Designing Sports: Exertion Games

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Submitted in total fulfilment
of the requirements for the degree of
Doctor of Philosophy

December 2010

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Produced on archival quality paper

Abstract

Exertion games are computer games that require intense physical effort from its users. Unlike traditional computer games, exertion games offer physical health benefits in addition to the social benefits derived from networked games. This thesis contributes an understanding of exertion games from an interaction design perspective to support researchers analysing and designers creating more engaging exertion games.

Playing with other participants can increase engagement and hence facilitate the associated benefits. Computer technology can support such social play by expanding the range of possible participants through networking advances. However, there is a lack of understanding how technological design can facilitate the relationship between exertion and social play, especially in mediated environments. In response, this thesis establishes an understanding of how mediating technology can support social exertion play, in particular when players are in geographically distant locations.

This understanding is forged through the design of three “sports over a distance” games. The experience of engaging with them was studied qualitatively to gain a rich understanding of how design facilitates social play in exertion games. The three games “Jogging over a Distance”, “Table Tennis for Three”, and “Remote Impact - Shadowboxing over a Distance” allow investigating different perspectives of mediated exertion play, since they represent three categories of richness on a social play continuum across both the virtual and the physical world.

Studies of the experience of engaging with the three games resulted in an exertion framework that consists of six conceptual themes framed by four perspectives on the body and three on games. A fourth study demonstrated that the understanding derived from the investigation of the use and design of the games can support designers and researchers with the analysis of existing games and aid the creative process of designing new exertion games.

This thesis provides the first understanding of how technology design facilitates social play in exertion games. In doing so, it expands our knowledge of how to design for the active body,

broadening the view of the role of the body when interacting with computers.

Offering an increased understanding of exertion games enables game designers to create more engaging games, hence providing players more reasons to exert their bodies, supporting them in profiting from the many benefits of exertion.

Declaration

This is to certify that

I. the thesis comprises only my original work towards the PhD,

II. due acknowledgement has been made in the text to all other material used,

III. the thesis is less than 100,000 words in length, exclusive of tables, maps, figures, bibliographies and appendices.

20 December 2010

Florian Muller

Preface

The research reported in this thesis builds upon my prior research work on exertion in interactive systems. This work began while studying at the MIT Media Lab (USA) and continued while working for Media Lab Europe (Ireland). The Table Tennis for Three system was developed at the University of Melbourne just before I commenced my doctoral candidature. It was designed in collaboration with my supervisor, Martin Gibbs. I was responsible for collecting all the data used in chapter five. The analysis presented in this thesis was my own work and entirely completed during my candidature.

The research in this thesis was supported by multiple grants that enabled extended research visits to the following research institutions: Microsoft Research Asia (People's Republic of China), Stanford University (USA), Distance Lab (UK), the University of London (UK), and the University of Sydney (Australia). The supervision and support I received at these institutions contributed significantly to the intellectual development of the arguments presented in this thesis. Although the research presented is entirely my own, I acknowledge the support I received from: Darren Edge (Microsoft), Scott Klemmer (Stanford University), Stefan Agamanolis (Distance Lab), Jennifer Sheridan (The University of London), and Bert Bongers (The University of Sydney).

Videos of the exertion games are available at:

http://exertioninterfaces.com

The following is a list of publications that emerged from the research reported in this thesis, including a note to indicate the most relevant chapter to the publication:

Mueller, F., Vetere, F., Gibbs, M. R., Edge, D., Agamanolis, S., & Sheridan, J. G. (2010). *Jogging over a distance between Europe and Australia*. In Proceedings of the 23rd annual ACM Symposium

on User Interface Software and Technology (UIST '10), New York, New York, USA. 189-198. (Chapter 4)

Mueller, F., Vetere, F., Gibbs, M. R., Agamanolis, S., & Sheridan, J. G. (2010). *Jogging over a Distance: The influence of design in parallel exertion games*. Proceedings of the 5th ACM SIGGRAPH Symposium on Video Games (SIGGRAPH ’10), Los Angeles, CA, USA. 63-68. (Chapter 4)

Mueller, F., Gibbs, M. R., & Frank, V. (2010). Towards understanding how to design for social play in exertion games. *Personal and Ubiquitous Computing*, 14(5), 417-424. (Chapter 5)

Mueller, F., Agamanolis, S., Vetere, F. & Gibbs, M. R. (2009). *Brute force interactions: leveraging intense physical actions in gaming*. Proceedings of the 21st Australasian Conference on Computer-Human Interaction (OZCHI ’09), Melbourne, Australia. 167-170. (Chapter 6)

Mueller, F., Agamanolis, S., Vetere, F. & Gibbs, M. R. (2009). *A framework for exertion interactions over a distance*. Proceedings of the 5th ACM SIGGRAPH Symposium on Video Games (SIGGRAPH ’10), New Orleans, LA, USA. 143-150. (Chapter 7)

Mueller, F. (2009). *Exertion in networked games*. Proceedings of the 4th International Conference on Foundations of Digital Games (FDG ’09). Doctoral Consortium Extended Abstracts. Orlando, FL, USA. 346-348. (Chapter 7)

Mueller, F., Gibbs, M. R. & Vetere, F. (2009). *Design influence on social play in distributed exertion games*. Proceedings of the 27th International Conference on Human Factors in Computing Systems (CHI ‘09), Boston, MA, USA. 1539-1548. (Chapter 5)

Mueller, F., Agamanolis, S., Gibbs, M. R. & Vetere, F. (2009). *Remote Impact: Shadowboxing over a Distance*. Proceedings of the 27th International Conference on Human Factors in Computing Systems, Extended Abstracts (CHI ’09). Boston, MA, USA. 3531-3532. (Chapter 6)

Mueller, F., Agamanolis, S., Gibbs, M. & Vetere, F. (2009). *Brute Force Interface: Leveraging Intense Physical Exertion in Whole Body Interactions*. In Workshop on Whole-Body Interactions at the 27th International Conference on Human Factors in Computing

Systems (CHI ’09), Boston, MA, USA. http://lister.cms.livjm.ac.uk/homepage/staff/cmsdengl/WBI2009 (Chapter 6)

Mueller, F., Gibbs, M. R., Vetere, F. & Agamanolis, S. (2008). Design space of networked exertion games demonstrated by a three-way physical game based on Table Tennis. *ACM Computers in Entertainment*, 6(3), 1-31. (Chapter 4)

Mueller, F., Gibbs, M. & Vetere, F. (2008). *Taxonomy of Exertion Games*. Proceedings of the 20th Australasian Conference on Computer-Human Interaction (OZCHI '08), Cairns, Australia. 263-266. (Chapter 2 & 3)

Mueller, F., Agamanolis, S., Vetere, F. & Gibbs, M. R. (2008). *Remote Impact: Shadowboxing over a Distance*. ACM SIGGRAPH 2008 posters (SIGGRAPH ’08). Los Angeles, CA, USA. (Chapter 6)

Mueller, F., Agamanolis, S., Gibbs, M. R. & Vetere, F. (2008). *Remote Impact: Shadowboxing over a Distance*. Proceedings of the 27th International Conference on Human Factors in Computing Systems, Extended Abstracts (CHI ’08). Florence, Italy. 2291-2296. (Chapter 6)

Mueller, F. & Gibbs, M. R. (2007). *Evaluating a distributed physical leisure game for three players*. Proceedings of the 19th Australasian Conference on Computer-Human Interaction (OZCHI '07), Adelaide, Australia. 143-150. (Chapter 5)

Mueller, F. & Gibbs, M. R. (2007). *A physical three-way interactive game based on table tennis.* Proceedings of the 4th Australasian Conference on Interactive Entertainment (IE ’07), Melbourne, Australia. 1-7. (Chapter 5)

Mueller, F., Vetere, F., Gibbs, M. R. (2007) *Design experiences with networked exertion games*. 4th International Symposium on Pervasive Gaming Applications (PERGAMES ’07), Salzburg, Austria. 1-10. (Chapter 2, 3 & 5)

Mueller, F., Agamanolis, S., Vetere, F. & Gibbs, M. R. (2007). *Brute force as input for networked gaming*. Proceedings of the 19th Australasian Conference on Computer-Human Interaction (OZCHI '07), Adelaide, Australia. 167-170. (Chapter 6)

Co-organizing the following workshops also contributed to the intellectual development of the thesis.

Mueller, F., Agamanolis, S. (2008). *Exertion Interfaces*. Workshop Co-Organizer. Proceedings of the 27th International Conference on Human Factors in Computing Systems, Extended Abstracts (CHI ’08). Florence, Italy. 3957-3960. (Chapter 2 & 7)

Bernhaupt, R., IJsselsteijn, W., Mueller, F., Tscheligi, M., Wixon, D., (2008). *Evaluating User Experience in Games*. Workshop Co-Organizer. Proceedings of the 27th International Conference on Human Factors in Computing Systems, Extended Abstracts (CHI ’08). Florence, Italy. 3905-3908. (Chapter 1 & 3)

Mueller, F., Agamanolis, S. (2007). *Exertion Interfaces*. Workshop Co-Organizer. Proceedings of the 26th International Conference on Human Factors in Computing Systems, Extended Abstracts (CHI ’07). San Jose, CA, USA. 2857-2860. (Chapter 2, 7 & 9)

Acknowledgement

This research would have not been possible without the help of many others.

I thank Stefan Agamanolis for his ongoing support of the exertion research, starting with our time together at MIT Media Lab, USA, and MIT Media Lab Europe, Ireland, where the idea of exertion grew. Stefan provided invaluable input and support during my time at his Distance Lab in the UK and during conferences, including two great workshops at CHI on exertion interfaces he organized with me, I thank him for making them so much fun. I also thank all the workshop participants who significantly helped to shape my theoretical understanding of exertion in so many ways.

I also thank all the other staff at Distance Lab who supported me in developing Remote Impact and made it possible for this system to travel the world and be shortlisted for the European Innovative Games Award next to Wii Fit.

I also like to thank Jennifer Sheridan who was tremendously supportive in getting me to visit the London Knowledge Lab at the University of London through the support of a Ubicomp Grand Challenge grant of the UK government to work together with her, Sara Price and Richard Noss on the development of the idea of kinaesthetic literacy.

I thank Bert Bongers for helping me secure a grant to work with him and his lab members on exertion games at my time at the University of Sydney, Australia, inventing a new “Hanging off a bar” game.

I thank Microsoft for the wonderful opportunity of a Microsoft Research Asia Fellowship, that allowed me to conduct some of my research at Microsoft Research Asia in Beijing, where Darren Edge, James Landay, Desney Tan and everyone else in the HCI and Kinect team have been wonderful to work with. Darren Edge, especially, has been exceptional in making me feel at home at Microsoft and offered excellent intellectual exchange.

I also thank Fulbright and Telstra for having giving me the wonderful opportunity to spend one year at Stanford University to develop the idea of exertion games further. At Stanford, I thank Terry Winograd, BJ Fogg and Larry Leifer for their insights and in particular Scott Klemmer for his invaluable support and encouragement to push the contributions for designers further. Thanks also to Steven Dow and Wendy Ju for their invaluable feedback during my time at Stanford.

I thank all the volunteers in my studies who sweated for the good of science with no compensation but their bodies thanking them. Thank you also to those participants who let me use their pictures, and thanks to Kerin Bryant and Lana Daubermann for taking them.

I also would like to thank Nokia and Telstra for their equipment support.

I thank the University of Melbourne for their Melbourne Abroad Travelling Scholarship, the Overseas Research Experience Scholarship, and the Cultural and Community Relations Grant, the Department of Information Systems travel grant, the Department of Information Systems studying overseas grant and the John and Betty McCreery Scholarship. I also thank HCSNet for their Travel Grant and Network Award and the Foundations of Digital Games grant for supporting me in attending their conference on a Disney Cruise Ship in the Caribbean.

I thank Chris Wolf and Stefan Greuter for their invaluable thoughts throughout the entire thesis process. I also thank Bernd Ploderer, Kostas Kasakos, Beryl Plimmer, Lassi Liikkanen and everyone else who helped at some point during this journey.

I especially thank my supervisors Martin Gibbs and Frank Vetere, and committee member Steve Howard, for their support, help and intellectual stimulation during this exciting PhD journey.

I thank my parents and my sister for their ongoing support and my Irish schnitzel for everything.

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1. Stretching for Exertion: Introduction

1.1 Exertion Games

Advances in human-computer sensing technologies have led to emerging computer systems that place the users' bodily actions in the centre of the experience, fostering physical exertion as part of the interaction. These "exertion" interactions are interactions with technology that require intense physical effort from the user (Mueller, Agamanolis, & Picard, 2003).

The merging of exertion interactions with computing technology has been investigated from a perspective of health services (LeBlanc, 2008) and athlete training (Chi, Song, & Corbin, 2004), but it is computer games that currently provide the most buoyant genre for exertion systems. For example, Dance Dance Revolution (Behrenshausen, 2007) is an arcade game that requires two players to follow dance instructions on a screen based on fast music beats by stepping on touch-sensitive tiles on the floor, resulting in exerting dance moves. Nintendo's Wii (Nintendo, n.d.-a) game console uses handheld pointing devices that can detect movement in three directions, supporting large arm movements as input for computer game interactions. Sony's Playstation Move (Sony, 2010) arrived as an answer to the Wii and uses a different tracking system to detect the position of its motion-sensing handheld pointing devices that users need to wave around with their arms when interacting with the game. Microsoft's Kinect (Microsoft, 2010) also aims to support exertion interactions in the home by using a depth-sensing camera to track players' body actions in front of the screen. Exertion systems beyond the console and arcade game market exist, too. For example, the Apple Nike+ system uses a sensor in the shoe to track a user's jogging performance when running with an iPod or iPhone (Apple, n.d.). Upon arriving at home, the jogger can upload the data, and engage in social exchange and competitive challenges with a worldwide community of Apple Nike+ joggers online. Computationally-augmented exercise bikes (Tacx, 2009) allow investing physical effort on stationary bikes that are connected to the Internet. Riders' performance is measured and distributed amongst participants who engage in competitive races with their avatars on virtual cycling tracks. All together, these systems contribute to a design space that highlights the role of exertion when interacting with technology. Consequently, an exertion game is a computer game that utilizes exertion interactions.

Previous work in human-computer interaction (HCI) contributed to an understanding of how these technologies persuade their users to exercise (Ahn et al., 2009; Sunny Consolvo et al., 2008; Lin, Mamykina, Lindtner, Delajoux, & Strub, 2006; Sinclair, Hingston, & Masek, 2007; Yim & Graham, 2007). Researchers with a background in behavioural science have offered perspectives such as "persuasive technology" to explain why people engage in exertion interactions: For example, it has been argued that exertion technologies can provide enhanced feedback that users find motivating (Fogg, 2002). Furthermore, research suggests that incorporating games into physical activity has the ability to distract from the discomfort of working out (Fogg, 2002). However, other factors besides simple distraction must also be at play, as engaging in exertion gameplay can change the entire character of the experience (Bianchi-Berthouze, Kim, & Patel, 2007; Lindley, Le Couteur, & Berthouze, 2008). This is supplemented by self-reports from users highlighting that these games can engage players for months who otherwise would not engage in physical activity (DeLorenzo, 2007).

To understand exertion games further, researchers have turned to a perspective of play, leaning on research on fun and games. In particular, the notion of "fun" has been investigated when users interact with technology (Davenport, Holmquist, Thomas, & Participants, 1998). Computers can play a key role to support this play aspect, as they have been described as exceptionally good enablers of fun when it comes to games (Juul, 2009). Understanding computer games from a fun perspective provides insights into why people engage with computer games, however, as such an approach does not differentiate between whether the game facilitates exertion or not, it cannot shed much light on any specific role exertion might have towards the game experience.

In contrast, researchers with a background in human movement have taken the bodily actions displayed in exertion games as a starting point and have found that the movement in these games can contribute to more affective responses and as a result leads to more engaging play (Bianchi-Berthouze et al., 2007; Lehrer, 2006). Furthermore, social benefits facilitated by the introduction of exertion have been debated as part of this discussion (Bogost, 2007b; Lindley et al., 2008), kindled by the observation that exertion games are often played with others (Behrenshausen, 2007). These works highlight the effects of including exertion in computer games; however, they fall short with providing an understanding of how exertion could be designed for in the first place.

In sum, these perspectives highlight that computers can support exertion interactions. In particular, they suggest that facilitating exertion through games is a beneficial approach. Moreover, they also point out that computers are a particularly good medium for games (Juul, 2003). Lastly, these perspectives also highlight that including exertion in games can foster engagement and social play. However, what is still lacking is an understanding of how to design for these exertion games, in particular how to design for both, exertion and social play. By gaining such an understanding, we enhance our knowledge about exertion and computer games in particular, but also about the role of the active body in general.

1.2 Motivation

Various health benefits have been attributed to exertion games, in particular social and physical health benefits have been identified (Weinberg & Gould, 2006). Health physicians have begun investigating whether exertion games can facilitate energy expenditure and hence contribute to weight loss (Graves, Stratton, Ridgers, & Cable, 2007; Lanningham-Foster et al., 2006; Maddison et al., 2007), thereby addressing the rising obesity issue (World Health Organization, 2010). Although the current verdict is that present exertion games do not require the same amount of energy expenditure as the conventional sports they often emulate (Graves et al., 2007), they can contribute to an active lifestyle and as a result support physical health (Lanningham-Foster et al., 2006).

Exertion games not only offer physical health benefits, they also lend themselves to more social experiences (Juul, 2009; Lindley et al., 2008; Strömberg, Väätänen, & Räty, 2002; Wakkary, Hatala, Jiang, Droumeva, & Hosseini, 2008) when compared to non-exertion computer games. In this context, non-exertion computer games are understood as computer games that utilize a conventional gamepad or mouse and keyboard as input. In contrast to exertion games, conventional non-exertion computer games have often been associated with isolated, lonely play (Magerkurth, Engelke, & Memisoglu, 2004).

Due to the associated health benefits, exertion games have frequently been compared to sports (Bogost, 2007b; Lanningham-Foster et al., 2006; Martin Ludvigsen, Veerasawmy Nielsen, & Fogtman, 2008), as they also feature involvement of bodily actions within the context of a game. Given this resemblance, it is not surprising that exertion games are suitable for facilitating social experiences (Lindley et al., 2008). After all, it is recognized that sporting activities can facilitate social benefits, such as teambuilding, social bonding, rapport experiences, and social well-being (Cashmore, 2005; Sampselle, Seng, Yeo, Killion, & Oakley, 1999; Weinberg & Gould, 2006).

The interrelationship between exertion and social benefits in sports has been investigated from both a social science and sports research perspective. For example, researchers have examined the role of participating in sports activities towards the development of social skills and behaviours (Bailey, 2005, 2006). The link in the opposite direction, from social to exertion, has been investigated particularly from an athlete's perspective to increase performance. For example, social facilitation theory suggests that having others join an exertion activity can affect the exertion outcome (Cohen, Ejsmond-Frey, Knight, & Dunbar, 2009; Weinberg & Gould, 2006). Although the extent of this effect is debated (Bond & Titus, 1983), there seems to be consensus that investing physical effort with others can at least contribute positively to the experience and facilitate engagement (de Kort & Ijsselsteijn, 2008; Fogtmann, Fritsch, & Kortbek, 2008; Lindley et al., 2008). However, what is still missing is an understanding of how to design for this interrelationship between exertion and social play (de Kort & Ijsselsteijn, 2008; Lindley et al., 2008).

By establishing such an increased understanding of exertion games, people will increasingly profit from the benefits of exertion. This line of reasoning is based on the following beliefs:

1. Fostering such an increased understanding of exertion games affords improved designs of these games. Such a belief in causality between increased understanding about interactive experiences and improved design has a rich history in HCI, for examples see the works by Benford et al. (2006; Benford, Greenhalgh, Reynard, Brown, & Koleva, 1998; Benford et al., 2005). This also applies to games: Game researchers similarly advocate for an increased understanding to design better games, see for example the works of game theorists who are also game designers, such as Jesper Juul, Ian Bogost and Jane McGonigal.
2. Improved designs of exertion games facilitate a heightened engagement with these games. This belief that better designs afford better experiences is one of the underlying principles of interaction design (Sharp, Rogers, & Preece, 2007) and the motivation behind many game iterations (Pagulayan, Keeker, Wixon, Romero, & Fuller, 2003).
3. If players experience a heightened engagement with an exertion game, they are more likely to play longer, harder (i.e. invest more physical effort) and come back to play again. Computer games have an ability to draw people in by offering a “pull” (Juul, 2009) that entices people to play longer. Research in sports suggests that increased engagement can result in intensified investment in the activity (Weinberg & Gould, 2006). Similar increased investments can therefore be expected when the pull of computer games is combined with sports experiences, as the example of Dance Dance Revolution suggests: A study of players reports that players quickly intensified their

investment and kept coming back to play (Behrenshausen, 2007).

4. If people play longer, harder, and more often, they are exercising their body more, resulting in an increase of the benefits associated with exertion.

So by gaining an understanding of the interrelationship between exertion and social play, the benefits are fostered for the participants. This understanding is important for co-located experiences, but particularly pertinent when supporting distributed participants.

