experience prototyping to design and experience the interior of an airplane) (Buchenau & Suri, 2000), designers build a replica of the environment for which they design, so as to be able to understand the space for which they design, and to test their designs in a controlled way (Buchenau & Suri, 2000; Schleicher et al., 2010). It is interesting to note that this view of the context as fixed extends somehow also to *people*: some methods use role-playing to understand users' needs, emergent situations, possible issues, and design possibilities (Arvola & Artman, 2007; Blomkvist et al., 2012; Brandt & Grunnet, 2000; Buchenau & Suri, 2000). For example, in *use-case theater* practices, designers employ living personas to act as props and people in the setting they design for, and in *embodied storming* designers act as people involved in the activity and environment being designed for (Schleicher et al., 2010). While embodied storming is less scripted than the former methods, and is used before ideation as a way to understand better the domain analysis, the setting built and the actors are only used to facilitate this understanding and not to build something new and as part of what is built (Schleicher et al., 2010).

**III Physical and hands-on engagement with a non-scripted activity**

In line with the previous point, many ideation methods mentioned above typically use scenarios of some sort. Some use simulated environments that are built with more (e.g. strong prototyping (Schleicher et al., 2010)) or less accuracy (the staged office example in Oulasvirta et al. (2003), or the restaurant and the grocery stores, part of the food-delivery service in Blomkvist et al. (2012)) relative to the actual setting. Some use actors (e.g. in role-playing a train journey experience prototype in Buchenau and Suri (2000)) or scripted roles (e.g. bodystorming in a staged office in Oulasvirta et al. (2003)). Others play out in a real-world situational context to imagine how their design ideas would fit (e.g. bodystorming in original locations in Oulasvirta et al. (2003)).

Although the value of lived scenarios and personas is recognized as facilitating designers' empathy towards their end users and the situations they might experience, this author shares the reservations of Oulasvirta et al. (2003) with regards to the effectiveness of such explorations. They questioned whether acting was frustrating participants more than helping them, given that the outcome from such ideation methods did not show additional sensitivity to "physical, social or interactional details" compared with those coming from traditional brainstorming methods (Oulasvirta et al., 2003, p. 7). This author reasons that acting might be seen by participants as an artificial add-on to the ideation process, detached from the design goals and outcome. Factors such as acting skills, performance anxiety, and embarrassment may contribute to making it a hindrance to creative ideation.

In embodied sketching explorations, the activities that designers engage in lie very close to the end activity for which they are designing. This makes them inherently meaningful: designers play and move together with their peers to design for play and for movement-based social activities. None of our embodied sketching methods require heavy scripting, and while light scripts are sometimes used, this author has emphasized above how the organizing designers should be prepared to change these on the fly.

#### IV Designing movement through playful engagement in design

A unique feature of embodied sketching is the use of playful engagement in designing in and for movement. In most of the design exercises in this thesis, play or playfulness were also design goals. The section about bodystorming discussed the inherent potential of play to spur creative thinking among, and lower the stakes for, participants. The latter is particularly important when participants are asked to move, because this is a socially exposing activity.

Play requires establishing a safe circle for play, and the social agreement of a safe space for play might be easier to establish if the design goal is also play. It might be harder to facilitate play engagement in design contexts where play is not a design goal. During the Move:ie design collaboration, some strategies in the form of warm-up exercises were put in place to deal with this issue. While the designers responded very positively, investigating the applicability of embodied sketching in other contexts remains as further work.

#### V A sensitizing and design-conducive space

This characteristic emerges as a result of all the above. When performing embodied sketching, designers are exposed to and engage with activities related and meaningful to the activity they are designing for. They develop sensibilities for the activity while designing. This author considers this a unique feature of embodied sketching.

However, this is only partly the case in the proposed exercises for sensitizing designers, because they rely on separating a practical somaesthetic activity from a subsequent design activity. These are nevertheless closely connected; the type of articulation that the brainstorming facilitates arises from persons having just experienced a shared embodied activity.

## Embodied sketches and ephemeral design constructs

The properties of embodied core mechanics only fully emerge when lived and played. Even if designers have put in place a designed structure with various activity supports to sustain a particular embodied core mechanic, it is only when players engage with this design construct that an embodied core mechanic comes to life. What emerges can be something very different.

It is also when, and *only* when, enacted that embodied core mechanics become visible, something termed above an embodied sketch. Just as the puppet comes alive when handled by the puppeteer, embodied core mechanics are designs that exist only while people engage in the activity of enacting, performing, or playing them.

This highlights a particularity of gestures and enactment in general (Arvola & Artman, 2007; Tuikka, 2002), and by extension the embodied core mechanics: their ephemerality. They only last one moment, while played, and then vanish from the visible and tangible world.

Embodied sketches still share the essential ability of sketches to "talk back" to the designer (Schön, 1992), "to stimulate new and different interpretations" (Buxton, 2007, p. 115), and even to say something about "[…] the yet nonexistent entity which is being designed" (Goldschmidt, 1991, p. 140), to allow designers to "see as" and "see that" (Goldschmidt, 1991). Illustrative examples are the embodied sketches created in bodystorming in the HangXRT case. They were fluently created, at a fast pace, visible one moment only to vanish and transform into the next sketch, but still conducive to supporting a tangible creative process.

The generative power in classic sketching arises not only from its making, but also from the designers' "ways of seeing" (Goldschmidt, 1991). With persistent sketches, this seeing can happen at a time and place other than where the sketch was produced. Fällman described this property of sketches as being able to capture thinking that took place somewhere and sometime else (Fällman, 2003a).

The ephemerality of embodied core mechanics and their sketches creates a critical issue for their use: how can an embodied sketch package design thinking for *later* reflection? Can they document and present knowledge in a way similar to that in traditional sketches, and what is lost by attempting this? At the time of this thesis, this is ongoing work with fellow researchers. Some initial attempts have already been presented to document the workshops, such as the Bodystorming Braid (see Figure 28) and its video counterpart with annotations (paper IX). This author is currently exploring with fellow researchers ways of visualizing important aesthetic aspects of sensitizing explorations, and of packaging design knowledge related to embodied core mechanics. However, much future work remains.

# Chapter 8. Conclusion

This thesis proposed to explore options within the design space of movement-based co-located social play by focusing on alternative design approaches to technology-centered ones. The suggested approach is activity-driven, context-embracing, and ecological.

The activity-driven aspect emerges as a reaction to mainstream technology-centered design processes, where the technology capabilities not only shape, but they also dictate the whole play activity. The locus of attention is placed on the creation, development, and implementation of a technology, instead of on designing a rich interactive experience that is enabled by the technology. In those design processes, the embodied core mechanics that shape the experience are designed once the technology is in place, and they rely heavily on what the technology can support, conforming to its limitations. These limitations translate into rigid and limited play options. In this thesis, the embodied core mechanics of a play activity drive the design process, and they are not bound to the technology capabilities, but are designed even before the technology is implemented.

The context-embracing aspect refers to *what* is designed. Following a technology-supported approach to design, this thesis proposes to consider the technology as just one resource. In addition to technology, the studies have involved a range of socio-spatial elements. This thesis has foregrounded the use of artifacts, and the location of players in space as well as their agreed rules.

Finally, the ecological aspect refers to the *how*: how to design an activity supported by a combination of elements (design resources, or activity supports) that only come together as a design construct when lived or played.

The research questions are revisited below, followed by discussions of the type of contribution this thesis makes and of validity issues. The chapter finishes with a section about implications for research and design.

## Revisiting the research questions

The core research question of this thesis was:

> How can we design movement-based interactive play in a co-located social setting in a way that foregrounds the physical and social engagement in the play activity?

This overarching question speaks about designing taking an embodied interaction perspective. The thesis began by describing what that would mean in the domain of movement-based co-located social play: making the technological, physical and social context that is part of our life world also part of the design process, and leveraging the players' and designers' ways of acting and doing to shape the final designs as well as the design process.

This goal has been the pivotal design value for this thesis, and all the design projects included share the final goal of promoting activities that are physically and socially engaging and worth doing in and by themselves. While the precise goals vary depending on the application context, an embodied approach to design pervades all cases, foregrounding the participants' engagement with the physical and social world around them. This also motivates the technology-supported approach that this thesis follows, considering the technology as only one aspect of that which is designed.