1.2.1 Supporting distributed participants

Isbister calls an active engagement with a game by more than one person "social play" (2010). One of the key advantages of introducing computers to games is that computer technology can enable such social play between geographically distant participants (Salen & Zimmerman, 2003a). Networking advances expand the range of available participants, enabling social play when co-located participants are not available. It has been suggested that exertion games might benefit similarly from the advantages of networking technologies (Mueller et al., 2003), however, prior work on social play has mainly considered co-located participants (Ahn et al., 2009; Behrenshausen, 2007; Lieberman, 2006; Lindley et al., 2008; Webb et al., 2006; Yim & Graham, 2007), hence little is known about how computer mediation affects the interrelationship between exertion and social play (Klasnja, Consolvo, McDonald, Landay, & Pratt, 2009). Non-exertion mediated interactions can pose unique challenges, but also opportunities, when compared to face-to-face interactions (Preece, 2001; Thurlow, Lengel, & Tomic, 2004). As a result, this interrelationship between exertion and social play is likely to also feature opportunities and challenges. Borrowing from traditional sports might help highlight these challenges: Many sport games feature body contact that is an essential character of the game and maybe even contribute to the social experience. Replicating these body contact experiences in mediated environments is limited by the involved technology, and designers will need to design with these restrictions in mind. An understanding of exertion and social play can support designers in such efforts by providing insights into what aspects of the design should be prioritized while considering the restrictions of the technology.

Mediating exertion games might also benefit an understanding of co-located exertion games. After all, the opportunity to mediate social interactions over computer networks has helped researchers understand co-located social interactions (Thurlow et al., 2004). By looking at how technology design can facilitate social play in mediated exertion games, our understanding of exertion games in both co-located and mediated settings might benefit. However, so far, there is only a limited understanding of how design can support the interrelationship between exertion and social play of exertion games (de Kort & Ijsselsteijn, 2008; Lindley et al., 2008). Moreover, there is a lack of exertion games that could enable such investigations, as most existing exertion games focus on co-located experiences.

1.3 The problem of designing for exertion

Interaction designers who want to utilize the benefits of exertion are faced with a challenge: There is a limited understanding of how to design exertion games (de Kort & Ijsselsteijn, 2008). Researchers benefit from knowing the key elements of exertion in interactive systems, however, they lack a theoretical understanding of the experience. In consequence, there is a lack of guidance for designers on how to support exertion (Hummels, Overbeeke, & Klooster, 2007).

The lack of understanding of how to design for exertion has also affected the games industry. Game review analyses have discovered that game titles that use button-press gamepads receive, on average, higher independent game reviews than those titles that use exertion game mechanics, even if it is the same title (Graft, 2009). Several causes could be attributed to this, however, I believe that one of the reasons might be the designer's lack of understanding of how to grasp the intricacies of the new interaction techniques these games afford, as suggested by Graft (2009) and hinted by the elaborations on the challenges of novel game interactions by de Kort and Ijsselsteijn (2008).

Related areas provide some guidance. For example, interactive dance often also puts the body in the centre of the interaction (Larssen, 2004; Loke & Robertson, 2010). In addition, research of computer games could offer additional insights into the gaming aspect of the interaction (Bogost, 2007a). Lastly, findings from sports science could contribute to an understanding from an exerting body perspective (Weinberg & Gould, 2006). This thesis examines knowledge from these fields and uses it to comprehend the user experience of playing exertion games to arrive at an understanding of how to design these games. With such an understanding, researchers will have a tool that allows them to analyse and compare these games. Moreover, designers will have guidance that supports them to make better games. As a result, users will have more opportunities to profit from the benefits of exertion.

In sum, there is a lack of understanding of exertion games for both researchers and designers. In response to this, this thesis aims to establish an understanding of how to design exertion games with a particular focus on mediating social play.

1.3.1 Hindrances to addressing the problem

There are two key reasons why such an understanding has not been gained so far.

Firstly, there is a lack of empirical studies that could inform such an understanding of exertion (de Kort & Ijsselsteijn, 2008). Several studies have investigated the health outcomes of exertion games (Graves et al., 2007; Lanningham-Foster et al., 2006; Maddison et al., 2007), and some researchers have investigated guidelines for how to design technology so that it is sturdy enough to be used in sports (Chi et al., 2004). Others have designed technology to improve athletic performances (Pope, Kuhn, & Forster, 2009). However, what is missing are empirical studies of the user experience (McCarthy & Wright, 2004) in exertion games. Having such a perspective on the user experience is important, since it is the user experience that draws users to games (Bernhaupt, 2010a).

Secondly, there is a lack of games that support a wide range of social play that could feed such empirical studies. For example, most existing games rely on a small number of commercial input devices that only support a limited range of bodily interactions: They either require riding an exercise bike (Daum, 2008; Electronic Sports, n.d.; Gamebike, n.d.; Mokka, Väätänen, Heinilä, & Välkkynen, 2003; PCGamerbike, n.d.; Tacx, 2009) or focus on specific limb movements that confine the body to a small space in front of a TV (Microsoft, 2010; Nintendo, n.d.-a; Sony, 2010). First of all, most of these games support only single-player experiences, but if they do support multi-player, then they are often not supporting richer social play experiences than race games (Daum, 2008; Gamebike, n.d.; PCGamerbike, n.d.). Moreover, only very few - the exception are Breakout for Two (Mueller et al., 2003) and networked exercise bikes (Daum, 2008; Tacx, 2009) - support distributed experiences that could inform an understanding of how these social experiences unfold when computationally mediated. Having access to a diverse set of games is important, as a one-size-fits-all approach is probably not suitable for exertion games, as there is no universal sport that suits all players. Different people with different bodies enjoy different sports, and the same might apply to exertion games (Moen, 2006). To understand exertion games, it is therefore important to know what different experiences exertion games afford, and to do that, a diverse set of systems are needed that can facilitate these different experiences.

1.3.2 What needs to be addressed

To gain the desired understanding of how to design for exertion, it appears the following needs to be addressed:

- First, an explication is needed for how exertion games, and in particular their support for social play, can be characterized.
- Second, a rich set of exertion games is required to be able to study the interrelationship between exertion and social play.
- Third, an explication of how design can support this interrelationship is needed.

1.4 Focal point

The following section reiterates the focal point of this thesis (Figure 1-1).

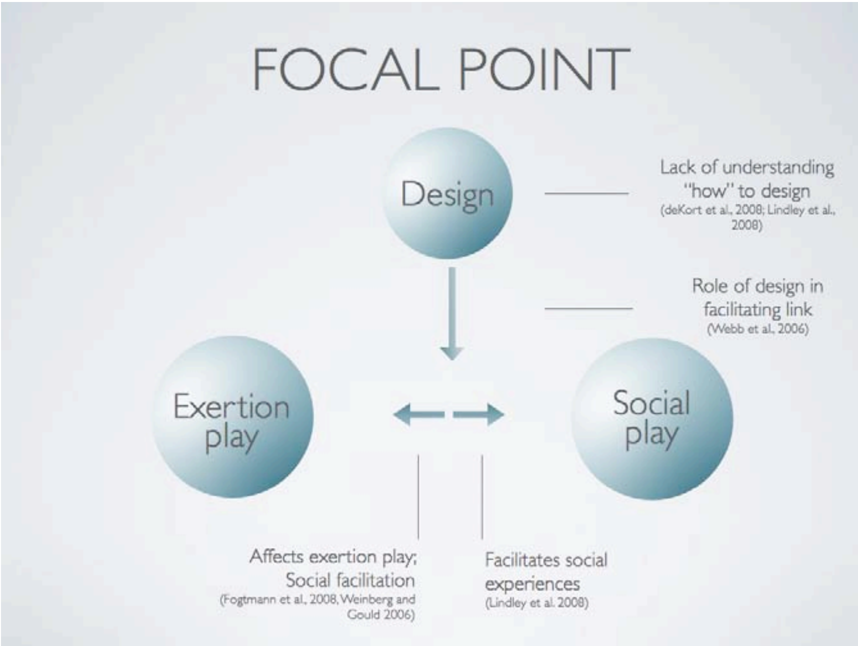


Figure 1-1: Focal point of this thesis

Exertion play is play in a digital game that requires intense physical effort (Mueller et al., 2003). Play can occur outside games (Salen & Zimmerman, 2003a), however, the focus here is on exercise and sports-like experiences that are determined by goals, in line with a widespread definition of games, hence the focus in this thesis is on games (Salen & Zimmerman, 2003a).

Social play is an active engagement with a game by more than one person (Isbister, 2010). As with exertion play, social play lies on a continuum of various levels of social engagement (Frost, Wortham, & Reifel, 2005).

An interrelationship between exertion and social play exists: Investing physical effort in play experiences can facilitate social play (Lindley et al., 2008). Notably, there is also a relationship in the other direction: Introducing social play can affect the exertion experience (Bond & Titus, 1983; Fogtmann et al., 2008; Weinberg & Gould, 2006). This interrelationship between exertion and social play can be facilitated by design, in particular technology design (Webb et al., 2006). However, there is a lack of understanding of how to design for this interrelationship (de Kort & Ijsselsteijn, 2008; Lindley et al., 2008).

The particular focus in this thesis on how to design for this interrelationship is on mediated interactions, as mediated interactions can extend opportunities for social interaction (Thurlow et al., 2004), such as supporting distributed participants (Salen & Zimmerman, 2003a).

The aim of this thesis is to establish an understanding of how to design exertion games that facilitate social play. The resulting understanding aids designers in creating better exertion games, ultimately supporting users in profiting from the associated benefits of exertion.

1.5 Approach

Achieving the aim of this thesis is approached through the following steps:

1. A current understanding of exertion play is constructed by drawing from previous work across related domains, such as from sports and computer gaming. This includes related work on existing exertion games.

2. This understanding is supplemented with an investigation into what is known of social play, for example from child development research.

3. With this understanding, a diverse set of exertion games are designed that serve as research vehicles to be able to develop insights on the user experience when engaging with these games.

4. The user experience gained from three studies of the three games is discussed, resulting in an understanding how design affects the interrelationship between exertion and social play.

5. The insights gained from these investigations result in a theoretical framework that offers an understanding of how to design exertion games, with a particular focus on social play.

6. To demonstrate the utility of the framework, a less abstract instantiation of the framework is constructed and used as design tool in a set of workshops that shows the value for designers when designing exertion games.

1.6 Scope

To focus the contribution of this work, the following is outside the scope of this thesis:

1.6.1 Motivational factors to engage

This research focuses on how design can support the experience of playing exertion games; hence the scope is limited to the immediate game activity. Factors leading up to the activity have been listed previously and supplement this thesis' work. For example, user self-reports suggest that players of exertion games approach exertion games often to achieve weight loss (DeLorenzo, 2007). Some play these games for the enjoyment they offer (Voida & Greenberg, 2009). Psychologists have identified particular persuasive tactics that motivate people to engage in exertion activities (Fogg, 2002; McElroy, 2002). Also, prior work has already demonstrated that technology augmentation can lead to behavioural change (Lin et al., 2006). I acknowledge that the subject of the goals people approach the exertion activity with is an important one, however, this work assumes that the user is already motivated to engage in the exertion experience.

1.6.2 Results beyond the activity

Although exertion game play can lead to health benefits, this thesis does not focus on an instrumental goal of weight loss or on how to design the most effective exercise, although positive health benefits are welcomed. Instead, the focus is on facilitating a more engaging experience through informed design, making the assumption that more engaging experiences lead to enhanced participation, resulting ultimately in more health benefits.

1.6.3 Performance increase

Although performance increase can be beneficial, this research does not focus on isolated exertion achievements. How to utilize technology to maximize individual athletic performance is the domain of sports research (for an overview see for example Dabnichki & Baca (2008)), and such approaches are more suited for the professional athlete who strives for optimal performance above all else. In contrast, this thesis focuses on understanding how to design technology to enhance the experience, making the assumption that enhanced experiences lead to enhanced participation, resulting ultimately in increased performance.

In sum, this research focuses on the immediate exertion experience and how design facilitates it. As a result, motivational aspects that lead up to engagement with this activity, and isolated performance enhancements are outside the scope of this thesis.

1.7 Contributions

This thesis adds to our understanding of how to design interactive technology for the active body, and it does so through several contributions:

1.7.1 Contributions to practice

The main contributions to practice are the insights gained and the implementation details from the design of three exertion games that demonstrate how exertion games can facilitate social play between distributed participants across a diverse set of different exercise mechanics and categories of social play. Furthermore, the three exertion games contribute towards addressing the call by de Kort et al. (2008) who highlight the need for more systems that challenge our perception of the design space from a design perspective. The games function as research vehicle to answer the research question, but also demonstrate additional benefits that technological augmentation can offer to the player, besides supporting distributed participants:

- Jogging over a Distance demonstrates that technology can enable participants of different athletic abilities to jog together (chapter 4).
- Table Tennis for Three demonstrates that technology can support a scaling of player numbers that enables three players to fairly play a table tennis-like game together (chapter 5).
- Remote Impact - Shadowboxing over a Distance demonstrates that technology can be used to reduce the risk of physical harm often associated with traditional sports activities without eliminating the exertion aspect (chapter 6).

1.7.2 Contributions to theory

This research makes the following theoretical contributions:

- This research contributes towards redressing the lamented lack of empirical studies on exertion games (de Kort & Ijsselsteijn, 2008; Moen, 2006) by presenting the first empirically grounded work on mediated exertion games.
- The work makes a contribution to the domain of user experience in games (Bernhaupt, 2010a) by highlighting an emerging trend of games that centre on the human body, extending the current focus on button-press games.
- This work not only expands the view of games beyond button-press input devices, it also contributes to current knowledge on games by demonstrating how the body can be more strategically used to enhance the user experience of games.
- By studying how users engage in exerting interactions with technology, it will be revealed how exertion can be facilitated and supported by technology. In particular, it will be explicated how aspects of technology can facilitate

experiences beyond what is currently possible in sports without technology.

- Methodologically, this work adds an experiential account of how the user experience in exertion interactions can be approached.
- By drawing from both sports and HCI extensively, this research also serves as theoretical bridge between sports and HCI, offering a language that mediates between the two, with the aim of inspiring other approaches that bring these two fields closer together.

1.8 Structure of thesis

The research comprises four key elements: The research background, data collection and analysis, conceptualization of a theoretical framework, the demonstration of its utility, and discussion. Table 1-1 provides an overview of these stages and their main function in achieving the research aim.

Table 1-1. The research steps and their purposes

Research step	Purpose
Research background	
Literature review (chapter 2)	Analyses current literature and identifies gap
Research design (chapter 3)	Describes methods for conducting research
Data collection and analysis	
Game 1: Jogging over a Distance (chapter 4)	Identifies themes for design
Game 2: Table Tennis for Three (chapter 5)	Identifies themes for design
Game 3: Remote Impact (chapter 6)	Identifies themes for design
Conceptualization	

The exertion framework (chapter 7)	Helps to attain understanding of exertion games
Demonstration of utility	
The exertion framework in action (chapter 8)	Demonstrates utility of insights gained in studies through series of designer workshops
Discussion and Conclusion (chapter 9)	Discusses findings and suggestions for future research

Chapter 1 introduced the topic of exertion games and described the interrelationship between exertion and social play. It motivated the research by explicating the benefits of exertion, and offered a structure as to how this research will be carried out.

Chapter 2 begins by providing definitions of key terms used in this thesis. Following this, it critically examines current theoretical and design research approaches that can aid to develop an understanding of exertion in interactive experiences. The chapter also identifies a gap in existing knowledge of how design facilitates the interrelationship between exertion and social play. In concluding chapter 2, this gap is synthesized into the research question that guides the overall direction for the first three studies of this research.

Chapter 3 presents the methods chosen to approach the research question. It describes how the process of designing and analysing exertion games links with the study of their use. This chapter also explains what motivated the three designs and explicates how each one of them offers a different perspective on social play that contributes to the overall understanding of exertion games.

Chapter 4 describes the design of Jogging over a Distance and the associated study. The study investigates the unique challenges and opportunities when supporting social play in exertion games in a race-type scenario. Theoretical themes are derived from an analysis of the user experience of jogging pairs who ran together although as far apart as Europe and Australia. These themes serve as a start for a framework that can be used as a theoretical lens to understand and analyse exertion games with a particular view on social play.

Chapter 5 describes the design of Table Tennis for Three and the associated study. The study investigates how social play emerges when participants' bodies act upon each other, leading to offensive and defensive play as known from traditional table tennis. The themes derived from the analysis extend the framework established in the previous study.

Chapter 6 describes the design of Remote Impact – Shadowboxing over a Distance and the associated study. The study investigates how social play can be facilitated in exertion games where participants contend for control of each other's bodies, as inspired by boxing. The derived themes conclude the framework.

Chapter 7 consolidates the findings from the data gathered in the three studies and presents a framework called "the exertion framework".

Chapter 8 describes a study with designers in a series of workshops that demonstrates the utility of a set of design cards that were derived from the framework, hence strengthening the value of the framework.

The final chapter discusses the results and concludes this thesis. It consolidates the findings from all studies and reflects upon how these findings have responded to the main research question of this thesis. It describes the contributions and details how they built upon and extend theory and practice. Criticisms of the research process are presented with recommendations of how improvements could be made. The chapter closes with suggestions for future research and concluding remarks.

2. Warming up for exertion: Towards understanding the body in social play

This chapter provides a brief review of current theory and system approaches as evident from the literature. Equipped with this, the research question is derived. The review also inspires and motivates the subsequent game designs as well as informs the methods used during the empirical studies.

2.1 Overview of this chapter

I begin by providing some definitions of key terms used in this thesis. Then I provide a critical review of current work:

- In the first section, the role of exertion in human-computer interaction, sports science and games research is examined. The section also offers a brief overview of the history of exertion systems. The conclusion indicates the need to strengthen the current understanding of exertion in interactive experiences, as currently, only fragmented understandings of exertion exist.
- Section 2.4 establishes the background of user experience and why such an approach is particularly suitable to investigate games. The section also identifies a lack of investigation into exertion games from the perspective of the user's experience. However, the review confirms that exertion can be designed for and highlights the inherent social role of the body and the benefits of considering this social role in exertion activities.
- The review of the literature identifies an interrelationship between exertion and social play. Section 2.7 describes how social play has previously been used successfully to facilitate sports activities and hence suggests the need to consider social play when investigating exertion games. In consequence, social play is reviewed.

- In order to provide a more integrated way to approach exertion, the "body lens" is constructed that encapsulates different perspectives of how to see the human body when interacting with technology based on prior approaches towards the body interacting with technology.
- Section 2.8 identifies the advantages of supporting distributed participants, but also the technological challenges due to the exertion involved. The review identifies the need to understand the user experience of participating in these games in order to elucidate just how exertion and social play are intertwined and how technology can facilitate this interrelationship, even when mediated.
- The chapter concludes by identifying the gap that defines the problem for this thesis. It presents the research question that aims to gain an understanding of how to design exertion games, with a particular focus on social play. This question guides each of the systems and studies in this thesis.

2.2 Definition of Terms

This thesis brings together theories and understanding drawn from human-computer interaction, game research and sports research. As such, some terms may hold different meanings in different disciplines. Thus before presenting a critical review of the literature, I will first define key terms relevant for this research program.

2.2.1 User experience

User experience refers to what people experience when interacting with technology, taking into consideration the emotional, intellectual, and sensual aspects of the interaction (McCarthy & Wright, 2004).

2.2.2 Exertion

Exertion is the act or an instance of exerting, especially a strenuous and vigorous effort (*The American Heritage Dictionary of the English Language*, 2000/2000). Although effort can have mental origins, for this thesis, effort refers to the physical effort of the human body.

2.2.3 Game

Many researchers and philosophers have tried to define what precisely a game is; however, no consensus exists (for summaries, see Salen and Zimmerman (2003a) or Juul (2003)). I lean on Suits (in Salen & Zimmerman, 2003a, p. 76) and define a game as a system in which player(s) voluntarily engage in activity towards a goal, using only means permitted by rules, to overcome unnecessary obstacles, and where such rules are accepted just because they make possible such activity. This definition highlights that games are freely entered into, that they have a goal, that playing the game means accepting the rules that prohibit more efficient, in favour of less efficient, means.

Physical activity in sports research has been similarly defined: physical activity is intentional, voluntary movement directed towards achieving an identifiable goal (Newell, in Hoffman, 2005/2008). As a result, exercise activities such as jogging are also considered games for the purpose of this thesis: joggers voluntarily engage in the activity, they strive towards a goal (joggers often have multiple goals, for example beating a personal best and losing weight) and accept rules that prohibit less efficient means (the jogger agrees not to take a shortcut or use alternative transportation).

2.2.4 Exertion game

An exertion game is a digital game that utilizes an exertion interface. An exertion interface is an interface that requires intense physical effort from its users (Mueller et al., 2003), hence an exertion game is a digital game that requires physical effort where the outcome of the game is predominantly determined by this physical effort.

The term "exergame" is often used in industry for systems that combine gaming with exercise (The exergame network, n.d.). I prefer exertion game because it highlights that the physical effort invested directly affects the game outcome, as evident by the reference to exertion interface. For example, running on a treadmill while playing a button-press console game is not an exertion game, although some might call it an exergame. The use of the label "game" also highlights that participants voluntarily engage in the activity, and as a result, this understanding excludes non-voluntary activity such as professional sports and physiotherapy. Although such activities might benefit from exertion games, they fall outside the scope of this thesis.

If an exertion game supports geographically distributed participants, it is an "exertion game over a distance".

2.2.5 Social play

Social play is an active engagement with a game by more than one person (Isbister, 2010). Isbister points out that computer games can support both co-located and distributed social play (2010), where supporting geographically distant players is one of the key advantages of involving computer technology in social play (Salen & Zimmerman, 2003a). Although some believe that interacting with non-player characters in games is a form of social play (Isbister, 2006; Lazzaro, 2008), I, like Isbister (2010), exclude it in my understanding of social play.

2.3 Exertion games

Exertion games are currently probably the most buoyant form of exertion in interactive systems. The field of exertion games surfaced through interactive systems first that designers developed to explore the space, before theories emerged, similar to other emerging areas in HCI such as tangible interfaces (Hornecker & Buur, 2006). In consequence, I begin with a brief overview of the history of exertion games.

2.3.1 Brief overview of exertion games

Several authors (Bogost, 2007a, Chapter 10; Johnson, 2008; Lazarus, 2010; Orland & Remo, 2008; Sinclair et al., 2007) have provided historical accounts of the emergence of exertion games, and the following provides a brief summary of the highlights.

One of the early systems attached to Atari consoles was the Joyboard (Johnson, 2008) that was the precursor to many balance board controllers, such as the Nintendo Wii Balance Board (Nintendo, 2009). Other early systems utilized an exercise bike that controlled an avatar on a bike on the screen (Johnson, 2008). Pads that measured input from feet utilized the same input mechanism later used by Dance Dance Revolution (Behrenshausen, 2007). Bogost argues that many of the early Olympics-inspired games that required intense rapid movements with the joystick can also be seen as facilitating exertion (Bogost, 2007a). Mobile phone based games that are fuelled by exercise have also emerged, they often track people's movement and reward the player with virtual goods for their physical effort investment (S Consolvo et al., 2008; Lin et al., 2006). These games usually focus on the moving body by sensing particular body movements. Other games, such as the biathlon game by Nenonen et al. utilize how the body responds to exercise: the player's heart rate is measured and used as input in a game that requires both raising and lowering it in quick succession to win the game (Nenonen et al., 2007). There are also systems such as Tetris Weightlifting (Tucker, 2006) which utilize interactions with equipment such as an exercise machine that controls a Tetris game. System such as Nintendo's Wii (Nintendo, n.d.-a), Sony's Playstation Move (Sony, 2010) and Microsoft's Kinect (Microsoft, 2010) are newer generations of game consoles that also focus on movement, but with more accurate sensing systems than their precursors.

Having now established the necessary background perspective on exertion game systems, I begin with examining the literature on these games, starting with research that aims to understand computer games via the user experience of playing these games.

2.4 User experience

I begin by explicating prior research that suggests that in order to understand computer games, one needs to understand the user experience players have when playing these games. This perspective is based on an approach by McCarthy & Wright who propose to see people's interactions with technology as one of experience (2004). Human-computer interaction is seen as a creative, open and relational part of experience, pointing to technology's potential to be more than merely functional (McCarthy & Wright, 2004). When HCI was beginning to embrace the idea of user experience, interest by game researchers sparked who became curious if this approach can help them to understand the experience players are having while interacting with a game (Bernhaupt, 2010c). Since then, user experience has been used to understand the subjective relationship between player and game, and HCI and game research have learned from one another, exchanging user experience evaluation methods from HCI and aspects of the gaming experience, such as fun and enjoyment, from game research (Bernhaupt, 2010c). This is not surprising, as games lend themselves to investigations from a user experience perspective, because players are not as much concerned about the outcome as they are about the experience, in particular when contrasted to task-oriented work (Pagulayan et al., 2003). This is a consequence implied by the definition of games that states that players voluntarily overcome unnecessary obstacles. If the outcome would be the main goal, participants would not agree to the rules that set these unnecessary obstacles, as more effective means to reach the goal exist.

In sum, an approach to understanding computer games benefits from a view of the user experience players have when playing these games due to the nature of the game itself. With this approach to games, I now turn to exertion in games by starting to look at exertion in human-computer interaction.

2.5 Exertion in human-computer interaction

The human body and, in particular, exertion has taken on several very different roles over the history of human-computer interaction. Initially, exertion was viewed has having negative connotations in HCI. Early work in the field was focused on ergonomic aspects that saw any restrictions the body imposed as flaws that technology needed to address (Grudin, 2008). The goal was to minimize exertion to reduce injury.

Following that, advancement in computer and sensor technology led to areas such as ubiquitous computing (Weiser, 1993) that allowed for a richer and more positive appreciation of the human body when interacting with the world and technology. However, the computer was often used only as analytical tool to measure bodily movement rather than to enhance the experience (Kidd et al., 1999). Consequently, the third wave of HCI (Harrison, Tatar, & Sengers, 2007) took a more holistic view by embracing the user experience agenda, as inspired by phenomenology, and proposed to see the human body as an integral part of what makes people's experiences in the world (Boehner, Depaula, Dourish, & Sengers, 2007; Harrison et al., 2007).

The tangible interfaces research area is a prominent example of growing HCI research that appreciates specific characteristics of the human body. This research highlights that bodily interactions with physical objects can be computationally augmented, proposing that physical objects have affordances for the human body design should exploit (Ishii, 2003). The results are often systems that focus on the physicality of tangible objects that users manipulate with their bodies (Ishii, 2003). In other words, the body is seen as facilitator to interact with physical objects rather than an active contributor to the experience, for example the fact that the human body might get exhausted when interacting with these objects is rarely considered explicitly.

Tangible interface work has been described as a subset of a larger agenda of embodied interaction, which promises to place the human body in the centre of the investigation (Dourish, 2001).

Here, the argument is that people interact using their bodies, while the action often involves the handling of a physical object. However, the physicality lies in the quality of the interaction, not just within the manipulation of the object (Dourish, 2001), highlighting the movements that lead to the interactions with technology. This focus on the movements of the human body has also played a prominent role in many interactive arts projects (Dinkla, 1994), based on the conceptual ground that movement can stand for "significant human expressions which communicate messages of inner emotions and intentions" (Furht, 2008, p. 281). Human movement has potential to support self-expression, however, the art focus appears to not often leave room to consider the consequences of supporting movement: for example, not many studies have considered injury and exhaustion as consequence of movement with a few exceptions such as the act of falling in expressive dance (Loke & Robertson, 2010) and physical effort in live art (Sheridan & Bryan-Kinns, 2008). It appears that the design of interactive art often assumes that the body can engage seemingly forever with ease, and never gets tired.

The human body and hence exertion has been investigated in HCI previously, although with different intentions and hence from different perspectives: there is focus on injuries, movement and interactions with objects and the world. It appears that each approach highlights an aspect of the body that another does not, however, none seems to capture the full gamut of different perspectives on the human body in exertion interactions with technology. However, a few research works emerged recently that dealt with specific aspects of exertion and games relevant to the research program under investigation here, and they can therefore contribute towards a foundation for understanding exertion games, which will be explored next.

2.6 Understanding exertion games

Larssen et al. found out that increasing physical effort in games can enrich the user experience (Larssen, Loke, Robertson, Edwards, & Sydney, 2004). Research also discovered that participants in exertion games perceived their exertion not as high as without the game, even though their heart rate was the same (Fogg, 2002). Berthouze also found that increasing exertion leads to higher levels of arousal and positive experiences (Bianchi-Berthouze et al., 2007). With all these positive results, it seems surprising that there is still a limited understanding of exertion games. Moen attributes this to the limited amount of empirical studies that investigate these exertion experiences across a range of rich interactions (Moen, 2006). With that, she points to the limited richness existing systems support in their interactions (2006), hindering the development of further insights. This can be attributed to the technological challenges in designing these games: studies of exertion games identified that there are still many technological limitations when it comes to incorporating exertion (Smith, 2005). Such limitations, for example insufficient accuracy in sensing the moving body, can significantly impact the user's experience (Smith, 2005). One way towards better games seems to be addressing the technical challenges, however, another complementary way is to deal with the limitations of the technology by means of smart design (Consolvo, Everitt, Smith, & Landay, 2006; Sunny Consolvo et al., 2008; S Consolvo et al., 2008). Smart design can be guided by theories and conceptual frameworks, however, most frameworks on games so far do not cater for exertion games but assume button-press input devices, for example see the popular theories by Salen and Zimmerman (2003a) and Koster (2004).

Research has also pointed out the opportunities the incorporated technology can offer to the experience. For example, by considering sensing physiological data from the body, designers could create systems that dynamically adjust the difficulty level to accommodate the tiring body (Smith, 2005). Such an approach could provide challenges to the user that are always on the margin of the player's ability, facilitating the emergence of "flow" (Campbell, Ngo, & Fogarty, 2008). A player experiences flow most likely when skill and challenge are matched (Csikszentmihalyi, 1990), and the importance of flow seems particularly relevant in sports to optimize the experience (Jackson & Csikszentmihalyi, 1999). Flow can also occur in computer games (Chen, 2007), hence it seems plausible to assume that appropriate design can also facilitate flow in exertion games.

Using frameworks from traditional, button-press computer games can supplement an understanding of exertion games; however, not having a dedicated exertion framework will prevent designers from utilizing the many benefits of exertion. For example, Larssen et al. found in a study of a camera-based game that players performed movements that were not needed for the game, but were nevertheless suited to the context of the game (Larssen et al., 2004). The authors refer to Bower & Hellstrom's (Bowers & Hellstrom, 2000) notion of expressive latitude that allows for rest and physical performance to explain what happened. Computer gamers do not usually need to rest from physical exhaustion, nor do they commonly perform movements that are not necessary for the game, hence a framework oriented on button-press games would have missed these aspects of the user experience.

Another example why a dedicated framework for exertion can offer benefits is the story of Kickasskungfu (Hämäläinen, Ilmonen, Höysniemi, Lindholm, & Nykänen, 2005; Hoysniemi, 2006). The authors have found that incorporating the moving body allows for new opportunities to map digital representations: they mapped martial arts athletes to virtual characters, however, modified the mapping (Hämäläinen et al., 2005; Hoysniemi, 2006). The virtual avatar was performing exaggerated movements that allowed the athletes to see their movements in a different way, facilitating a learning effect. Such non-uniform mappings of body data offered opportunities that are hard to achieve in real life without the game technology. Without a dedicated framework on exertion, such opportunities are easy to miss.

Bogost's (2007a) work on how exertion games convince people to exercise also points to another difference between exertion games and button-press computer games: In conventional computer games, designers usually build the goal players need to achieve into the game (Pagulayan et al., 2003). Even if there is no explicit goal, such as in the Sims series (Electronic Arts, 2010), the designer of the game provides opportunities for players to create goals that are still imbued with value from within the game. However, in exertion games the context within which exertion games are played can be another source for goals that the designer might need to consider. He found that successful exertion games couple the game's points system with the player's own goals, such as completing an exercise routine (Bogost, 2007a, p. 311). Smith points to additional contextual aspects unique to exertion that might get lost when seen from a traditional game's perspective: he suggests, for example, that designers of exertion games incorporate warm-up exercises to reduce the physical risk of injury (Smith, 2005).

These insights point to the need for a dedicated framework of exertion games in order to capture the specific characteristics of exertion that are lacking in existing theory on computer games. Despite the knowledge gained from individual investigations of specific systems, a comprehensive framework that incorporates the different perspectives of the human body appears to be still missing: for example, Loke et al. tried to understand movement-based interactions and concluded that, although only focusing on movement and not the entire body lens, a comprehensive framework is still missing (Loke, Larssen, Robertson, & Edwards, 2007). One exception is the framework proposed by Fogtman et al. (2008) that aims to reveal the bodily potential in HCI, however, the authors are still planning on empirically informing it. The authors derived it from analysing existing systems rather than from empirical investigations into the user experience; hence their approach is descriptive rather than prescriptive.

2.6.1 Focus on single-player experiences

Most studies on exertion so far only investigated single-player experiences. The decision to focus on one user only in such studies allows concentrating on the exertion aspect, however, this approach misses the interrelationship with social play, and hence might fail to take into account an important element that can help understand how exertion is facilitated. For example, Swetser and Wyeth (2005) propose that social interaction is a key element to facilitate flow in games, and Behrenshausen points to the inherent social nature of Dance Dance Revolution and uses it to explain the success that it is (Behrenshausen, 2007). As a result, studies that aim to inform a theoretical understanding of exertion games might need to consider social play in relation to exertion.

Very few studies investigated multi-user play, however, if more than one user was considered in empirical studies, then the interaction was often not very rich, or not integrated with the exertion activity. For example, many studies on the mobile phone-based exercise systems only supported competitive interactions to determine the winner in a race-like activity: after the activity, participants were given an abstract summary of their exertion activity that they then compared to their partner's (Consolvo et al., 2006; Lin et al., 2006; Toscos, Faber, An, & Gandhi, 2006). Campbell et al. were not satisfied with the social component of commercial systems such as the Nike+ (Apple, n.d.), and hence proposed to facilitate richer social play by integrating a virtual world inspired by massively multiplayer online games. Their game allows for rich social play, however, it is limited by a disconnect afforded by the underlying technology between the social interaction and the exertion activity: in the game, participants first jog, then upload their data to the computer, and only then they can socially interact in the online world (Campbell et al., 2008). This temporal disconnect between when the exercise and when the social interaction occurs means that the participants might miss out on any social effects facilitated by the heightened state of arousal induced by the exercise activity (Hagger & Chatzisarantis, 2005, p. 201).

Studies that investigate social play as part of, rather than in consequence of, the exertion are still missing; hence frameworks lack the opportunity to derive insights from such studies in regards to this aspect.

In sum, more empirical studies are needed that consider social play in exertion games in order to be able to establish a theoretical understanding of these games. In order to establish a background on social play in games, I review literature on social play next.

2.7 Social Play

Understanding social play means understanding the engagement with a game by more than one person (Isbister, 2010). As a result, framing an exertion game as social play refers to the view that the relationships between the players and hence their bodies in the game are social relationships: the players participate in play together, communicating via game play, "in which the game becomes the context for stylized communication, mediated through social interaction" (Salen & Zimmerman, 2003a).

Computer game researchers have begun to structure arguments about the importance of social play (Isbister, 2008; Lazzaro, 2008) and empirically demonstrated differences between solo and social play such as "more positive effect, less tension, and more competence" (Gajadhar, de Kort, & IJsselsteijn, 2008) as well as less frustration (Mandryk, Atkins, & Inkpen, 2006). Isbister argues that playing with others creates a fundamentally different experience, pointing out that many computer games, even single-player games, are often played in social contexts. Based on the insights on the importance of social play in computer games, she proposes that in order to understand social play, it is essential to approach evaluation and iteration from a perspective of supporting social play (2010). She concludes that social play is an important aspect of the player's experience which the research community is only beginning to understand better (Isbister, 2010). Investigations on social play in exertion games will contribute towards this understanding.

2.7.1 Social play and exertion

Given that exertion games resemble sports in a number of ways, it is not surprising that these games can also support social benefits. After all, it is recognized that sporting activities can facilitate social benefits and sports games are associated with team building, bonding and rapport experiences (Weinberg & Gould, 2006). However, sport can also be a trigger for negative social behaviour (Weinberg & Gould, 2006). As a consequence, it would be too simplistic to assume that more exertion means more social benefits. However, although sport is a complex social phenomenon, sports players have learned through the evolution of sport how to utilize the social effects of sports and how to derive social benefits from them into their sports activities (Weinberg & Gould, 2006).

Engagement with sport activities has been demonstrated to benefit from, as well as lead to, social participation. For example, investigations based on social facilitation theory suggest that having others join an exertion activity can contribute positively to the exertion outcome (Cohen et al., 2009; de Kort & Ijsselsteijn, 2008; Lindley et al., 2008; Weinberg & Gould, 2006). Working out together has been attributed with heightened engagement and fun, and it has been described as a facilitator to socialize (O'Brien & Mueller, 2007). Recent exertion studies in high schools found improvements in students' social skills (Ratey, 2008).

These social benefits from sports appear to also apply to exertion games: facilitating exertion in computer games is associated with richer social play (Strömberg et al., 2002; Wakkary et al., 2008), in contrast to the isolated character of traditional computer games (Magerkurth et al., 2004). Furthermore, exertion games are believed to facilitate more social game experiences (Bianchi-Berthouze et al., 2007) because they can facilitate engagement, but also transfer the quality of the game from "hard fun" to "social fun" (Lindley et al., 2008). Lastly, exertion games are also believed to be particularly suitable for a social context (Eriksson, Hansen, & Lykke-Olesen, 2007). In sum, exertion games, similar to sports, seem to afford a social play experience. Given this, the question is now how to design for this.

2.7.2 Designing for exertion and social play

Salen and Zimmerman explain that although social play is an indirect, emergent outcome of players' experiences with a game, and hence social play cannot be directly designed for, a game's design can contribute to the emergence of social play (2003a). Webb et al. take it a step further and argue that affordances for social interactions can be designed for in exertion actions (Webb et al., 2006). Empirical research in exertion interactions suggests that design can facilitate the relationship between social play and exertion (Bongers & Veer, 2007; Lindley et al., 2008; Moen, 2006). De Kort et al. propose that exertion can "radically" impact social play, and that this social play can be designed for (de Kort & Ijsselsteijn, 2008). However, the work by Hoonhout and Fontijn (2008) seems exemplary for the state of the field: the authors designed an exertion game and found that the "source of fun" for their participants was social play, however, they could not explain *how* the design facilitated it. In sum, it seems there is still a lack of understanding of how to design for the interrelationship between social play and exertion.

2.7.3 Categories of social play

In order to understand how to design for social play and exertion, the different categories of social play need to be understood. For instance, prior investigations on exertion games have found that the different social roles of the body should be considered in design as it affects the experience whether participants are acting or observing, competing, co-operating, or co-acting (de Kort & Ijsselsteijn, 2008). Fogtmann et al. (2008) suggest that researchers can expect different social effects in games depending on whether players focus on thwarting opposite players or are merely playing in parallel. Sheridan et al. (2008) and Reeves et al. (2005) have contributed to an understanding of how interactive technology can facilitate the social experience between users and audience, highlighting another important social relationship. It seems design needs to consider different social categories of social play, however, what is still missing is what these categories are.

In order to address this, I investigated if other domains discuss different categories of social play. Research on social play in child development reveals that there are different levels of social play that are reached with increases in age (Frost, Wortham, & Reifel, 2008). Three main categories of social play have been identified that are indicators of social participation, beginning with "parallel play, where the child plays independently, and does not try to influence or modify the activity of the children near her. The child plays beside, rather than with, the other children" (Frost et al., 2008). In later stages of life, children engage in associative play and then cooperative play, where the child begins to play "with other children" (Frost et al., 2008), cumulating in playing organized formal games. Associative and cooperative play is often difficult to differentiate, and as a result, Rubin suggests focusing on two broad categories of social play: parallel and group play (2001).

The notion of parallel play is also used in physical education research, where Vossen uses it to explain the social characteristics of different sports (2004): She proposes that most sports activities can be seen as either a parallel or non-parallel form of social play, where non-parallel play is her equivalent for group play. Vossen says that in parallel play, each player performs his or her exertion actions independently from one another. The players have no direct influence upon the difficulty of the task faced by other players, as they cannot directly interfere with one another. Fogtman makes a similar distinction for interactive systems, differentiating between joint and opposed bodily interactions: she found that in non-parallel play players are thwarting other players (Fogtmann, 2007), whereas in parallel play, they are not.

Colloquially, the word "sport" is mostly associated with non-parallel activities, whereas "exercise" or "race" is reserved almost exclusively for parallel activities. An analogy in traditional sports would be a track and field 100 meters race (parallel) in contrast to a wrestling match (non-parallel). In the 100 m race, the players' bodies cannot directly influence one other, in fact it is the rules of the game that prevent such interference: the white line between the lanes marks separate physical spaces for the runners. In contrast, in a boxing match, for example, the participants' bodies share a physical space, and contention for this shared space with their bodies is a key aspect of the game.

Vossen (2004), Rubin (2001) and Frost et al. (2005) agree that social play lies on a continuum, yet has specific categories. The continuum ranges from no social play to rich social play. Two broad categories have been identified previously: parallel and non-parallel play. The categories mark important areas on the continuum, but have porous boundaries rather than being discrete.

The continuum details how social play becomes *richer* towards one end. For example, parallel play is social play, however, non-parallel play is richer social play. Frost et al. says that "more social categories of play" exist at the positive end of the continuum, explaining that these categories only occur later in the development stages of a child because they require more advanced levels of understanding of how social play unfolds (2005). As a result, further to the positive end of the continuum indicators of social participation increase.

It should be noted that one could identify a zero-point on the continuum where there is no social play, as there is a lack of social participation. The continuum therefore characterizes the essential difference between the concepts of non-social play and social play. It highlights if players are playing "alone" or "together", and if together, to what degree. In other words, the continuum can help understand how design can move from "playing alone" to "playing together".