The details of how this is concretized respond to the sub-questions. The overarching question could be addressed in various ways, and this author has chosen to follow an explorative and constructive design-oriented approach, focusing on not only ontological but also practical aspects of the main research question, asking *what* can be designed and *how* this can be done. Hence, the first sub-question involves the identification of important design resources in the domain of movement-based co-located social play.

> What is it that we can design to foreground the physical and social engagement in the play activity?

This question has been mainly answered in Chapter 6, in several ways. First, that chapter presented the concept of *embodied core mechanics* as a useful design goal because it focuses on designing the in-the-moment activity, by designing actions that are particularly interesting from an embodied perspective. In Chapter 6, embodied core mechanics are presented as desirable and repeatable movement-based play actions that are supported by a variety of design resources that make use of the social and physical context of play.

Second, a variety of design resources or activity supports were suggested that include the technology, as well as others, to shape play. The design resources suggested for consideration are, including the technology, belong to the physical and social reality that we encounter in our everyday life. Inspired by traditional children's outdoor games, this thesis suggests that designers should also use socially agreed rules, physical artifacts, assigned roles, and, perhaps most interestingly, the spatial configuration of these. These have also been called activity supports because first, taken together they encourage activities that are supported technologically, socially, and by the space of the activity. Second, because for some of them, the designer's role involves arranging them in the space, in relation to one another, and assigning them roles in order to facilitate the physical and social activity designed for.

While the first sub-question refers to *what* we can design, the second focuses on *how*:

> How can we understand and consider relevant aspects of the physical and social play activity, and explore and generate design ideas?

This question has been primarily answered in Chapter 7, but is touched upon earlier, in Chapter 6. It is an important methodological question, concerning how the designer can design constructs (embodied core mechanics) that only come into being when lived and played. The ephemerality of these constructs and their need for social supports makes it difficult to use only the designer's first-person explorations. While these can be useful (e.g. the first-person explorations at the beginning of the Oriboo case), they are insufficient to cover important aspects of the co-located and social play activity – the design goal in this thesis is after all *social play* unfolding between a group of players.

Chapter 6 explored specific design strategies to address this, such as using and designing the socio-spatial configuration to regulate attention. In Chapter 7, the focus was shifted towards the design process as such, suggesting ways to implement embodied ideation methods to explore embodied core mechanics. The overarching design practice of *embodied sketching* was proposed, and illustrated through three different cases: embodied sketching for bodystorming, for co-creating with users (participatory embodied sketching), and for sensitizing designers. These forms of embodied sketching differ in their requirements, in who is participating, in what is done, and in what outcome is sought. They nevertheless share the same characterizing principles and they all help in early design phases.

These contributions are supported by case studies: multiple exemplars in the form of designs, sketches, and studies that ground the contributions in this thesis in empirical data. The case studies form contributions in and of themselves. The exemplars can inspire other designs, while the studies offer interesting insights regarding the participants or the situation explored (e.g. rehabilitative therapy for the elderly, and interactive games for children in various contextual venues). They also offer methodological suggestions, such as the way to playtest different designs, and how to document and analyze studies.

## A meta-reflection on the approach

The research questions in this thesis could have been approached from multiple perspectives. One way could have been to focus on opening the design space to find different design possibilities, reflected by design exemplars. Such an approach was used by, for example, Mads Hobye in his thesis, who designs for social exploratory behavior (Hobye, 2014). In such an approach it would have been the array of exemplars that would create a map of the design possibilities of the researched domain.

Although the projects and collaborations in this thesis include an array of design exemplars, they are not primarily meant to map a design space. Rather, the designs emerged gradually, to support some interesting aspects of the embodied experience, as observed when participants have been put in a situation to interact with (actual or simulated) technological interventions. What these "interesting aspects" were varies among the examples.

Alternatively, this author could also have focused on designing to foreground and support certain aesthetic experiences. This approach was taken by Höök et al. (2016) in their design for somaesthetic appreciation. Using theoretical underpinnings that are important in this thesis, the authors suggest a possible direction for the design of interactive technologies: one that addresses the subjective felt experience. While this thesis has not detailed and articulated any particular aesthetic experience in the same manner, there is one that has influenced the design decisions and approach followed in the examples.