An example of a game from traditional sports that highlights that social play lies on a continuum that has a blurry boundary between parallel and non-parallel play is tennis. In tennis, the players are not directly influencing each other, as in the boxing example. However, they influence each other through a mediating object, the ball. In tennis, the players' bodies are not sharing the same space; the net marks a physical separation of the spaces the bodies are allowed to occupy. The ball, however, traverses the spaces, and the players aim to control the ball across these spaces. As such, tennis enables richer social play than jogging together, but is also a different social play experience than boxing. This resonates with findings on social play with children around objects: the sharing of objects has been identified as an important step towards richer social play, however, richer forms still exist (Frost et al., 2005).

It is important to note that the proponents of the continuum do not suggest that richer social play is always desirable. Such an argument would be as fruitful as trying to argue to a jogger that a boxing match is superior as it offers more opportunities for social interaction. Different exertion activities are for different people, and the continuum is meant to help seeing these differences in terms of social play.

2.7.4 Bodily reciprocity

Rubin suggests that there is a spatial aspect to social play: the spatial relationships of the bodies involved facilitates different forms of social play (2001). This is not surprising when considering sports: in a 100 m race, the participating bodies are physically separate, in a wrestling match contact is one of the key characteristics. It seems therefore reasonable to look at social play in exertion games from a perspective of bodily reciprocity. Bodily reciprocity is the degree to which bodies depend on one another, and richer opportunities for bodily reciprocity means richer opportunities for social play. In a 100m race, the participants' bodies do not depend on one another as much as they do in a boxing match, and as a result, boxing affords richer social play.

There are other ways to support rich social play besides bodily reciprocity, for example, joggers can use language to make their jog a rich social play experience (O'Brien & Mueller, 2007), encouraging each other to run faster. However, as the focus of this thesis is on exertion, bodily reciprocity is of primary interest.

2.7.5 Bending the rules moves games along the continuum

The rules of the game most often clearly determine where on the continuum a game is located (Vossen, 2004). However, players "bend" these rules, resulting in play experiences that shift the game's location on the continuum. Whether people are playing sports (Weinberg & Gould, 2006) or computer games (Consalvo, 2007), there are players who cheat or bend the rules. Such bending of the rules affects where the game is located on the continuum. For example, although the rules explicitly allow only parallel play, players might try to exploit non-parallel play behaviour to gain an advantage in the game: bicycle or running events are parallel activities according to the rules (the athlete's body cannot interfere or obstruct another athlete). However, it is no secret that athletes use their bodies (elbows) and their competitors' bodies (wind resistance) to gain an advantage in the race, maybe even cutting one another off when going around bends. This shift of social play along the continuum is a display of a human characteristic quite prominent in exertion activities: the desire to maximize one's athletic performance even if it means to "stretch" the game's rules and incorporate non-parallel behaviour. Such investigations show that the game, by means of the rules, but also players themselves by bending these rules, facilitate enriched social play experiences.

2.7.6 Current exertion games along the social play continuum

The continuum of social play allows categorizing existing exertion games. Many exertion games available at the time of writing are featuring no social play, as they are designed for single users only. The games that support social play mostly only offer race-type parallel play. The typical Wii setup explains why: players are occupying separate spaces in front of the TV, not interfering with each other, the bodily reciprocity is similar to one of a 100m race. In other words, current exertion games facilitate only a limited social play experience (Fogtmann, 2007; Moen, 2006), especially when compared to the richness of social play commonly associated with traditional sports.

In summary, exertion games can facilitate social play, and this social play lies on a continuum ranging from no social play to rich social play, with parallel and non-parallel play being two broad categories. However, there is also a distinction between activities that are contending for a ball and activities without a mediating object. Games that share characteristics of what is colloquially described as a race tend to be located towards the parallel play end of the continuum. A category of richer social play is non-parallel play that can be characterized by an increased bodily reciprocity between players. Such an understanding of the social play continuum becomes particularly important when the bodily interactions between participants are to be mediated by technology.

2.8 Mediating social play

Eriksson et al. have described the ability to support distributed participants as one of the key challenges in regards to the body in interactive systems (2007). However, as the ability to support players who are geographically apart has been hailed as one of the key advantages of introducing computers to games (Salen & Zimmerman, 2003a), the introduction of exertion should not eliminate this significant benefit of the involved technology.

There are many benefits for supporting distributed participants: enabling network has the potential to enhance people's participation level, as research suggests that finding the right exercise partner is not always easy (O'Brien & Mueller, 2007; Weinberg & Gould, 2006). Furthermore, the lack of exercise partners can negatively affect participation levels (O'Brien & Mueller, 2007; Weinberg & Gould, 2006).

Prior work on exertion games and social play has mainly considered co-located participants (Ahn et al., 2009; Fogtmann, 2007). By promoting the use of networking technology participants could be located anywhere while still enjoying the benefits of exertion. Networking advances can also offer the benefit of expanding the range of available participants, helping people to find suitable exercise partners and enabling social play with friends and family far apart. Additionally, traditional computer games have already embraced social play through networked systems (Salen & Zimmerman, 2003a). Exertion games might therefore benefit similarly from the advantages of networking technologies. However, two challenges lie ahead when mediating exertion games over computer networks: Firstly, there are technical challenges. By looking at the social play continuum, it becomes apparent how with increased richness of social play the technical challenges might increase: for example, in a 100 m race, the runner's bodies do not depend on one another much; hence mediating such an interaction over a computer network is a different technological challenge than a boxing match, where bodies are contending with one another. Secondly, as mediated interactions can have distinct advantages and disadvantages when compared to face-to-face interactions (Thurlow et al., 2004), it is not obvious if the social benefits attributed to co-located exertion games are necessarily also applicable in mediated environments, hence dedicated investigations into mediated social play are needed.

2.8.1 Exertion games over a distance

Designers have explored the space of mediated exertion games with several systems in recent years. Many of those utilize an exercise bike connected to the Internet that allows racing another player, who uses an identical bike in another location, by means of seeing each other's avatars on a virtual bike track (Daum, 2008; Pantometrics, 2009; Tacx, 2009). The race character of the activity makes it a typical parallel play activity. Others have developed jogging and power walking support systems that allow exchanging progress reports after the exercise such as comparing how many calories were burnt via text messaging and alike (Anderson et al., 2007; Apple, n.d.; Consolvo et al., 2006; Sunny Consolvo et al., 2008; S Consolvo et al., 2008; Lin et al., 2006; Toscos et al., 2006). These are also parallel play activities, where the social interaction often only occurs after the exercise at the user's home computer where the data needs to be uploaded, separating exertion and social play temporally.

Only a few systems facilitate social play experiences different to parallel-play races, including Breakout for Two (Mueller et al., 2003) and the system by Yim & Graham (2007). Yim & Graham developed a game that can be played online in which the avatars can experience social interactions in a virtual world (Yim & Graham, 2007). These authors claim their design can facilitate rich social play despite the exercise bike mechanic that facilitates a race character of parallel play due to the virtual world interactions. However, an evaluation of the social benefits is still outstanding. In sum, there is still a lack of guidance on how design can facilitate the interrelationship between exertion and social play (de Kort & Ijsselsteijn, 2008; Lindley et al., 2008; Shinkle, 2008), especially when mediated, as computationally augmented exertion is a relatively new phenomenon.

I have now concluded the brief review of current theory and system approaches from the literature. As part of this, I have identified that prior work has examined different perspectives of the human body when interacting with technology, however, a consolidated view is still lacking. As a result, I will now construct such a view in the form of the "body lens".

2.9 The body lens

Prior work has explored the human body when interacting with technology previously: research dealt with physiological responses of the body, movement, interactions with objects and even social play amongst bodies via bodily reciprocity. However, no approach seems to capture the full gamut of different perspectives on the human body in exertion interactions with technology. In order to address this, I construct such an encompassing view on the human body that allows a dedicated focus on exertion. I call this conceptual construct the “body lens”, which consists of four different perspectives from which the body can be viewed, inspired by the different approaches in the literature.

The goal with a consolidated view on the human body in interactive experiences is to have an analytical lens through which to see the investigations on exertion games that will follow. This view will also serve as aid to develop a language that can help expressing how designers can approach the body with interactive technology by offering conceptual handles towards the exerting body. The body lens begins with the fundamental and central role that the body plays when it comes to exertion.

2.9.1 The layers of the body lens

This body lens leans on a framework from Jacob et al., which aims to explain new interaction styles that rely on the human body and its interactions with non-keyboard controlled devices while considering contextual factors coming from the environment and social others (Jacob et al., 2007; Jacob et al., 2008). The authors’ proposed four-layer view was used successfully to analyse new systems that featured the human body, suggesting that with four layers, a reasonable compromise was found between sufficient detail and enough abstraction power. As a result, the body lens is also structured around four layers, which are folded around the human body (see Figure 2-1).

The individual layers of the body lens are inspired by van Manen’s phenomenological approach to the analysis of “lived” experience in terms of corporeality, temporality, spatiality and relationality (Van Manen, 1990). This approach emphasizes how both corporeality and temporality, or the body and change, are at the very heart of people’s experience of exertion. I call this layer the view of the *responding body*. In the second layer, temporality and spatially are combined in the *moving body* – moving causes a responding body, however, a responding body might not necessarily imply movement. Movements are related to the surrounding layer of the *sensing body*, or how the body perceives and acts within the hybrid physical and virtual environments of exertion games. The outer layer of the *relating body* is borrowed directly from van Manen, and encompasses the ways in which bodies can relate to one another when mediated by digital technology. Together, these layers create a body lens of four complementary perspectives on the exerting body.

The priority is not how these layers overlap (for example, the moving and sensing body is often integrated (Moen, 2006)), but how the lens can help researchers and designers see the body.

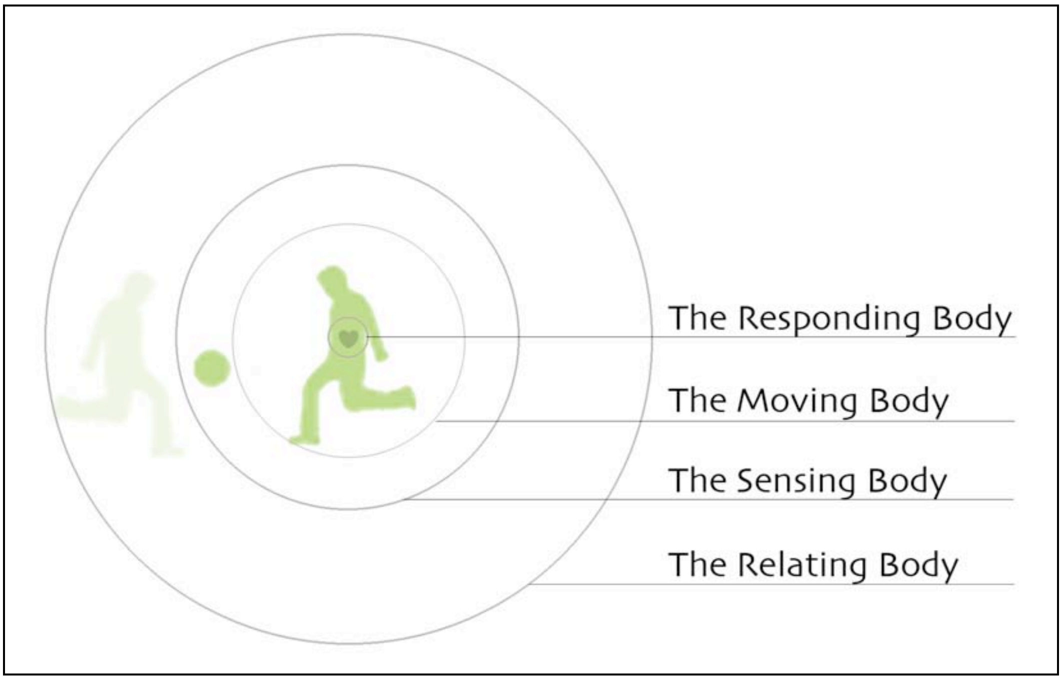


Figure 2-1: The body lens for exertion interactions

2.9.2 Layer 1: The responding body

The responding body is a view of the body "from the inside", and how the body's internal state changes over time as a result of the exertion it is subjected to. It is concerned with what exercise physiology describes as the body's response to exercise (Plowman & Smith, 2007). This is the innermost layer of the body perspective: any activity from outer layers necessitates a physiological response from the body.

The body reacts to physical activity by responding internally in a way that maintains balance, or homeostasis (Plowman & Smith, 2007): the user's heart rate typically increases, breathing becomes more frequent, and sweating occurs. These are consequences of exercise the user has not consciously initiated, but is usually aware of. Other changes such as fuel mobilization and enzyme actions occur unconsciously.

The body responds not just in anticipation of and during exertion, but also after such activities. For example, the body might lose weight, develop increased muscles, repair broken tissue, and so forth. These are all responses that continue to develop and persist beyond the "magic circle of play" (Salen & Zimmerman, 2003a), that is when the game ends. The body's response can facilitate positive or negative experiences for the user beyond the experience: for example, the body might release endorphins, facilitating an athlete's "high" (Cohen, Ejsmond-Frey, Knight, & Dunbar, 2010), or users might experience pain through muscle soreness or injury.

Interaction designers have previously utilized the responding body layer as input for games, for example by using heart rate (Nenonen et al., 2007) and EEG (electroencephalograph) feedback (Kuikkaniemi et al., 2010) as control mechanisms. Successful performance in such games is not likely to be determined by strategy only within a game, but exertion behaviours spread across and between many games. This is in line with both Moen and Sheridan et al.'s view that technology should help participants learn more about their body and how its capabilities are transformed by exertion (Moen, 2006; Sheridan & Mueller, 2010).

2.9.3 Layer 2: The moving body

The moving body focuses on participants' muscular repositioning of body parts relative to one another during the course of physical activity. This view highlights movement characteristics such as intensity (movement can carry "weight"), continuousness (movement exhibits preparatory and follow-through phases) and variety (the richness of human movement) (Moen, 2006). Prior research on movement has helped to identify these characteristics, and the dance perspective the researchers took has highlighted the expressive power of the body (Loke et al., 2007; Moen, 2006), lending itself to performative interaction (Sheridan & Bryan-Kinns, 2008) that involves an audience (Reeves et al., 2005).

A view on movement also highlights the potential of exploiting the kinaesthetic sense or proprioception, which governs user's awareness of the position of body parts (Moen, 2006). Moen calls it a "bodily intelligence" that allows people to react intuitively without having to think about every single movement (2006). This kinaesthetic sense has been described as underexplored in HCI (Fogtmann et al., 2008; Moen, 2006), and a dedicated view on the moving body is a response to this.

2.9.4 Layer 3: The sensing body

The sensing body describes how the body is sensing and experiencing the world that it impacts and is impacted by. In the world of sports, many popular games involve objects, ranging from simple balls in soccer to very specialized equipment in cycling, which aid and shape the exertion activity. The physical and technological environment also shapes the activity – playing in a big stadium is not the same as playing on a local pitch, even though the size of the pitch is the same (Van Manen, 1990). The sensing body view therefore aims to offer a contextual perspective, highlighting the body and its interactions with the world. This perspective differentiates exertion games from conventional sports in that the world of exertion games consists of both physical and virtual objects and spaces. Adding virtual objects and spaces creates even more opportunities for exertion game design, since participants must navigate the additional challenges of a hybrid space (Benford, Giannachi, Koleva, & Rodden, 2009).

In response to the sensing body, Hornecker has suggested utilizing non-uniform relationships between the body and the virtual world to exploit the use of technology (Hornecker & Buur, 2006). An example for this is the mapping of the Wiimote controller in the various tennis games: in Wii Sports Tennis (Nintendo, n.d.-b), almost any arm up-down movement is mapped to a successful tennis serve in order to engage beginners. On the other hand, in Wii

Grand Slam Tennis (EA Sports, 2010), the movements are mapped differently due to a different sensor attached to the Wiimote, making successful serves more difficult in order to engage more experienced players.

2.9.5 Layer 4: The relating body

The relating body offers a view on the bodily interactions that occur with other bodies as part of the exertion activity. The relating body therefore points to bodily reciprocity, highlighting how the interdependence of bodies can facilitate social play.

How bodies relate to one another has been previously highlighted by sports research: Social facilitation theory suggests that people engaging in sports with others can improve their athletic performance (Hagger & Chatzisarantis, 2005), while studies have shown that athletes exhibit a higher tolerance to pain when exercising together (Cohen et al., 2009). Different bodily relations exist, for example Sheridan et al. point to a wide variety of roles such as co-players, opponents and audiences (2008). These roles are also of significance beyond the game, as joint exertion can contribute positively to social outcomes (Lindley et al., 2008; Strömberg et al., 2002; Wakkary et al., 2008). The relating body perspective highlights how bodies affect each other in exertion interactions.

In sum, the body lens can be seen as a response to the previous fragmented approaches to the human body: while prior works mostly focus on one particular layer, the body lens highlights that exertion is about the responding, the moving, the sensing and the relating body as a whole.

A body lens that provides structure on how the body in exertion interactions can be viewed helps to see exertion games from different perspectives, which aids the development of the argument made in this thesis. Having reviewed the literature and constructed a guiding lens, I can now outline the research question that informs a suitable research agenda.

2.10 Research question

The review of the literature found that although HCI, games research and sports studies have investigated technology design, the human body and social play, an integrated picture of how technology design can support exertion is still lacking.

This has been attributed to the following factors:

1. A lack of engagement with the interrelationship between social play and exertion, for example most exertion game studies only investigate single-player play.

2. A lack of systems that enable investigations into rich social play experiences.

3. A lack of empirical research that can provide insights into the user experience of exertion games, in particular exertion games over a distance.

The exertion games developed as part of this thesis will contribute to factor 1 and 2. Empirically-grounded studies of these games will contribute to factor 3.

So far, no work has been done to establish an understanding of how to design for the interrelationship between exertion and social play, in particular when mediated. As a result, in order to address this gap, the research question as surfaced from the literature review is:

How can design facilitate social play in exertion games, in particular when mediated?

This research question is approached with a view on the design of exertion game systems that mediate social play in order to support distributed participants. By investigating the opportunities, but also challenges of mediating social play within the constraints of current technological limitations, I believe a more comprehensive picture of social play can be painted, whether social play is co-located or distributed. As a result, the findings should also be valuable for co-located exertion experiences; however, the focus of this thesis is on mediated exertion games.

2.11 Conclusion

The chapter has uncovered the call to extend and enrich the understanding of the role of the body when interacting with technology. The chapter also indicated that an effort to establish an understanding of exertion in games and its interrelationship with social play could contribute towards addressing this call. As a result, this thesis aims to establish an empirically grounded understanding of social play in exertion games.

The following chapter will explain and describe how I will approach the gaps in order to answer the research question. First, I will explain the choice of a holistic view on designing exertion games, before detailing why the games as presented in this thesis were designed in their particular ways in order to address the research question. Lastly, I will describe the methodological underpinnings of the studies undertaken. These studies will contribute cumulatively towards an understanding of how to design for social play in exertion games and in doing so add to an enriched knowledge of the body when interacting with technology.

3. Ready, set, go: Methods

3.1 Introduction

This chapter presents my research approach. It begins by explaining why a holistic view on exertion games is taken which considers the sum of the elements of exertion games to be bigger than the individual parts. Next, the chapter presents the need for novel exertion game prototypes and details their role as research vehicles to drive the individual studies of the thesis. This chapter ends with justification of why particular methods were chosen for each study and why they are appropriate for the various empirical investigations in order to answer the research question.

3.2 A holistic view of exertion games

I begin with the stance that exertion games are more than the sum of their parts: I believe that simply adding exertion to a computer game or incorporating a computer game to an exercise machine does not utilize the full potential of exertion games. This theoretical stance emerged out of engagement with philosophical worldviews such as phenomenology and embodied interaction and formed my basis for the methods I chose to approach the research question with. The following elucidation will explicate how I arrived at this theoretical stance.

3.2.1 Phenomenology and embodied interaction

Research in HCI has built upon phenomenological investigations that see the mind, the body and people's interactions with one another as complexly intertwined: early on, Winograd and Flores stressed the social aspect of meaning-making when interacting with the world using computing devices (1986), pointing at the existence of a social component inherent in our bodily interactions. Dourish sees embodiment as both physical and social as the features of technological systems are related to the features of social settings (2001). His notion of embodiment has been described as “an approach that involves leveraging users’ natural body movements in direct interaction with spaces and everyday objects to control computational systems. Philosophically, the approach is based on a phenomenological paradigm that emphasizes the role of action, perception and experience in meaning making” (Antle, Corness, & Droumeva, 2009). The idea of leveraging movements in interaction with spaces and objects appears to lend itself quite well when aiming to understand sports-like interactions in exertion games.

Wright agrees with Dourish that embodiment is both a physical and a social phenomenon: “Embodied interaction is the creation, manipulation and sharing of meaning through engaged interaction with artifacts” (2008). However, Wright also notes that although “Dourish acknowledges both the physical and the social aspects of embodiment, he does not explore how these interrelate” nor how designers can design for them (Wright, 2007). Bellotti et al. (2002) wanted to address designers and proposed that such a worldview can be practically applied to the development of interactive technology, the authors give as an example that looking at the body in human-to-human interactions can inform the design of sensing systems.

Phenomenology has not only been a worldview in human-computer interaction, it has also informed investigations in sports. Allen-Collinson has investigated traditional sports activities and found that phenomenology offers a powerful framework for an analysis of the “lived sporting body” (2009). She calls for more work in this area, believing that an embodiment perspective in sports “re-awakes ourselves to the idea that we are beings who live with and through bodies” (Kim 2001, p. 69, in Allen-Collinson, 2009). A phenomenological worldview has also been used to describe how human beings can excel in very fast sports that defy an analytical approach to the activity due to the rapid movements involved: Sutton proposes that we do not think when doing sports, but act first, then think second. He proposes that skiing is not about knowing physics; otherwise, to become a good skier, one would need to master Newtonian physics (2007). He uses Merleau-Ponty’s words to explain that when engaging in sports, “we merge into this body which is better informed than we are about the world" (Sutton, 2007).

Such a worldview has also previously been used in investigations of exertion games: Behrenshausen has demonstrated the utility of phenomenology for exertion games through a study of Dance Dance Revolution (2007), Tanenbaum identified a ludic, kinaesthetic, and narrative experience in the Rock Band game by leaning on phenomenology (Tanenbaum & Bizzocchi, 2009), and Larssen also used a phenomenological worldview to approach the study of human movement in games as one of performance (2004).

3.2.2 A holistic design approach to exertion games

The embodied perspective sees the mind, the body and interactions with others as mutually intertwined. So if a player engages with an exertion game, the experience should be one that is inseparable from the human body and interactions with other social beings.

Taking such a worldview on embodiment and user experience has implications for how design needs to unfold. This means that for exertion game design the creative process of designing the game cannot be separated into independent tasks, assembled together only at the very end. In other words, an exertion game should be seen, and hence designed as, an integrated whole. For example, if a game publisher with such a worldview were aiming to create a new exertion game, then this person would assemble a multi-disciplinary team to create an exertion game together. Without this worldview, the publisher might instead assign individual components to isolated specialists: an artist could work on the graphics, a physiotherapist designs the mechanical input device, and so forth, and in the end, they meet and assemble their works together. This latter, more positivistic approach is not uncommon, as it can have practical advantages for implementation. For example, the commercial "Gamersize" (Gamersize, n.d.) product appears to have been developed with such a worldview (see Figure 3-1).

Figure 3-1: The Gamersize system requires exercise to turn the game console on Picture credit to Gamersize, Richard Coshott. Printed with permission.

The Gamersize is a foot-stepper exercise equipment that connects to any of the major game consoles. If a player exercises on the foot stepper, the console becomes "active" and the player can play any game title using the conventional gamepad controller supplied with the console. However, if the player stops exercising, the Gamersize stops the console in order to motivate the player to keep on exercising.

The Gamersize system is one of individual components that are only loosely integrated, suggesting an underlying positivistic approach to exertion games. The game is predominantly controlled with a gamepad while the foot stepper only functions as on/off switch. Moreover, the speed of the foot stepper does not affect the game, meaning the game character on the screen does not run faster if the player exercises faster on the foot stepper. The advantage of this approach to exertion is that the exercise hardware is independent from the game, allowing players to play a wide variety of games without additional development cost.

Some researchers appeared to have also adopted a positivistic approach when analysing exertion games. For example, Sinclair et al. propose a dual-flow model to analyse exertion games, separating the “attractiveness of the game” from the “effectiveness of the exercise” in order to understand the individual components better (2007). Their approach would be well suited to analyse the Gamersize system above.

Unlike these approaches, I take a holistic worldview on exertion games, where the game, the exertion, and social play are intertwined and mutually engaged, based on the philosophical stances of embodied interaction. This worldview informs the methods that I chose to answer the research question.

3.3 Research question revisited

With this worldview in mind, I repeat the research question:

How can design facilitate social play in exertion games, in particular when mediated?

This research question sets the aim of the thesis and guides the direction of the research undertaken. The individual systems and studies will contribute cumulatively to answering this main question.

3.4 Methodology and methods

Methodology is the analysis of the assumptions and principles in a particular approach to inquiry, and as such encompasses methods (Neuman, 2006). Methods are “sets of specific techniques for selecting cases, […] gathering and refining data, analysing the data and reporting on results” (Neuman, 2006, p. 2). With this differentiation in mind, the next couple of paragraphs describe how I chose my methodology and any associated methods. I began by looking for guidance from my research question.

3.4.1 Guidance from research question

My thesis research question explores the emergence of social play in exertion games. Social play can be supported by design, however, it arises through the players themselves (Salen & Zimmerman, 2003a). Engaging in play, and hence engaging in social play, is a choice a player makes (Pagulayan et al., 2003), where the player is interested in the outcome of play, but also in the play activity itself. The player wants to know the score at the end of the game, but the experience of playing to achieve this score is also of importance. This is particularly pertinent when contrasted with more traditional HCI tasks such as word processing where the outcome is more important. With word processing, the outcome is of uttermost importance. In games, the experience of playing has also a high priority. So if the experience in gaming is important, and this experience facilitates social play, it can be concluded that an investigation into social play should understand the user's experience in these games and how the game facilitates this experience.

Another popular approach to investigate games in HCI is to look at the game's outcome for the participants. Such an approach has already been used to demonstrate that social play in computer games can occur, and provided the community with numerical data on how much people's perceptions and bodily responses change when playing with others (Gajadhar et al., 2008; Mandryk & Inkpen, 2004). For example, research has demonstrated that playing a computer game against a friend results in different physiological responses than playing against the computer (Mandryk & Inkpen, 2004). The authors say that experience-centred research does not have methods that are sufficiently robust for this context (Mandryk & Inkpen, 2004). However, what is difficult to achieve with such approaches is an understanding of the experience players have, and in particular how the design of the game facilitated this experience.

It therefore seems imperative to investigate the experience players have with exertion games. A view on experience in games acknowledged that games are good instances of how technology can support experiences (Bernhaupt, 2010b). The user experience in games can therefore be seen as a subsection of the larger agenda that is concerned with technology as experience (McCarthy & Wright, 2004). Such a view on technology as experience lends itself to certain methods, in particular interpretive and qualitative methods, which I will explain next.

3.4.1.1 Interpretive perspective

"All research […] is based on some underlying assumptions what constitutes 'valid' research […]" (Myers, 1997). It is therefore important to know what these assumptions are. My philosophical assumption about knowledge and how it can be obtained is an interpretive one.

"Interpretive researchers start out with the assumption that access to reality (given or socially constructed) is only through social constructions […] studies generally attempt to understand phenomena through the meanings that people assign to them" (Myers, 1997). This focus seems to be suited for a research question concerned with social play and the experience of it in games. Myers further explains "the philosophical base of interpretive research is hermeneutics and phenomenology" (1997). This philosophical base matches the holistic approach to exertion games mentioned in the previous chapter. In sum, these insights led me to choose an interpretive perspective.

3.4.1.2 Qualitative research

Qualitative research enables "researchers to study social and cultural phenomena" (Myers, 1997), and McCarthy and Wright argue that qualitative research is advantageous when it comes to understanding technology as experience (2004). As this thesis is concerned with how design can facilitate a game experience, qualitative research will provide a deeper understanding. Moreover, as this thesis investigates social play in games, and qualitative research is particularly suited to capture the social capabilities of humans (Myers, 1997), it seems the most fitting approach to tackle the research question.

3.4.1.3 Direction of theorizing

I approach the building of my theory in an inductive direction. This direction of theorizing begins with specific observations of empirical evidence in order to generalize and build towards increasingly abstract concepts and theoretical relationships (Neuman, 2006, p. 60). The inductive approach was chosen because the empirical world is observed first and then it is reflected on what is taken place, “thinking in increasingly more abstract ways and refining ideas while moving toward theoretical concepts” (Neuman, 2006, p. 60). In the context of this thesis, this means that observations of participants’ use of the games build towards more abstract thinking about the theoretical concepts that describe the experience. However, as the qualitative research style emphasizes an ability to draw on a variety of approaches where there is fit (Neuman, 2006, p. 158), I was also open to any theorizing in the opposite direction, starting with existing knowledge I gained from my own research and the literature. As Neuman points out: “In practice, most researchers are flexible and use both approaches at various points in a study” (2006, p. 59).

3.4.1.4 Grounded in data

I approach the research question with a grounded theory-inspired method. Grounded theory (Strauss & Corbin, 1998), as a method, aids in developing “theory that is grounded in data” (Myers, 1997). As the aim of this thesis is a theoretical framework based on people’s experiences with games, borrowing from this method seems to be supportive in achieving this goal.

Inspired by this method, I used a systematic set of procedures to develop and inductively derive theory about my phenomenon. Similar to many other research projects that utilized grounded theory approaches, this research also includes making comparisons of empirical observations (Neuman, 2006, p. 60); here it is the set of studies around the exertion games. Lastly, the fact that grounded theory benefits from continuous interplay between data collection and analysis (Myers, 1997) makes it also suitable for an approach that includes prototypes: as the prototypes were iteratively refined based on data through exposure of the system to pilot users, they emerged out of a tradition that builds on this interplay between data and analysis.

My approach is not precisely grounded theory, but grounded theory-inspired, because “true” grounded theory benefits from an open mind towards the data (Neuman, 2006), but as I had previously conducted studies on related phenomena (Mueller, 2002), this is hard to achieve. This predicament is recognized even in generic grounded theory approaches (Neuman, 2006). In order to address this, previous research has often reverted to utilizing mixed methods (Bortz & Doring, 2002). Consequently, I also drew from other methods where I saw fit, relating back to the research question, to previous studies and the relevant literature.

3.4.2 Prototypes

In the previous chapter, I have argued the benefits for investigating mediated interactions in exertion games. Moreover, I also detailed that, at the time when this thesis commenced, not many exertion games existed that support distributed play, and the few that existed did not offer a diverse set of rich social play required to successfully approach the research question.

This finding led to the realization that answering the research question can profit from additional exertion games over a distance. I have therefore developed three exertion games in the form of novel prototypes. These games afford different types of richness in terms of social play, being situated on different locations on the social play continuum. All three were developed to support social play between distributed participants. The studies of these games will show whether I have succeeded, and if so, how the design facilitated this social play.

These prototypes function as research vehicles for the studies of this thesis. Each exertion game, together with its associated study, takes on the role of a case as a unit of analysis (Myers, 1997) that contributes to the overall research question.

The goal was to examine many features of a few cases in depth. Neuman suggests to carefully select a few key cases to analytically study them in detail, and as a result, the data gathered is usually detailed, varied and extensive (2006, pp. 40-41). The goal was to use the cases "to connect the micro level to the macro level", supporting the generation of new thinking and theory (Neuman, 2006, pp. 40-41). As this thesis aims to produce new theory in form of a framework, this approach seems to be most suited.

3.4.2.1 Design research

The games developed as part of this research program serve as research vehicles to investigate the research question. As they were designed and developed by myself, they naturally also informed my thinking and contributed to my understanding of the topic.

Klemmer and Hartmann described such a process as reflective practice, where thinking occurs through prototyping: “The epistemic production of concrete prototypes provides the crucial element of surprise, unexpected realizations that the designer could not have arrived at without producing a concrete manifestation of her ideas” (2006). Such an approach has been described as particularly relevant when designing for the moving body: “If you design for movement-based interaction, one has to be an expert in movement, not just on paper, theoretically, but by doing and experiencing while designing” (Hummels et al., 2007). Bongers and Veer also used prototypes successfully in their process of “going from theory to practice and back again” and found it useful when aiming to arrive at a framework (2007).

Zimmerman et al. describe in their “research through design” approach how interaction design researchers integrate the *true* knowledge (models and theories) with the *how* knowledge (technical opportunities demonstrated by engineers) in order to make the *right* thing, a product that transforms the world from its current state to the preferred state (2007, emphases by the authors). In order to evaluate the contribution of an interaction design researcher, they propose to examine the process, invention, relevance and extensibility of the design. Using this set of criteria, it becomes clear how the games developed as part of this research program are aimed to form part of the contribution of this thesis: I will evaluate in the end of this thesis if this aim was achieved.

As such, the process of designing the prototypes created as part of this research program constitutes a complementary method to answer the research question.

3.4.2.2 The challenge with prototypes

I have described how a qualitative approach was selected, fuelled by data coming from studies of prototypes. Furthermore, I detailed why qualitative research is best suited to address the research question, and described why novel prototypes needed to be developed.

However, using a qualitative approach with prototypes poses a few challenges. Firstly, qualitative research is well suited to capture contextual information, and studies often stress that such an approach allows investigating people “in the wild”, rather than in artificial settings such as laboratories. Secondly, such research studies can benefit from observations conducted over long periods of time, sometimes months or even years (Neuman, 2006). This is difficult to achieve with prototypes that involve novel technology. These prototypes are often fragile, expensive, in a constant state of redevelopment, prone to breaking, need maintenance, and so forth. This makes long-term investigations, in particular “in the wild” and over long-periods of time, where these prototypes will be used without technical supervision, very challenging.

This is a common issue with any systems research in HCI. Many researchers have pointed towards the benefits and downsides of developing novel prototypes for research studies, pointing to the compromises interaction designers need to make in this kind of research (Consolvo et al., 2006; Dan R. Olsen, 2007; Landay, 2009; Lau, 2010).

For this thesis, a set of measures were undertaken in order to minimize the shortcomings when working with prototypes while at the same time trying not to restrict the advantages that come with their use:

- Independent use: The prototypes were designed in a way so that they could be used with minimal supervision within practical limitations. Although I was available to troubleshoot any technical complications that might haven arisen during use, participants mostly used the prototypes without intervention or supervision.

- Context: Two of the three prototypes had to be placed in a lab environment due to technical and practical constraints (which will be explained later in detail). However, I tried to create an “in the wild” environment by getting inspiration from environments where such exertion systems could be installed, for example public exercise gyms or social areas. This was done to offer a contextual environment similar to what participants might experience in other settings where such games might be placed.

- Long-term: Due to the complexity and value of the technology, long-term studies over months or even years were difficult to realize. However, in order to gain insights into how people's experiences might change over time, I let participants of Jogging over a Distance, the first prototype, come back and re-use the equipment again as often as they liked, even with other co-participants.

3.5 Data collection and analysis

The research question pursued in this thesis requires rich data that can refer to bodily and social experiences. In order to acquire this data, suitable techniques must be identified. These techniques must consider the playful nature of the experience while being able to capture the technology's influence on this experience. In consequence, I chose video and interview data as the best suited to acquire an account of social play in exertion games.

3.5.1 Data collection

I use video to capture body movements and interactions with technology as demonstrated previously by researchers concerned with the moving body (Larssen et al., 2004; Loke et al., 2007; Moen, 2006). Observing players' bodily actions with video cameras allows to easily slow down, pause and replay body movements in the analysis phase, while it also supports the matching with verbal expressions of the participants.

Interviews have previously been used successfully in order to understand mediated interactions between participants over computer networks, as they provide insights into how users perceive one another and their interactions within the limitations of technology (Harrison, 2009). I therefore also opted for recording interviews and I also took notes during the interview process.

A first review of the video data removed unsuitable footage, such as video with insufficient audio level, and so forth. Then, the videos were imported into qualitative data analysis software. The footage was coded, and, where necessary, any verbal expressions of the participants transcribed along with the time-code of the video.

3.5.1.1 Data gathering techniques

The main data gathering techniques were video recordings of participants engaging in the exertion experience and interviews with the participants. These were varied according to the needs of each study. Where appropriate, additional demographic data through questionnaires was captured. Specifics of the techniques will be discussed more fully in the following sections, but briefly, the techniques for gathering data were:

- Jogging over a Distance: Audio-recordings during the activity, recorded open-ended interviews afterwards in teams
- Table Tennis for Three: Video-recordings during the activity, recorded open-ended interviews afterwards in teams
- Remote Impact: Video-recordings during the activity, recorded open-ended interviews afterwards in teams
- Workshops: Video-recordings during the activity, recorded open-ended interviews afterwards with all participants

3.5.2 Data analysis

Qualitative researchers often use general ideas, concepts or themes as tools for generalizations. This concept formation is an integral part of data analysis and one way to organize and make sense of data (Neuman, 2006, p. 460). I began the task of creating concepts or themes during data collection, while being guided by the research question. An iterative coding process complemented with affinity diagrams was used to identify important themes, ideas and theoretical concepts that emerged from analysing the data.

3.5.2.1 Coding

The coding process was used to reduce the vast amount of data and categorize it analytically. I coded the data in a three-step process in order to impose order on the data and be able to "acquire a higher-level thinking about it" (Neuman, 2006, p. 461). Coding is mechanical data reduction but also analytical categorization of data. Codes are tags for assigning units of meaning, capturing the qualitative richness of the phenomenon (Neuman, 2006, p. 460). In order to "see" and not miss any themes in the data, I followed a basic approach to coding that has roughly three stages as described by Neuman (2006, p. 461).

In the first pass of the data, coding was used to locate concepts in an attempt to condense the data into categories. Aspects related to the research question sensitized me, but I was also open to creating new concepts. I created annotations on segments of the data I found particularly interesting, and wrote down analytic memos during the coding process as reflective commentaries to form a basis for deeper analysis.

The list of concepts I created from the first pass helped identify emerging concepts, and informed the next coding step when the data was viewed again. In this second iteration, the focus was more on the concepts and the relationships amongst them. The initial codes were reviewed and examined before it was checked if some of them could be combined.

In a subsequent pass of the data, the focus was on instances that illustrated concepts. I tried to make comparisons and identify contrasts to support the conceptual coding categories I have developed so far.

Then, the emerged concepts were arranged into logical groups and hierarchical categories were created. The frequencies of the occurrences of concepts were also computed to identify indicators of strong connections between concept and data. Furthermore, the analytic memos were used to link related segments together.

3.5.2.2 Affinity diagramming

I sorted the generated annotations, memos and codes into logical groups to create categories of important elements. Next, I used the analytic memos to form clusters of data and matched it with corresponding annotations and created analytic labels. I condensed these findings further to create key analytic categories. In order to identify links and conceptual levels I placed these themes in a spatial affinity diagram, looking out for whether the results are specific to a particular prototype or exertion games in general. I then described these concepts in more elaborate language to facilitate "thinking through writing" in order to refine them further (Neuman, 2006). The aim was to draw conclusions based on a systematically developed and conceptually coherent explanation of the data.

3.6 Research Design

I conducted a total of four studies. The understanding gained in the first three studies cumulatively fed towards addressing the research question. In the last study, the resulting framework was demonstrated in action. A summary is provided in Table 3-1.

Table 3-1. Research studies

Empirical Study	Data source	Data collection	Exertion game	Purpose	Chapter
One	32 participants Teams of 2	Audio-recording Semi-structured interviews	Jogging over a Distance	Addressing research question	4
Two	42 participants Teams of 3	Video recording Semi-structured interviews	Table Tennis for Three	Addressing research question	5

Three	20 participants Teams of 2	Video recording Semi-structured interviews	Remote Impact	Addressing research question	6
Four	134 participants across 7 workshops	Video recording Semi-structured interviews		Demonstrating the utility of the framework	8

The first three studies allowed an investigation towards the research question from three different exertion game perspectives. The result is a theoretical framework that highlights important themes in exertion games. In order to demonstrate the utility of the framework, the last study elicited feedback from designers on their use of the insights gained from the studies.

Next, I will discuss the overall research design.

3.6.1 Study 1: Jogging over a Distance

3.6.1.1 Audio

Participants' interactions during their engagement with Jogging over a Distance were audio recorded. The participants experienced the activity delivered via headphones, and as the audio was already captured as it was transmitted over the network.

As participants in study 1 were free to choose their own location in which they would like to jog, and also because their partners were on the other side of the world, video recording of their activities was not very practical.

3.6.1.2 Semi-structured interviews

Semi-structured interviewing is a technique most suited to answering the research questions posed in this thesis. This is because of the experience-centred nature of computer games, and interviews are one way of getting behind this experience, as they operate from the perspective that knowledge is situated and interpreted. Such an interview style also allows for follow-up questions, which supports the elucidation of a deeper revelation of a participant's logic, thinking process and frame of reference (Neuman, 2006, p. 287), supporting the idea of understanding being a co-production between the interviewer and interviewee.

3.6.2 Study 2: Table Tennis for Three, Study 3: Remote Impact

In order to capture the involved bodily actions between the participants, a method of observation using video recording was chosen.

3.6.2.1 Video

Video captured participants playing. The recording material included all interactions from entering the game space to leaving it, while it also captured any associated audio. The camera was mounted on a tripod, positioned away from the participant in order not to interfere. When suitable, I also recorded data using a handheld camera in order to be able to focus on particular aspects of the interaction.

The advantage of using a video camera was that I was able to gather vast amounts of both video and audio data. As participants interacted via the videoconference, the remote actions were also captured.

Participants were constantly reminded that they were being filmed due to the presence of the camera. I tried to minimize this by position the tripod away from the immediate field of vision of the participants. Also, I engaged with the participants through the camera beforehand to get them familiar with how they were being recorded.

3.6.2.2 Semi-structured interviews

The studies also included semi-structured interviews. The interviews were conducted with the participants together with their game partner(s).