This aesthetic is similar to that of children playing outdoor games, looking at the way such play activities include other players, spatial and physical elements, movements, and actions to make a meaningful whole. This aesthetic of physical playful activity is also shared with previous work on Head Up Games (Soute & Markopoulos, 2007; Soute et al., 2010). It then shares important aspects of open-ended play Bekker et al., 2010; De Valk et al., 2013), in particular concerning how players act as co-designers, and improvisatory play emerges to create (and also to change) structures that frame play. Finally, it foregrounds a focus on "playing well" together (DeKoven, 2013), and on the festive context of play (Wilson, 2011).

## Type of knowledge produced

The main concepts put forward in this thesis represent intermediate-level knowledge as presented by Höök and Löwgren (2012). The concepts are abstracted from the particulars formed by the studies reported in this thesis, but also grounded in theory. The main contributions of this thesis could be considered close to being strong concepts (Höök & Löwgren, 2012) or bridging concepts (Dalsgaard & Dindler, 2014). In the same way as strong concepts, the concept of embodied core mechanics was identified bottom-up, arising from examining common features and strategies that appear to work in several instances and application domains. Nevertheless, the concept of embodied core mechanics is not a strong concept since it does not extract a single design pattern that lies at the core of all the design particulars.

However, the concept of embodied core mechanics is also grounded in the underlying theories; it is derived as much top-down as bottom-up. The very notion of core mechanics comes from game design theory, in that it refers to participants' *action*, what participants (can) do in a play activity. The concept is appropriated here by re-thinking core mechanics from an embodied perspective, understanding them as something worth engaging with, as an end instead of a means to advance the game. Embodied core mechanics may, but need not, affect any game state. This allows embodied core mechanics to be seen as design goals in themselves, as a way to identify interesting embodied phenomena by how they leverage, support, and enrich the physical and social aspects of an activity.

## Judging the contributions against established criteria

Here well-established criteria in IxD are used to judge the main concepts that emerged from the RtD process in this thesis: Zimmerman et al.'s (2007) and Höök and Löwgren's (2012), which partially overlap.

The main contributions in this thesis are *contestable* (Höök & Löwgren, 2012) and can be considered *inventions* (Zimmerman et al., 2007)[31]. The two main contributions together suggest a novel approach for the design of co-located physical and social play, complementing others' work in the field. The claim that this approach will always render working designs is not one this author is making, but that the suggested approach works towards identifying and supporting embodied play experiences. Nevertheless, the contributions in this thesis have been *defended*[32] (Höök & Löwgren, 2012) through the analysis of multiple case studies, represented by individually published articles. This argument was grounded in the empirical data, in local design projects and external design collaborations, and in relevant theory in the field.

The case studies can be considered *substantive*[33] (Höök & Löwgren, 2012) and *extensible* (Zimmerman et al., 2007)[34] because of their acceptance through publication. Furthermore, the main contributions in this thesis are meant to inspire the research community (Gaver, 2012, p. 945), generating new possible actions and ways of doing design in this domain (Latour, 2004).

[31] Both *invention* and *contestable* refer to novelty.
[32] Defensible means they might cause discussion and disagreement, but they can be defended, and can potentially convince detractors with empirical and theoretical argumentation.
[33] i.e. relevant for the research community.
[34] That they can be built upon.

Finally, the goal of this overview or thesis introduction has been to extend on the *relevance*[35] and the *process*[36] (Zimmerman et al., 2007) by articulating overarching research questions and design goals, and by illuminating how a common research approach supports the design projects in this thesis, including the collaborations in external projects.

Moreover, this overview has served to reinforce the vertical and horizontal grounding (Höök & Löwgren, 2012). Horizontal grounding refers to relating the contribution to similar concepts, highlighting similarities and differentiators, i.e. the novelty of the design contribution, and how it extends, complements, and relates to previous works (ibid.). Vertical grounding refers to substantiating contributions both from empirical work (vertical grounding towards the particulars from the researcher's own work, and from others' work), and with theory (ibid.). The concept of embodied core mechanics is elaborated throughout this thesis, and applied in the various design projects and design collaborations, grounding it vertically towards the particulars. This overview also shows how the main concepts presented in this thesis concretize more abstract theory, and extend or complement some earlier concepts (in particular core mechanics and kinesphere).

## Additional contributions

Apart from the contributions framed by the research questions, this thesis contains some contributions at a more general level.