3.6.3 Study 4

Study 4 was carried out to evaluate the utility of the insights gained from the previous studies. In order to make the framework suitable for practical design tasks, it was converted into design cards that were aimed to speak the language of designers. By observing participants work with the design cards, this study sought insights into the utility of the framework. I was interested in finding out if designers and researchers would find the framework useful, and if so, how it could support their work. Data gathering consisted of video recording of participants' engagement with a design task, including the presentations of results, as well as semi-structured interviewing.

3.6.3.1 Video and semi-structured interviews

The workshop sessions were video recorded, however, for the analysis, the audio part became most valuable. Participants also had access to tools and stationery items such as pens, paper, balls, tape, and so forth to support the creative process. Any artefacts resulting from the use of these items were also captured, for example, notes on paper, diagrams in books and drawings on butcher paper were photographed and used in the analysis. These artefacts were also used to ask probing questions during the semi-structured interviews.

3.7 Summary

In order to gain an understanding of social play in exertion games, the empirical investigations carried out in this thesis take a qualitative interpretive approach. This thesis includes the design of novel exertion games that serve as research vehicles for a series of studies on their use. These studies focus on the user experience when playing these games, which guides the choice of appropriate techniques for data collection as well as approaches towards analysis.

4. Jogging over a Distance

Jogging over a Distance allows distributed joggers to run together using spatialized sound that is informed by their heart rate.

Figure 4-1: Jogging over a Distance

4.1 Introduction

This chapter describes the first exertion game, Jogging over a Distance (see Figure 4-1) and its associated study.

Jogging over a Distance allows distributed joggers to run together using spatialized sound that is controlled by their heart rate. The system also allows runners of different athletic abilities to run together, therefore treating the geographical distance between them as an opportunity, rather than as a challenge the technology has to "address".

A depiction of the design rationale of the system is followed by a description of a study that involved participants between Australia and Europe using Jogging over a Distance.

By using a theoretically sensitized approach to data analysis, the findings suggest a set of themes that can aid designers in understanding how design can support social play in exertion games, with a focus on the limited bodily reciprocity inherent in jogging activities.

These themes will serve as one puzzle piece to inform and guide further empirical investigations, contributing to a richer understanding of how to design for social play in exertion games.

4.2 Aim and approach

The aim of this first game and its associated study is to establish an understanding of how participants experience social play in an exertion game. This aim is approached through a study of an exertion game that is based on a parallel exertion activity: jogging. The associated system supports distributed participants in order to highlight mediated social play and the associated influences of technology.

Although the activity of jogging is not often called a game, I consider the practice joggers engage in a game-like experience, as the runners voluntarily (they do so on their own will) engage in an activity, governed by rules that prohibit more efficient means (they are not allowed to take the bus), towards a goal (keep jogging until the end of the park). These characteristics match my previous definition of a game.

4.3 Jogging over a Distance

With Jogging over a Distance, two jogging partners arrange to run at the same time. Each jogger wears a headset and a wireless heart rate monitor strapped around their chest (see Figure 4-2). They also wear a small pouch around their waist, which contains a mini computer and a mobile phone. Although the audio could be transmitted via VoIP, the mobile phone voice channel helps keep latency to a minimum. Before the run, the system prompts users to enter their preferred target heart rate (often known by the participants through the use of heart rate monitors, otherwise acquired through a "test" run), which allows users to specify the physical effort they plan to invest based on their fitness levels and goals.

Figure 4-2: Jogging over a Distance hardware

While the participants jog, their heart rate data is sent wirelessly to a server. Each jogger can hear the audio of their jogging partner, captured through a microphone on the headset. The participants' relative heart rate data affects the position of the audio in a 2D plane that is oriented horizontally around the jogger's head. The spatialization is achieved through a binaural software simulator implemented on the mini computer that places the sound source in a 2D audio environment, moving around the jogger's head from the front, to side-by-side, to the back depending on the difference of the relative heart rates. This software simulation is achieved through head-related transfer functions and reverberation (Begault, 1994), changing the mono sound coming in through the remote microphone to create the illusion of the sound source placed in space around the local jogger, as inspired by the audio behaviour when jogging in a co-located setting. Etter et al.'s work (2005) describes that spatialized audio can support people running around outdoors, however, running aggravates sound localization (Marentakis & Brewster, 2006). To overcome this problem, the spatialization effect is amplified by slightly shifting the centre axis as described by Mueller et al. (2007).

The spatialized audio provides an indication of the relative heart rate of the jogging partner. When both joggers are at their preferred heart rate, they hear the audio coming from right beside them, as if they were running side-by-side. The same applies when both joggers divert from their preferred heart rate at the same percentage, for example, if both joggers raise their heart rate to 110%, the audio stays in the centre. However, if one of the partner's heart rate increases, the audio sounds as if it is moving ahead of the other runner, or if the heart rate decreases, the audio sounds as if it is coming from behind the jogger. For example, if the remote jogger raises her heart rate to 120%, her voice coming through the headphones is softer in volume and appears to come from the front, thanks to the spatial audio effect. This way, the jogger is able to detect whether their partner is putting in more, the same, or less, effort, based on the relative heart rate to one another. The system lets the jogger know when he or she needs to speed up or slow down in order to 'stay' with their partner.

4.3.1 Design rationale

I opted for jogging as the core exertion mechanic as jogging is a common parallel play activity: participants do not interfere with each other's bodies during the jog. Nevertheless, jogging can be a social activity, as people enjoy jogging with others. However, exercise partners who run at the same pace are not always easy to find (O'Brien & Mueller, 2007). Jogging over a Distance is targeted at social joggers, who talk during the activity. Talking while jogging is not uncommon, for example it has been suggested that, as a rule-of-thumb, how fast a beginner should run for optimal health benefits is a pace that allows the runner to still be able to comfortably talk (Porcari et al., n.d.).

Several versions of Jogging over a Distance were created, based on feedback from users before the study was conducted with the final version. Several GPS-based implementations were tested but the accuracy of reported pace was not satisfying. Also, most step-counters were too inaccurate for the demands of the joggers. I therefore opted for heart rate, which had the additional benefit that many joggers were already familiar with using a heart rate monitor. Furthermore, it also allowed focusing on the physical effort people invest rather than the athletic performance, which often depends on particular bodily characteristics. Research systems such as those presented by Nenonen et al. (2007) and de Oliveira et al. (2008) have already demonstrated that heart rate data can be successfully used to control interactive experiences; here its first use in an outdoor environment across countries is demonstrated. Lastly, the use of heart rate data suggests that the system could also be used with other core mechanics, such as cycling.

I chose to represent position information via spatialized audio, in contrast to, for example, via the screen on the mobile phone, as I did not want to distract participants visual focus away from the path in front of them, which could cause tripping over and falling. The use of audio headphones might also distract participants from their environment, however, the prevalence of headphones used in current jogging practice suggests that participants are comfortable with using headphones during jogging activities.

Jogging over a Distance is unique as it offers opportunities for social interaction throughout the duration of a distributed exertion activity, unlike most other jogging support systems such as Nike+ (Apple, n.d.) and Fish'n'Steps (Lin et al., 2006), which support social exchange only after the exercise occurred. These and other mobile exercise support research projects (Consolvo et al., 2006; S Consolvo et al., 2008; Toscos et al., 2006) focus on absolute performance, that is distance travelled over time, however Jogging over a Distance considers the users' heart rate data. Lastly, Jogging over a Distance does not use heart rate data directly, but adjusts it computationally relative to the heart rate of the other person in order to allow people with different athletic abilities to enjoy a jog together; something they could not do if they were co-located.

4.4 Study

The goal of the study was to understand qualitatively what it was like for participants to jog with the system, and how the technology design supported them in their exertion experience.

4.4.1 Participants

First, three pilot studies were conducted to ensure the correct working of the system as well as to test if the format of the study was appropriate, considering that participants had to accommodate jogging time, their partner's availability, interview time, recovery and getting-changing time. The pilot studies were affirmative, and a study with 22 runs was conducted next.

Potential volunteers were invited from personal contacts who fit the profile of social jogger (jogging with others, but not regularly in competitions) via email, also asking if they know of additional participants who have jogged before and can recruit a partner they would like to run with, looking out especially for joggers who migrated to one of the other international locations and wanted to run with their previous jogging partners. This worked well; overall, there were 32 different participants, five joggers wanted to run a series of runs with different partners, which was welcomed and marked in the analysis.

I aimed to recruit social joggers because I believe they are the most suitable target group for a system that combines jogging with social interaction. Serious running athletes do not benefit much from a social incentive, as their motivation to run is already high. On the other hand, people who have never run before do not have the experience to compare the Jogging over a Distance system to co-located jogging; insights I was seeking in the study.

A listing of jogging pair constellations is depicted in Table 4-1. All pairs had prior social relationships: they were either friends or siblings. The participants were all volunteers and they were not monetarily compensated for their efforts.

The participants were between 23 and 44 years old. Fourteen participants were female and 18 were male. Their jogging experience varied equally from jogging regularly between 2-4 times a week (16 participants), to others running only occasionally (16 participants).

Table 4-1: List of participant constellations

Participant	… jogged with participant	… how often
1 (Australia)	2 (UK)	4 times
1 (Australia)	3 (Australia)	once
1 (Australia)	4 (Australia)	once
4 (Australia)	5 (Germany)	once
6 (Australia)	7 (Australia)	once
6 (Australia)	8 (UK)	once
8 (UK)	9 (Australia)	once
10 (Australia)	11 (Australia)	once
12 (Australia)	13 (Australia)	once
14 (Australia)	15 (Australia)	once
16 (Australia)	17 (Australia)	once
18 (Australia)	19 (Australia)	once
20 (Australia)	21 (Australia)	once
22 (Australia)	23 (Australia)	once
24 (Australia)	25 (Australia)	once
26 (Australia)	27 (Australia)	once
28 (Australia)	29 (Australia)	once
30 (Australia)	31 (Australia)	once
32 (Sydney)	3 (Melbourne)	once

Fourteen runs were with participants in the same city (Australia) (see Figure 4-3), where jogging partners were asked to run in opposite directions along their usual jogging paths to simulate an "over a distance" experience. The other eight runs were with participants separated by over 16,000 kilometres, where one jogger was in Australia and their partner in Europe (UK or Germany).

Figure 4-3: Two joggers after their simulated "over a distance" run, showing the equipment

4.4.2 Procedure

Participants were asked to run at their usual location. Upon arrival, they were asked to enter a short survey to gather demographic information as reported above. Then they received a demonstration of the system. Participants were asked if they had a preferred heart rate they would like to run at, and if so, it was entered as the baseline into the system. If they did not know their preferred heart rate, I provided them with a heart rate monitor before the study to let them determine which heart rate they would be most comfortable with. The target heart rates entered ranged from 150 to 175 beats per minute.

Participants were asked to run for as long as they wanted; as the focus was on the experience, rather than the athletic performance, they were informed that the goal of the system was not to test if they could run faster or longer than usual, but rather that the aim was to gather insights into their experience. They were told that they can run slower, faster or at the same speed they usually run, and that no judgment will be made whether the system leads to faster or longer running times. Participants were also informed that their conversations during their run were recorded.

Each run was between 25 and 45 minutes long, with an average of 30 minutes.

4.4.3 Data collection

Audio recordings from interview data after participants ran in pairs were the main data source. Furthermore, the participants' interactions over the audio channel were recorded during their run in order to capture how their experience unfolded throughout the activity. As it was not practical, and likely to be intrusive, to follow the joggers with a video camera, recording their conversations was chosen as the most practical way of capturing the experience in-situ.

Upon their return from the jog, participants were interviewed together. If they were in separate locations, one participant was dialled-in with a speakerphone. These interviews were recorded. Interviews lasted around an average of 1 hour, with the longest one lasting 2 hours. The interviews contained open-ended questions about the participants' experience and their interactions with one another. Notes were taken during and after the interviews to allow for further reflection and analysis.

As the interviews were done in pairs, I was happy to let participants explore their experiences verbally with one another if they chose to do so, only jumping in when particular points of interest emerged that I wanted to hear more about. I encouraged participants to elaborate on their previous sports experiences and link back to their usual jogging routines, mentioning any differences. Many participants asked about the technical details of the system, which were also explained to them if desired.

Interviews concluded once I covered the areas I aimed for, but I was also open to any additional comments participants had. I took notes during these interviews as well as immediately afterwards to structure my thinking as well as capture any thoughts that arose during the interview.

4.4.4 Preparing the data

The study generated demographic information from the participants gathered through the survey, the recordings from the runs, the notes taken during and after the interviews and the interview itself.

4.4.4.1 Survey

The survey contained demographic information about the participants, including age and sex, but also how often they usually jog and with how many people.

These surveys were entered into a spreadsheet program and participants who jogged together were marked in order to be able to identify any correlations that might arise form the interview data.

During the analysis of the interview data, the spreadsheet was always open and used on the side to help getting a further understanding of the participant and contextualize the interpretation and analysis of the data.

4.4.4.2 Audio recordings from the runs

The audio recordings from the runs were marked so they could be matched to the relevant spreadsheet entries and interview data. Any utterances from the participants were also transcribed.

4.4.4.3 Notes

Notes were taken during and right after the interview to record any specific details coming from the participants, but also to capture any thoughts arising during the interview. These included illustrations of concepts I thought belonged together and that I associated with concepts from previous interviews. These notes were usually 1-2 pages long and on average 400 words. These documents were kept as digital documents and referred to as starting point and reflective tool during the analysis of the interview data.

4.4.4.4 Interviews

Before transcribing each interview, I listened to them first and added any additional thoughts I had to the original notes. Then the interviews were transcribed, including researcher's questions, and segmented into individual speech bursts. Each segment was marked where it came from in order to be able to match it to the survey and the run data. This included markings how often and with whom participants jogged in order to be able to identify any relationships. An average interview was about 3000 words.

4.4.5 Data Analysis

The analysis began by reading the notes for each participant pair in detail. First, I looked at the transcribed data from the runs. Then I read the interviews one after the other, reminding myself of data from participants who ran multiple times with the system. I kept the file with the demographic data open to be able to cross-reference anything of relevance I might find. I also had the notes for each participant pair handy to match each individual. Then I began the coding process of the data.

I used qualitative analysis software (Nvivo, http://www.qsrinternational.com) to help me with the coding of the data and I was guided by the research question during the inspection of the data.

While the codes I have chosen were informed by the research question as well as from the literature reviewed, they served primarily as initial guides, as I did not limit myself to them during the analysis but was rather open to additional ones.

The coding began by looking for all relevant mentioning of a social play experience, describing an experience of jogging together. This meant identifying instances that describe a shared activity, a social exercise, and so forth. These passages were highlighted and associated with the code of social play. I also looked out for any other instances that related to the experience. Then descriptions of how social play emerged and what could have led to it were coded.

Similarly, any mention of exertion and physical effort were identified. This included trying to look for evidence that points to the role of the body in the interaction. If I identified some, I looked for any indicators pointing towards specific roles of the body as suggested by the body lens.

Then I looked for indicators concerned with the design of the system. This meant identifying instances where participants described how their experience was shaped by the system. This included references that pointed to the distributed nature of the activity, including instances where participants compared their run to previous co-located jogs.

I also used affinity diagrams (Neuman, 2006) to group the codes in order to reduce the number of individual concepts. I laid the codes out spatially and began to identify relationships. I was looking for patterns and tried to create summarized themes. I used phrases and keywords to refine these themes. With the rest of the data still in mind, I looked for influences, conditions and consequences to show any relationships. For example, I was able to identify that the level of physical exertion participants invested depends on their individual approach, but also is a result of social negotiation with their partner.

A demonstration how this was achieved can be found in appendix 1.

Then I collected all the data concerning each higher-level concept and wrote a summary of each in a separate document, along with a higher-level description. Next, I looked at the emerged summaries and high-level descriptions and tried to link any relevant ones together. The resulting higher-level concepts formed the headings in the “results” section.

4.4.5.1 Checking data

Lastly, with these higher-level concepts I returned to the data and added them to the coding structure. I used them to go back to the participants to ensure that there was data that could support these concepts (Neuman, 2006). Again, I did so with both the interview and the run data, supplemented by the notes. This was the last stage of the coding process.

4.5 Results

The first section presents data that indicate both social play and exertion. In the next section, practices are detailed that explicate the relationship between both social play and exertion. These findings are related back to specific design features, and relevant design implications are discussed.

4.5.1 Exertion and social play

The findings indicate that Jogging over a Distance indeed facilitated social play, despite the geographical distance between the participants.

In the following section, evidence for this claim will be detailed, with an analysis of how this social play unfolded, relating it back to aspects of the system's design. I begin by describing evidence that exertion occurred and that this exertion experience was engaging. Participants found the experience comparable to co-located social jogging experiences. However, they also applauded the additional benefits the Jogging over a Distance system offered, such as the ability to jog with partners far away and to exercise with friends of different athletic abilities.

Participants were investing physical effort, and as a result, were often very exhausted at the end of the activity:

> *"I don't think I can run anymore.*
>
> *I am getting really tired!" [P16, run]*
>
> *"I've had enough already." [P27, run]*

Participants expressed enjoyment during their exertion interactions with their partners:

> *"This is totally cool." [P14, run]*

The joggers differentiated between running alone and running with the system, referring to the latter as one that they experienced "together":

> *"We did actually go for a jog together." [P30, interview]*

"It felt like it was running with someone. […] I thought 'Hey, I'm with [partner's name] for a run' as opposed to 'Ugh, I'm by myself'." [P14, interview]

Participants compared it to their conventional co-located jogging experiences where they are not using any mediating technology:

"I guess fun wise, it was pretty much the same, if you are having a jog with a friend next to you […] Purely as fun wise, it wasn't better or worse." [P21, interview]

The experience was similar to jogging side-by-side, while participants appreciated the opportunity to run with distant partners:

"I just felt like she was near me. It was like I was running with her but she was not beside me." [P17, interview]

The participants noted that

"one of the benefits is that you can run at different rates." [P5, interview]

"[I liked] the sociability aspect and the ability to exercise without having to compromise with someone else just because of a physical hindrance or whatever." [P28, interview]

The ability to jog together despite different athletic abilities enabled participants to jog with partners they usually would not run with due to their differences in running pace:

"When we were running around I observed a couple of guys who were jogging along and talking, having a full-on conversation side by side and I was talking into the headpiece to [partner's name] and I was effectively doing the same thing as those guys were doing. But they were able fitness wise to jog together but I'm not able fitness wise to jog with [partner's name] at [partner's name]'s chosen pace but we were still having that interaction." [P26, then P27, interview]

It is difficult to find exercise partners with the same running pace, and participants often ended up running with partners of different abilities, which can hinder engagement with the activity:

> *"It is really hard to find the right jogging partner, it's really hard. The fitness level is probably the biggest thing because if you're with somebody too fast or too slow I think it frustrates everybody to a degree." [P26, interview]*

The following jogger welcomed the opportunity to be able to *"run off"*, following his desire to push himself, without sacrificing it for the "together" experience of a social run:

> *"You wouldn't go on a social run and run off on the other person. "*

> *"Yeah, it's easier to push yourself to your own level of limits [...] 'cause you are still with the person." [P20, then P21, interview]*

In sum, participants reported a "together" experience, indicative of social play occurring during the exertion activity. In the next section, I describe the elements pain, rhythm, contending, and bodily exploration that supported the interrelationship between exertion and social play.

4.5.2 Pain

The participants pointed out that an important characteristic of jogging is the associated physical discomfort or pain that derives from the endurance they expose their bodies to. The participants experienced this pain directly:

> *"Ah, I've got tummy cramp." [P16, run]*

> *"In the end, you get tired, and you just do not want to run anymore" [P9, interview].*

4.5.2.1 Perceiving partner's pain

The participants noted that they could hear their partner's breathing through the headphones. This breathing allowed them to perceive how their partner's body responded to the exertion activity.

> *"Jeez, you are breathing like a motherfucker." [P22, run]*

> *"I can definitely hear heavy breathing." [p20, run]*

Hearing someone else's pain elicited empathetic actions:

> *"You've got the giving-birth breathing going, are you alright?" [P25, run]*

Participants explained that the focus on the audio as facilitated by the system emphasized the breathing of the other person, which made them more aware of the pain of their partner:

> *"It makes you focus on hearing someone else in pain." [P23, interview]*

4.5.2.2 Communicating pain

Participants also used the audio channel to communicate into how much pain they were. This supported them in their exertion activity:

> *"[…] because I could bitch about it to you […] once I got over it, it was gone and I could have done it for longer." [P25, interview]*

4.5.2.3 A trouble shared is a trouble halved

The ability to share pain affected participants' perception of their own exertion investment. One jogger described it as

> *"the idea of doing it together, so therefore half the effort." [P28, interview]*

In sum, participants reported that they shared pain by communicating their perceived pain and also became aware of their partner's pain. They did so because it helped them deal with the pain arising from the exertion activity. However, participants also pointed out that there were instances where the system provided a welcoming distraction from these bodily responses:

4.5.2.4 Distraction through talking

The participants reported that the talking to the partner was welcomed because it allowed them to shift their attention, offering a distraction from the discomfort of exercising.

> *"You are not focusing on the path in front of you, you are focusing on the conversation. That immediately becomes quite a distraction, so you can keep going and going." [P3, interviews]*

Another participant had been dealing with a permanent injury, and the talking from her partner distracted her from the usual pain associated with it, limiting the effects this usually has on her experience:

> *"I must admit from my injury perspective, to begin with I was like ok, let's just take it easy because I don't know how long I can last before it kicks in and I think she motivated me purely by talking to me - it was distracting me from having to think about it." [P29, interview]*

Being distracted from the discomfort arising from the activity affected how participants perceived their effort investment:

> *"For me it was just the same as if I was just listening to music. It was more having something to take my attention away from the fact that, hey, I'm just running. I could feel I was running faster than I normally would." [P21, interviews]*

4.5.2.5 Facilitating distraction through talking

Participants could only identify where their partner was in the virtual audio space by locating the sound source. Participants inferred the sound position through background noises, breathing and the sound of footsteps, but the most prominent way was through hearing the other person talking. This talking was subtly encouraged by the design: if participants talked, it helped to determine where in the audio space the other person was located. In particular, participants used the audio channel to establish, negotiate and confirm their relative "bodily" position in the audio space:

"You are getting really clear now."

"Can you keep talking."

"(Sings:) Oh my darling [partner's name][partner's name]." [P26, run]

However, facilitating conversation can affect exertion. Investing energy into conversing took away energy for jogging, participants reported. Furthermore, participants expressed that they felt they talked more due to the system's design:

"When we run together we run together so we can pace ourselves by that because we can't see each we talked to judge where we are."

[So you talked more too?]

"Yeah."

"Definitely." [P16, interview]

"Maybe I feel obligated to talk." [P5, interview]

4.5.3 Rhythm

Participants referred to a sense of rhythm in their jogging activity, whether that was an internal rhythm they achieved or strived to achieve, or a synchronized rhythm with the other person.

"Yeah, most of the time we were pretty close because I guess we got into a natural sort of pace that we were both comfortable with." [P24, interview]

"Then half way through when I started getting a little bit puffed, I fell into my standard rhythm. I think that being a regular runner means that it becomes more of a habit, you just get into a rhythm; automatic habit that you have."

"[In the 2nd round] I was listening to the rhythm more."

"Yeah, we were just getting used to it." [P3, then P4, interviews]

Here the jogger describes his ability to a "listening" of rhythm. Participants he identified a rhythm by listening to the breathing of the other person, but also through the rhythmic noise of the footsteps. Participants tried to synchronize their actions to these rhythmic indicators.

In sum, participants experienced a rhythm in their exertion activity that they tried to synchronize with either their preferred internal rhythm of jogging or with their partner's rhythm. These were not exclusive practices, and participants engaged in a rather complex web of utilizing rhythm in their exertion activity. The system allowed identifying their partner's rhythm and hence allowed to match this rhythm, while simultaneously their rhythm was being matched, making rhythm in Jogging over a Distance a social process.

4.5.4 The body at risk

During the interviews as well as during the run itself the topic of risk, and in particular the risk of injury, emerged. The severity of the impact injury can have on participants' current as well as future exertion activities highlighted its importance for the participants. Furthermore, participants noted that severe injury could impact their lives outside the exercise activity.

"[Because of my injury] I can't do this, and I can't do that, ..." [P6, 2nd, run]

Physical risk arose from three domains for the participants: participants were concerned by running too fast or too long, especially in hot weather, leading to overexertion and dehydration. Injury could also occur from accidents, such as stumbling on the unpaved tracks, or collide with traffic. Lastly, as the participants were running in different time zones, some of them had to run late at night or early in the morning, which was by some perceived to be an increased risk in terms of their personal safety, especially in the public parks they were running in, adding to the risk of injury inherent in exertion activities (see Figure 4-4).

Figure 4-4: Jogger running at night

4.5.5 Contending

Competition is a key factor in most popular sports activities today (Weinberg & Gould, 2006, p. 101), and consequently, discussions arising around the topic of competition were of no surprise. However, participants also collaborated, and often competition and collaboration came hand in hand, with participants contending for the same or a shared goal.

4.5.6 Contending: Collaboration

There were several ways how participants collaborated: they slowed down and waited for one another, they encouraged each other, they negotiated a jogging pace that suited both, and they found opportunities to collaborate with another to compete together against "the game".

4.5.6.1 Waiting for one another

Participants slowed down for their partner in order to wait for them to catch up:

> *"I could hear [partner's name] quite clearly at times, if he started to move further away I would just slow down my running a bit and then I hear." [P13 (2nd), interview]*

4.5.6.2 Encouraging

Participants encouraged each other verbally to increase their physical investment:

> *"I pushed the heart rate up which made him go softer which then made me start cheering or egging him on." [P21, interview]*

The banter sometimes turned to stronger tones, but stayed always in a playful manner:

> *"I could tell that I was running hard uphill because he was getting softer. I still had him there so I ran harder so I could abuse him more so he'd get softer so I could abuse him some more and tell him to go faster and harden the fuck up. So in that way you probably do work a bit harder, in your theory running faster and getting ahead, you can still hear them so you can still keep the banter going." [P20, interview]*

4.5.6.3 Collaboration enticed by conversation feature

The participants mentioned as reason for collaborating that this allowed them to talk; in other words, because they could communicate more clearly and more easily when their relative heart rate was aligned, it was an incentive for them to adjust their exertion investment:

> *"It was an incentive to get the heart rate right to be able to talk." [P7, 2nd, interview]*

4.5.6.4 Gaming it

Participants also found a new way to experience jogging together: they collaborated together against "the game".

> *"We tried to run so we could hear each other perfectly all the time perfectly through both ears." [P8, interview]*

As a result, the participants played a game together against the computer:

> *"It's a competition between us to meet the expectations of the game. It's not a competition between us." [P26, interview]*

4.5.6.5 Audio hinders identifying small location differences

Participants reported that the use of audio made competition difficult for them, especially when they were very close in their efforts. It was difficult to distinguish minor changes in audio location changes due to the nature of the audio space. Hearing if a person was in front or in the back was easier for participants than distinguishing between if a person was side-by-side or "a little bit" in front, and as a result they opted for a collaborative approach.

4.5.7 Contending: Competition

Participants also displayed competitive behaviour, although not as often as collaborative actions, however, joggers collaborated as well as competed often within the same run.

Three participant pairs stated that their run was a competitive affair:

> *"If you were in front, there wasn't the slow down option."*

"Yeah, it was competitive." [P22, then P23, interview]

Being competitive about the activity affected the participants' exertion:

"Definitely motivated to go out harder than I probably would have." [P23, interview]

They explained why they chose to be competitive.

"It's just about competing to get the best out of ourselves […] there wouldn't be any strings attached to the winner or loser, it would be more about: 'Next time, I'm going to kick [partner's name]'s butt.'" [P28, interview]

"We will both push each other as much as we can, but that is why you would get this application." [P23, interview]

For these participants, getting "the best out of ourselves" was a collaborative goal, achieved through competition. As a result, competition and collaboration were not mutually exclusive elements of the experience, but rather elements that they were able to utilize in chorus to their advantage, as facilitated by the system.

However, they also noted that the system was more setup for collaborative than for competitive activity:

"It could be made competitive. It wasn't really set up in a very competitive kind of way - it was more set up socially." [P17, interview]

4.5.7.1 Competition against self

Participants not only competed against their partner, they also competed against themselves, in particular, against their own bodily limitations:

"I tried to pace myself because I knew I wanted to run longer; 'cos I wanted to run for about half an hour." [P16, interview]

4.5.7.2 Facilitating competition

The ability to engage in competitive actions was attributed to the spatialization feature of Jogging over a Distance:

> *"[Using just a mobile phone] would have just been talking and running...probably wouldn't have run as fast." [P16, interview]*

4.5.8 Bodily exploration

Participants reported that the use of the system changed how they structured their exertion activity because they explored the relationship between their bodies and the system. For their run, it meant that they

> *"tried a few different sprints to hear the difference."*
>
> *"It works you out more when you do that little push and that sort of interval training kind of thing." [P22, then P23, interviews]*

This particular pair was training for their first "fun run", a fund-raising half-marathon. Using the system affected how they ran:

> *"Because we are training for the half marathon, my running has been more focussed on slow and steady running trying to go for a longer period so if you come out and do some sprinting and if you are not used to sprinting it tires you out pretty quickly so we wouldn't have done that sort of thing at this point in time."*

This pair would have even explored alternative exercises if they had not trained for the fun run:

> *"If we were doing it solely on heart rate then I would probably have stopped running at some point and started doing star jumps or some other exercise: push ups, chin ups, squats."*

The following pair expressed how they would have liked the system to support them more in gaining knowledge about their body and have an additional point of reference:

> *"It would have been nice as well to have our heart rate and to be able to see it and actually compare that to, because we wanted to see it and know that relates to how hard we were working […] it would have been nice to actually have that point of discussion as well, especially because you set your heart rate at whatever."*
>
> *"That's the basis that you'd push yourself on as well."*
> *[P28, then P29, interview]*

They were interested in learning how their exertion activity affects their absolute heart rate, not just in relation to their partner's. As they have used heart rate data as part of their exercise regime previously, it would allow them to compare their body's response across runs, and even across activities.

4.6 Discussion

Next comes a discussion of the findings that emerged from the data. This discussion harnesses the body lens as analytical tool in an attempt to understand the complexities of what was going on during the participants' experience. This in turn can suggest what core exertion elements contributed to social play, but also how certain social support factors were facilitating physical effort. I begin each section with a summary sentence of the contribution.

4.6.1 Exertion and Social play

Spatialized audio controlled by physiological sensing can level participants of different athletic abilities to facilitate an experience of jogging together even though participants might be in different geographical locations.

The data showed how the participants experienced social play, as they reported they were "jogging together", despite their different athletic abilities and the physical distance between them. In the next sections the elements that facilitated this experience will be discussed individually.

4.6.2 Shared pain

Supporting the ability to share pain – for example by amplifying the other's breathing intensity – can result in a decreased perception of the discomfort of exercise.

The participants considered the physical discomfort, the perception of the responding body or pain, associated with jogging a key part of the exertion activity. They accepted the pain because of the positive feeling they anticipated afterwards, and appreciated the ability to share it with their partner. The participants shared pain in two different ways: communicating pain and perceiving pain.

Participants communicated their pain to their partner through the audio channel by *"complaining"* about the discomfort. Being able to talk about the pain contributed to a perceived reduction of it.

The participants in Jogging over a Distance perceived their partner's pain through them talking about it, but they also perceived it without them explicitly communicating it verbally: participants expressed that they appreciated being able to sense how much pain their partner was in by the ability to hear the intensity of their breathing. This gave them the ability to identify any overexertion that might be occurring. They felt responsible for the health of their partner, and having the ability to sense their partner's bodily state in a more direct way than verbal communication, not regulated through language, allowed them to assess the "true" quality and identify any possible health risks. As a result of this social behaviour, participants reported a perceived reduction of the associated discomfort.

4.6.2.1 Designing for shared pain

The design of the Jogging over a Distance system facilitated the ability to share pain in two ways.

4.6.2.2 Verbalizing pain through the audio channel

The system's design allowed participants to communicate their perceived pain over the audio channel. Participants perceived how their body responded to the exertion activity, and abstracted it through language in a way that it could be communicated over the audio channel. The participants were able to complain about how exhausted they were, which they said helped them continue running.

4.6.2.3 Amplifying the responding body

The system design did not feature a video channel between the participants, hence there was no ability to perceive pain through visual cues as known from co-located jogging. By only allowing for audio communication, participants reported that this highlighted the other person's breathing. The relationship between breathing and exercise, and how it affects one another, has already been pointed out in the sports literature (Bernasconi & Kohl, 1993), here, the position of the microphone close to the mouth amplified the breathing. By removing any visual cues, the audio was emphasized, which highlighted awareness of the partner's breathing. This breathing was one of the body's responses to exercise, which gave participants an indication of the bodily state their partner was in. Knowing this bodily state set the conditions for the social behaviour mentioned above, such as feeling empathy for the other jogger.

Sports research suggests that the body produces more endorphins when exercising with others, compared to exercising alone as demonstrated by a higher tolerance to pain (Cohen et al., 2009). This makes pain both a social and bodily phenomenon, and the participants experienced this intertwined relationship as a sort of "a trouble shared is a trouble halved" experience.

This notion of shared pain has implications for technology design: knowing that the ability to share pain can have positive effects even in mediated environments, designers of mediating technology should consider how their systems can facilitate this sharing of pain. In Jogging over a Distance, the design allowed participants to express their perceived pain verbally. Furthermore, the system amplified one particular response of the body, the increased breathing intensity of the partner. Both provided the conditions for a sharing of pain.

Such an understanding of the role of being able to be aware of the body's response contributes to our knowledge on presence in mediated exertion games: de Kort et al. highlight that a sense of presence of the other person is important for successful exertion gaming (de Kort & Ijsselsteijn, 2008). The Jogging over a Distance study refines this by highlighting the different role of awareness of the responding body as one contributor to a social experience.

It has been suggested that bodily performance should not always be made visible for distributed participants, as it could facilitate evaluation apprehension, and hence be demotivating (Hagger & Chatzisarantis, 2005). In Jogging over a Distance, such evaluation apprehension was not identified in the data, hence it might be suggested that focusing on the body's response instead of communicating athletic performance in mediated environments might be beneficial. In other words, designers might want to consider focusing on sharing the body's response rather than traditional presence measures such as athletic performance.

Lastly, it should also be noted that participants acknowledged the opportunity to perceive their partner's pain as a way to check on their partner's physical health status, reducing the risk of overexertion. In future versions of the system, it could be beneficial to consider having the computer supplement this role: the computer could analyse the breathing intensity and make suggestions for avoiding overexertion.

4.6.3 Distraction from pain

Supporting social interactions can distract from the pain signals of the responding body, delaying the termination of exercise due to exhaustion. However, rewarding social interactions through game rules, although leading to more social interaction and hence distracting from pain, takes away energy participants otherwise expect to invest in the activity.

In Jogging over a Distance, participants encountered moments when they wanted to stop running, as their body responded to the activity with exhaustion. They reported that the system supported them in being distracted from the discomfort that can arise from the jogging activity. The participants welcomed the opportunity to be distracted from the signals from the body responding negatively to the exercise such as pain. Being distracted from these bodily responses made them less aware of them, facilitating continued engagement. This distraction has been described as a "disassociation" (Fogg, 2002) that the technology provides from the discomfort that comes with strenuous physical activity (Karageorghis & Priest, 2008). This suggests a notion of "dis-awareness" that the technology can facilitate on the responding body layer of the body lens.

The body reacts to physical activity by responding internally in a way that aims to maintains balance (Plowman & Smith, 2007): the user's heart rate typically increases, breathing becomes more frequent, and sweating occurs. These are consequences of exercise the user usually becomes aware of with increased intensity (Plowman & Smith, 2007). These signals tell the user to stop in order to regain balance, however, the user can decide to overrule these signals and continue with the exertion activity. However, ignoring warning signs from the responding body can be dangerous, as they can be indicators for serious injury.

4.6.3.1 Designing for distraction

The distraction that was mentioned the most was the talking from the other person, in other words, distraction had a social connotation for the participants. However, distraction arose also from external sources: players previously used music players to distract them from the discomfort of jogging. In addition, a Jogging over a Distance participant mentioned the role of the outdoor environment as resource for distraction, because he compared it to indoor treadmill running: the continuous stream of visual stimuli served as distraction for this participant. In other words, distraction from the responding body can be facilitated from all other layers of the body lens.

The features of the technology design not only enabled distraction through verbal conversation, it also enticed it by rewarding players: if participants talked, it was easier for them to assess how far ahead or behind the other person was. However, facilitating such distraction came with costs in Jogging over a Distance, as some joggers felt obliged to talk, and the talking prevented them from investing as much physical effort as they wanted because they found that talking took away energy they would have preferred being able to devote to the jogging activity instead.

Distracting from the discomfort of exercise can be beneficial, as it can facilitate enhanced physical investment as reported by the participants. However, ignoring bodily signs can also lead to serious injury, and managing this balance between enhancing performance by dissociating from the discomfort and being sensitized to the warnings of the body that indicate serious injury is a salient topic for athletes (Weinberg & Gould, 2006, p. 452). Technology design can do both, distract as well as highlight, and designing for exertion therefore means designing for a balance between the two.

The notion of shared pain is also associated with another aspect of exertion: rhythm (Cohen et al., 2009). The next section delves deeper into the role of rhythm in social exertion play.

4.6.4 Rhythm

Supporting participants in identifying a rhythm – from their own continuousness of movement, their partner's or external sources such as music – can be facilitated by emphasizing the beat within. This can facilitate exertion by reducing the perceived effort invested, however, rhythm can be "off" participant's own rhythm, affecting exertion negatively.

Participants' feedback suggests a strong role of rhythm when it comes to exertion. By rhythm I mean a uniform or patterned recurrence of a beat in bodily action. For participants, rhythm existed either from within movement itself, reflecting the inner pulse of the user (Moen, 2006) or emerged from the rhythm of the remote partner: joggers reported they identified a rhythm in their partner's breathing, as well as in the sound of their footsteps. For the participants, the social activity of jogging "together" involved synchronizing, or aligning, their rhythms to one another.

Participants benefited from this ability to find their own or their partner's rhythm, as they reported increased satisfaction, which they perceived made the exertion task easier.

The notion of rhythm is facilitated by the continuousness characteristic of movement, also been described as movement's ongoingness (Moen, 2006). This is particularly noteworthy when compared to the button-presses in conventional games that are mostly contained in a single action. Rhythm can still occur with button presses, but is characterized by breaks that separate actions in a staccato fashion. Examples are the early Olympics-themed games where players had to press joystick buttons in staccato-like fashion to mimic track and field events (Bogost, 2005). On the other hand, jogging derives rhythm from the continuousness of movement, as leg movement benefits from a rhythmic pattern that makes use of the particular make-up of the muscle-tendon system. The cyclic pattern of movement makes use of the body's ability to store energy in tendons and uses limbs as pendulums (Perry, 1992). In other words, rhythm plays an important role in jogging, as efficient energy use depends on utilizing continuousness of movement, which in turn is supported by rhythmic movement action. Utilizing the specific characteristics of the body has also been an important theme in robotics research (Pfeifer, Bongard, & Grand, 2007), where a phenomenological stance proposed that designing robots that make use of particular characteristics of the robot's body such as using robot parts as pendulum for movement yields superior results than software-coding each micro-step of the robot's movement.

It is interesting to note that the design of Jogging over a Distance did not facilitate the finding of participants' own rhythm, although the system is using heart rate, which its characteristic beat: instead of making participants aware of it, by, for example, turning heart rate into a beat delivered via the headphones, the system turned it into a stationary sound location, effectively removing any rhythm from it. Whether this facilitated participants seeking out their partner's rhythm is an avenue for future research.

External rhythm can also affect movement. For example, it has been shown that music played during exertion activities can regulate arousal, improve athletic performance, positively impact the acquisition of motor skills, help the attainment of a flow state and distract from the discomfort of exercise (Karageorghis & Priest, 2008). Dance Dance Revolution is probably the most widespread example of an exertion game centred on rhythm (Behrenshausen, 2007). Players can synchronize their movements to both the music and their partner, which makes for better performance (Cohen et al., 2009) and a spectacle for a watching audience.

In sum, being able to identify a rhythm can help participants to enjoy the exertion activity, run faster and with more ease. The literature on rhythm and sports suggests that rhythm can indeed enhance athletic performance, however, this process is not straightforward, as a "wrong" beat can also be detrimental, throwing participants "off" their rhythm (Karageorghis & Priest, 2008).

4.6.4.1 Designing for rhythm

By allowing participants to identify a rhythm, designers can support them in making use of their body's morphology. Designers have three main sources to tap into to facilitate the identification of a rhythm: rhythm can arise from a participant's own movement, or from another person's movement, or from external sources that exhibit a beat, such as music.

However, not all social rhythmic encounters need to aim for alignment: Some sports such as fencing draw on a breaking of synchronicity: counter-acting an initially rhythmic exchange with an element of surprise is one of the key attractions of sports such as fencing (Czajkowski). This could be applied to jogging as well: by amplifying the rhythm of the footsteps for the partner, participants might be able to interpret any "breaking" of the rhythm as a challenge for a sprint.

4.6.5 The body at risk

The data did not reveal many instances of the body at risk, but if it emerged, it was of high importance for the participants. In particular, the risk and resulting fear of injury was of concern for participants. This resonates with previous ethnographic research that identified the risk of bodily injury as a common topic amongst joggers (Shipway & Holloway, 2010).

A layered view on the body highlights that the body at risk emerged predominantly from two perspectives: firstly, the body could respond unfavourably to the exercise, resulting in overexertion and injury. Secondly, the environment could also contribute to the body at risk: being outdoors, in contrast to running indoors on a treadmill, introduced a significant increase of risk of accidents and personal assault to the exertion activity. On the one hand, participants could run indoors, reduce this risk, however, on the other hand, they would miss out on the distraction the changing environment offers them.

4.6.5.1 Designing for the body at risk

The technology design aimed to address some of these physical risks. Firstly, Jogging over a Distance does not feature a screen, as many other mobile phone based activity systems (Benford, Crabtree, Flintham et al., 2006; Consolvo et al., 2006; Sunny Consolvo et al., 2008; Lin et al., 2006; Toscos et al., 2006). As participants are jogging, not just walking, through their outdoor environment, I believe that distracting them with a screen might take attention away from the path in front of them, possibly leading to stumbling and falling.