One such contribution concerns analytic concepts that could help describe and design for movement-based co-located social activities more generally outside the play domain in focus for this thesis. The concept of the concrete kinesphere can be useful when designing for the moving body, as could the concepts of socio-technical space and socio-spatial configuration be for tangible computing. In particular, they complement and illustrate Hornecker and Buur's (2006) concepts of embodied facilitation and spatial interaction.

This thesis has also furthered the concept of the technology-supported approach, by investigating further what other design resources are involved in technology-supported designs. In this thesis, these concern in particular physical artifacts, and the social and spatial configuration of an activity.

Finally, a particular contribution lies in the emphasis on play and playfulness in shaping the design process. Play is leveraged in the design forms of embodied sketching presented in this thesis, but is also apparent in the main design projects. The prime example is PhySeEar, where play and playfulness were not goals at the beginning, yet emerged and shaped the design process.

[35] The articulation of a preferred state.
[36] The rigorous account of the RtD process and its methods.

## Implications for research and design

This thesis proposes to harness our ways of engaging with the physical, social, and technological world in design. This relates not only to the use of non-computational design resources, but also, and more importantly, to the role they play to support the designed activity, and in how they contribute to the participants' making sense of the way they interact with one another and surrounding artifacts.

Given that the approach proposed here makes use of the resources of the world that we inhabit directly, it can empower participants by inviting them to use their own ways of doing, to creatively engage with their resources in the ongoing activity. This creates a fleeting playful experience that unfolds with the technology, other participants, and other resources at hand. In the studies, this was observed in all explorations with children: they were not afraid of trying things out, and finding their way. Initially, this was interpreted as children "being children", but later it was also related to the way the exercises and activities centered on familiar elements and familiar play activities, and to the emergence of play and playfulness.

Sicart (2014) presents play from a phenomenological perspective:

> Through play, we are in the world […] Play is being in the world, through objects, toward others (Sicart, 2014, p. 18).

Play is first a way of making sense of the world (Ferreira, 2015), of exploring possibilities that are not accessible otherwise, which resonates with Gaver's (2002) characterization of *Homo Ludens*. Play serves to find new perspectives and relationships, and to imagine, visualize, and bring into life "another world" (Gaver, 2002; Sicart, 2014).

This speaks of the creative and transformative power of play. This thesis has illustrated how using play as a means (and not only as a goal) for design can be useful. This foregrounds an ecological understanding of play grounded in post-phenomenological thinking. Sicart (2014) discusses how play objects and diverse artifacts that can be used as playthings allow participants to shape and design play.

Second, play is transformative. Sicart (2014) presents play as *disruptive* in how it can unveil our assumptions, which from a phenomenological perspective are our habitual ways of being, our background of experience. In this thesis, play has been used as a defamiliarization tool (Wilde, 2008; Wilde et al., 2011) to disrupt the current state of affairs (e.g. our ways of moving), and to envision and build something new.

Transformation and disruption also refer to the context where play takes place and to the play activity itself. Sicart (2014), and Salen and Zimmerman (2003), acknowledge the power of play to create, destroy, change… to shape the play activity.

When players and designers play, they often come up with their own ways of playing, modifying the existing or pre-defined play structures that frame the activity. This aspect of play has been leveraged in this thesis to test, transform, and create design constructs, enabling both players (e.g. in participatory embodied sketching) and designers (e.g. in bodystorming activities) to shape both the "preferred state" and the design outcome (H. A. Simon, 1996; Zimmerman et al., 2010).

Finally, interactive play has typically relied heavily on rules implemented in the technology to shape the play activity (technology-sustained play (Waern, 2009)). This can lead to *alterity relations* with the technology, presenting it as our immediate world towards which our attentions and actions are directed, while the rest of the world fades away (Fällman, 2003b).

This thesis advocates for a different type of relationship with the technology. Frequently, the technology was not completely "finished", which invited participants to "step in and fill the gaps". However, even when this was not the case, the technology-supported and socially supported approach results in design constructs in which participants need to step actively into important roles. This created embodied and hermeneutical relationships with the technology, physical artifacts, and social actors. Through designing with embodied core mechanics a design space opens up, one that privileges the physical and social experience, one that leaves plenty of room for improvisation, appropriation, enjoyment – and play.

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