Secondly, a design choice identified during pilot studies resulted in a reduced perceived risk for personal safety. During testing, the system was configured to never bring the audio sources in the virtual space so far apart that participants could not hear one another anymore, even when heart rates were significantly different. This was done in order to be able to easily identify when a call was dropped. Otherwise, it was sometimes difficult to determine whether a call was terminated by a lost signal or if heart rates were simply very far apart. Interestingly, pilot participants valued this characteristic as a personal safety feature, because it gave them the perceived security of always being able to call for help if needed. During the study, the remote participants who jogged after dusk especially appreciated this safety feature. In other words, the perceived risk participants associated with the activity was mitigated due to the ability of being able to call one another for help. From a relating body view, the social other had a positive impact on the perceived risk of the activity.

Lastly, Jogging over a Distance facilitated movement actions participants were already familiar with from traditional jogging. By relying on existing actions, muscle injuries arising from unfamiliar movements were aimed to be avoided, contrasting experiences such as "Wii-arm" or "Wiiitis" caused by pro-longed engagement with the Nintendo Wii (Nett, Collins, & Sperling, 2008).

As the discussion reveals, the notion of the body at risk is a complex issue that is affected by many contextual factors. The risk inherent in the jogging activity itself was not affected by the design, however, the data showed how design can affect the perception of risk. As a result, this notion of the body at risk will be explored further in the next studies.

4.6.6 Contending

Exertion is fuelled by external goals, such as health objectives, which affects how participants are contending with the game and one another. Technology design can facilitate competitive or collaborative attitudes by mapping body data in different ways: allowing for comparisons facilitates competition, ambiguating body data facilitates collaboration.

Participants reported that they ran "together", engaged in the same activity of jogging, powered by the intrinsic motivation of exercising. However, jogging was also a goal-oriented activity. There were three immediate goals for the participants: One type of goal was to keep running, where the challenge was to "not stop", in a sense to overcome one's own bodily limitations. Another goal was to beat the other jogger in a competition. This goal was exclusive: only one participant could accomplish it. Another goal was to finish the run with the partner. This goal was shared between the joggers.

In sum, participants were contending for one or multiple goals. It is interesting to note that these goals emerged from the participants, and hence contrast the traditional goals in computer games, which "are almost completely defined by the game designer" (Pagulayan et al., 2003). The data suggests that the incentive for improved health participants associate with jogging contributes to this. Noting that goals can emerge from the user and are less of a domain of game designers when it comes to exertion games might be an important insight for game designers.

4.6.6.1 Designing for contending

Many participants expressed that they put a high value on the verbal communication aspect, which was encouraged by the system: participants reported that they collaborated in order to be able to converse.

Furthermore, the mapping from the heart rate to the audio space hindered competition, as it is difficult to identify minor location differences in the audio space. Through this design choice, collaboration was facilitated further.

4.6.6.2 Reduced social obligation for collaboration

Participants collaborated, however, some expressed a desire to compete with one another. Even though collaborating was meaningful for the participants, they explained that competition is appealing to them and can positively affect their exertion.

Kretchmar describes the transition from a collaborative activity to a competitive activity as a move from a non-zero-sum to a zero-sum activity (Kretchmar, 2005, p. 170). Collaborative jogging is a non-zero-sum activity: increasing pace does not prevent another jogger from increasing pace. Competitive jogging on the other hand is a non-zero-sum relationship: one person winning means the other is losing. Why would the joggers trade a potential win-win arrangement for a win-lose competitive project? Kretchmar suggests that participants engage in competition because they are enriched activities. Humans thrive for “tension, uncertainty and dramatic resolutions”, and competition is a surer way to facilitate them than collaborative activity, creating deeper experiences (Kretchmar, 2005, p. 170).

The design supported competition by reducing the social obligation for collaboration: the spatialization was set up so that participants could never “lose” each other, even when they were very far apart in terms of heart rate: they could still hear one another, although softly. Participants found this feature useful when engaging in competitive behaviour, as it reduced opportunities to breach social norms, such as the perceived social obligation to stay with one another when jogging in pairs.

4.6.6.3 Metagaming

The Jogging over a Distance system mapped heart rate for participants in a way that allowed them to compare it to their partner's: it was easy for them to identify if their partner was in front or behind, and this knowledge spurred a competitive attitude in some, fostering a desire to stay or get in front. Knowing their relative heart rate, participants used this to goad one another over the communication channel, this has been described as a form of metagaming, or the social interactions that happen outside the game (Salen & Zimmerman, 2003a). The communication channel was used for both positive encouragement, but also provocative goading.

4.6.7 Bodily exploration

In exertion games, exploration occurs on a body level that virtual worlds can extend by creating mappings across layers of the body lens. This bodily exploration contributes to an understanding of the body that informs future exertion activities.

Participants reported that the system facilitated exploring different ways of running together: they added sprints to their repertoire, compared their new-found activity to interval training and generally found new ways of running together. Participants experienced this exploration in a social manner, as they explored their body's abilities together, facilitating social play. The systems design facilitated this exploration of the body through the process of mapping body data to a digital representation, in particular, it mapped the usually hard to grasp heart rate to an easily identifiable audio location. Participants were aiming to figure out what this mapping was all about, and the way to do so was by exploring a rich set of bodily actions. As participants knew that their heart rate affected the virtual audio world, they knew that changes in speed affects the audio, however, they did not know *how* it affected it unless they started moving their bodies. They also realized that other activities, besides jogging, affects their heart rate, and as a result the virtual sound location. So for the participants, the mapping process they explored was a two-step process: from body movement to body response to digital representation. If seen from a body lens perspective, this highlights how participants explored the linkages across two of the layers.

4.6.7.1 Designing for bodily exploration

The technology design fostered this bodily exploration in two ways: First, it used heart rate data as input, rather than conventional pace data more commonly used in jogging support systems. Secondly, it offered relative feedback, meaning feedback always depended on the other person, rather than absolute feedback. As a result, the system gave participants a new opportunity to explore their bodies and their physical abilities. They explored how different speeds increased their heart rate, and how quickly their heart rate settled down again. As the mapping to the audio space was only in relative terms, the participants needed one another to learn more about how their actions affected their heart rate.

Participants explored their bodies through the representation in a virtual space. This has analogies with exploration in conventional computer games, where the exploration occurs often on a 3D world level, however, in Jogging over a Distance, the exploration occurred on the body level. The use of virtual spaces for exploration is a common feature in many computer games (Nitsche, 2009; Vorderer, Hartmann, & Klimmt, 2003), where one of the key questions computer games invite players to ask is “What happens if …?” (Pagulayan et al., 2003). Such exploration can contribute significantly to the enjoyment of the computer game experience (Lazzaro, 2004; Vorderer et al., 2003). In button-press computer games this invitation to explore usually refers to an exploration of the virtual world, as the game controller itself does not afford much exploration: in games such as Grand Theft Auto (Rockstar Games), exploration happens almost exclusively in the virtual world. Exploration on the controller level is rare, and if so, associated with negative connotations, for example Juul and Norton explain the frustrating experience of needing to explore what the many buttons on a gamepad stand for (Juul & Norton, 2009). However, if properly designed, such exploration can be part of the appeal for games (Juul & Norton, 2009). In Jogging over a Distance, participants explored how the movement of their bodies affected how their bodies responded in terms of heart rate, which was then mapped to a virtual space. As a result, exploration was facilitated on the body (the "controller") as well as on the virtual space level. The technology design facilitated exploration by utilizing the mapping from movement to heart rate. This mapping occurred 'within' the participant's body, hence was not technologically mediated, however, how the heart rate was mapped to the virtual space was a design choice. In Jogging over a Distance, this mapping was affected by the partner's heart rate in order to give the mapping a social component. As a result, the joggers explored the mapping in a social way.

However, in order to foster learning about their bodies, and in particular gain an understanding of heart rate, participants expressed that they would have preferred a visual indicator that is linked to their individual heart rate, rather than a social, relative representation.

4.7 Contributions

The main contributions pertaining to a deeper understanding how technology design supports social play in exertion games are depicted here again. First, the contribution of the design is:

> **Spatialized audio controlled by physiological sensing can level participants of different athletic abilities to facilitate an experience of jogging together even though participants might be in different geographical locations.**

Secondly, concepts arising from the analysis led to the following contributions. I begin each with a keyword that later informed the overarching framework:

1. **Contending: Supporting the ability to share pain – for example by amplifying the other's breathing intensity –**

can result in a decreased perception of the discomfort of exercise.

2. **Contending: Supporting social interactions can distract from the pain signals of the responding body, delaying the termination of exercise due to exhaustion. However, rewarding social interactions through game rules, although leading to more social interaction and hence distracting from pain, takes away energy participants otherwise expect to invest in the activity.**

3. **Contending: Exertion is fuelled by external goals, such as health objectives, which affects how participants are contending with the game and one another. Technology design can facilitate competitive or collaborative attitudes by mapping body data in different ways: allowing for comparisons facilitates competition, ambiguating body data facilitates collaboration.**

4. **Rhythm: Supporting participants in identifying a rhythm – from their own continuousness of movement, their partner's or external sources such as music – can be facilitated by emphasizing the beat within. This can facilitate exertion by reducing the perceived effort invested, however, rhythm can be "off" participant's own rhythm, affecting exertion negatively.**

5. **Understanding: In exertion games, exploration occurs on a body level that virtual worlds can extend by creating mappings across layers of the body lens. This bodily exploration contributes to an understanding of the body that informs future exertion activities.**

4.8 Limitations

Any study of a novel interactive system is limited by parameters that are shaped by feasibility and practicality. In Jogging over a

Distance, the use of a complex mix of computing and telecommunication technology that needed to be wearable, untethered, lightweight, power-resourceful and also be comfortable while coping with various outdoor conditions brought about certain limitations about how the study was carried out. In addition, the need for two participants to be available at the same time, in favourable weather conditions, with the desire to jog, resulted in further constraints, in particular when the volunteers were located across continents, making extensive logistical preparations necessary.

The study could have benefited from more runs by the participants. Participants experienced only a limited exposure to the system, many pairs only got a chance to use it once, while some jogged with the system several times, but not more often than four times. With an opportunity to experience the system more often, usage data might have revealed additional insights on the role of technology to support sustained exercise behaviour. This could help adding to our understanding of long-term behaviour change (Fogg, 2002), however, this is not the focus of this study.

Another limitation of the study was that not all participants were jogging “over a distance” but rather in the same park, in opposite directions. The aim was to recruit a noteworthy amount of participants to capture a wide range of possible variations within the limitations of conducting a practical study. 32 participants were recruited, however, the practicality of equipping joggers with the necessary equipment and capturing their interview data over a distance limited the amount of studies conducted with geographically distant joggers. As a result, the local jogging pairs recruited in the same cities were asked to run in opposite directions to simulate this “over a distance” scenario. Those participants stated that they could envision using the system in a distributed setting, and the joggers who used it in both “over a distance” and simulated settings did not display any significant difference in use, indicating that the data gathered in simulated settings also has credibility to contribute to an understanding of the experience.

Another limitation was that the study only observed pairs who knew each other well. Participants with no prior history might experience exertion activities differently. Furthermore, the study only observed two participants jogging at the same time. A system that supports more than two people simultaneously might draw attention to design issues that might not come to the fore in two-player settings, for example in multi-user distributed systems it might not always be obvious who did what. In Jogging over a Distance, interactions are always attributed to one specific person, as there is only one partner, however, mediating exertion interactions between multiple participants might reveal design challenges regarding accountability. In Jogging over a Distance, such issues could have not arisen, and hence not inform any understanding in this regard.

Lastly, the participants' interactions in Jogging over a Distance were only directed at each other physiologically. The joggers could not interfere with one another using their bodies, which was imposed by the distributed nature of the activity, but also by the nature of the exertion activity itself: joggers do not interact with one another bodily, there is no body-contact in jogging, as implied by the implicit rules of jogging. A characteristic of many sports activities is bodily reciprocity (Vossen, 2004), which can be a key element of exertion interactions, however, this was not investigated in the study.

4.9 Conclusions

In general, this study has led to a deeper understanding of how social play can be facilitated by design in an exertion experience. It began by demonstrating that social play can occur between participants even when they are distributed. This study then delved deeper and explicated specific concepts that facilitated this social experience. This was then related back to certain design features.

In sum, this study offered an understanding of how technology design can support people in investing physical effort, but that guidance for such design is not straightforward. In particular, the study highlighted that physical risk can be a salient factor in exertion experiences, and that technology can change the perception of risk, for example by introducing a social component. The study also sensitized the exertion games designer to the role of rhythm in exertion interactions by highlighting the beat arising from the body responding to exercise and also from the moving body. Technology design can also play a role in changing the perception of the physical discomfort or pain that can emerge from the exerting body: the Jogging over a Distance system made joggers more aware of their partner's pain by focusing on the breathing, but also distracted joggers from their own pain. Being aware of their own as well as their partner's pain led to a sharing of pain, which in turn affected participants' exertion. The study also showed that a designed mapping between the body and a virtual representation could facilitate exploration on a body level, fostering an understanding of the body. Furthermore, the study demonstrated that participants are contending against their own body's limitations, but they also compete and collaborate, which design can facilitate.

This study has also demonstrated the usefulness of the body lens in describing the various insights that emerged. The perspectives of the body lens helped to structure, articulate and frame the various concepts that emerged from the data, offering a scaffolding on which to pin the various conceptual findings.

Having a richer understanding of how participants experienced Jogging over a Distance allows an exploration of how the system design's features facilitated rich and complex social play. Comparing Jogging over a Distance to an earlier system that uses a straight audio communication channel using Bluetooth headsets (O'Brien & Mueller, 2007) helps illustrate this: in the mobile phone system participants can hear through the audio that their partner invested physical effort, but in the Jogging over a Distance system, participants could also tell how much effort their partner invested, at least in relation to their own. As a result, participants were contending to be in front or to stay together. Such activity is richer in bodily reciprocity than simply being aware that the partner is investing effort. This does not mean that jogging with a mobile phone is unengaging, to the contrary, as the study with the mobile phone system showed (O'Brien & Mueller, 2007). However, having the ability for more complex bodily reciprocity allows for more complex social play, giving participants richer opportunities for engaging exertion interactions.

4.10 A quick map for the road ahead

In the next chapter, system and study 2 will be described that present a view on how more complex bodily reciprocity affects people's exertion experiences. In order to accomplish this, another exertion game was developed: Table Tennis for Three. The aim of this system was to serve as case study for exertion play experiences of increased social play complexity. By adding insights from such a system, a more comprehensive picture of social play in exertion games will be painted.

5. Table Tennis for Three

Table Tennis for Three allows three players in three geographically distant locations to play fairly a table tennis-like game together.

Figure 5-1: Table Tennis for Three

5.1 Introduction

This chapter presents a study of Table Tennis for Three, a table tennis-like game that supports three players in three geographically distant locations. A qualitative study of the gaming experience of Table Tennis for Three illustrates how social play can affect and can be affected by exertion play, when facilitated by a shared object that fosters non-parallel play. The results illustrate how shared objects affect the exertion and social play interrelationship.

5.1.1 Motivation and goal of this chapter

The previous chapter described the social experiences that can occur in distributed jogging, where participants reported a "jogging together" experience although being apart. The study data suggested that the system facilitated richer social play than a simply race, however, I believe even richer social play is possible in mediated environments. The following design and associated study is aimed at investigating this.

Table Tennis for Three is a table tennis-like game that supports three players in three geographically distant locations. The design was inspired by table tennis, which affords richer social play than race-like experiences, and the aim of the design was to facilitate similarly rich experiences.

Additionally, Table Tennis for Three allows exploring opportunities in respect to the number of players. In Jogging over a Distance, only two participants were engaged at the same time. Computer games have already demonstrated that scaling to a large number of players is one of the strengths of incorporating network technologies (Salen & Zimmerman, 2003a), and in Table Tennis for Three, three players can play at the same time in a fair manner, something that is not possible in conventional table tennis. Scaling to an even larger number of players could be envisioned, but this chapter focuses on three players.

5.2 Playing Table Tennis for Three

The following section describes Table Tennis for Three, an exertion game that uses a real ball, bat and table while supporting players in three geographically distant locations. The prototype highlights the opportunity of technology to support the scaling of exertion experiences that are otherwise difficult to achieve in non-augmented settings, such as allowing three participants to play together equally.

5.2.1 Gameplay

Each player has an identical setup, including balls, a paddle and a table tennis table. The table is set up so that the ball can be hit against the vertically positioned opposite half of the table (Figure 5-1). This setup is familiar to table tennis players who practice on their own by playing the ball against the board. This backboard has projected images of eight large “bricks” on it. These bricks are identical for all players, i.e. they are synchronized across all three stations. A projector mounted to the ceiling projects the bricks in a semi-transparent fashion on top of two video streams of the other players in the game. One player is positioned on the left of the backboard, and the other on the right. Each table has a set of loud speakers and each player wears a microphone so the three participants can converse with each other.

The backboard is equipped with sensors mounted on the back that detect when and which brick the players are hitting. These bricks “break” when hit by the ball because the sensors register the location of the impact. All three players see the same brick layout and the same brick status layered on top of the videoconferencing streams. If a brick is hit once, it cracks a little. If it is hit again (regardless of by which player), it cracks more. The crack appears on all three stations (Figure 5-2). If hit three times, the brick “breaks” and is removed from play, revealing more of the underlying videoconference: the player “broke” through to the remote player. However, only the player that hits the brick the third and final time receives the point. This offers players a number of strategies for winning the game.

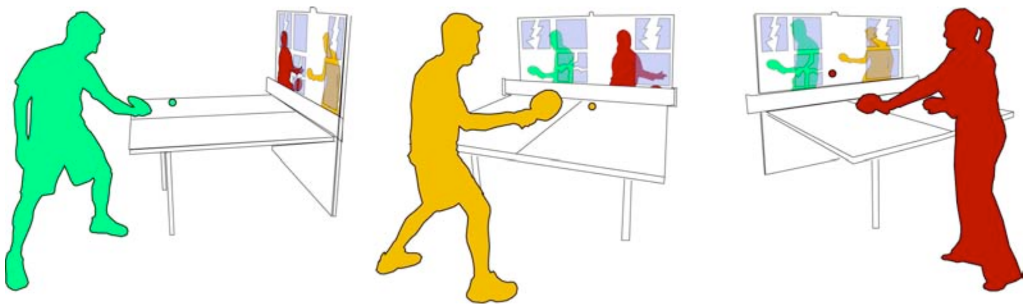


Figure 5-2. The bricks are shared across the three stations, a hit is visible to all players

The players can either try to crack as many bricks as possible by placing the ball quickly or they can wait for the opportunity to snatch away points from other players through hitting bricks that have been already hit twice by the others.

Each brick that is completely broken scores one point, and the running score is displayed along the top end of the projection. Play continues until all bricks have been cracked three times and been removed from play. At this point the player who has scored the most points is announced as the winner and after a delay of 15 seconds, the game resets all the bricks and play can recommence.

5.3 Study

5.3.1 Data Sources

The data used for the analysis comes from video recordings of participants playing Table Tennis for Three and videotaped interviews of all three participants together in one room. I also took notes during the interviews. The interviews contained open-ended questions about the players' experiences and their interactions with one another.

5.3.2 Data Collection

I recorded the participants during play with a video camera. Only one player was recorded at a time. If notable actions occurred on the remote end, this was observed through the videoconference. The interviews were also videotaped. Notes were also taken during the interviews.

5.3.3 Procedures

Each group played between 30-60 minutes. The players were brought together into one room after the game, where the interviews were conducted with all three of them together. The interviews lasted from 20 to 60 minutes.

5.4 Participants

42 participants were recruited through personal contacts, email lists and word-of-mouth. The volunteers were asked in the advertising material to organize themselves preferably in teams of three. If they were unable to do so, I matched them up randomly with other participants in order to have always three people participating at the same time.

I report on 14 teams of three. One participant played twice due to a last-minute cancellation (which was considered in the analysis). In total there were therefore 41 participants. The participants were between 21 and 55 years old (mean 31.6 years), and consisted of 27 males and 14 females. It is acknowledged that prior social relationships between participants can affect the social play interactions within a game (Salen & Zimmerman, 2003a), this aspect was taken into account by asking additional questions about how their existing relationships affected the way they played. The participants' prior exposure to table tennis was varied. One had never played before, 14 participants played less than 5 times, 18 players between 5 and 100 times and 8 volunteers played more than 100 times before.

5.5 Data Analysis

The video data was analysed using a coding process as described in the methodology section. I drew on sensitizing concepts that relate to the research question, to the previous study and the relevant literature. I used an iterative process with multiple viewings of the video data and also affinity diagrams to arrive at major concepts. Play and interview data was investigated separately first, but then analysed in terms of mutual theoretical constructs to validate the findings.

5.5.1 Coding

An iterative coding process was used to identify important concepts and ideas that emerged from analyzing the video data. The data was coded to locate concepts in an attempt to condense the data into categories. Aspects related to what I found in study 1 sensitized me, but I was open to new concepts that highlighted the unique characteristics of the system. I created annotations on segments of the data I found particularly interesting, and wrote down analytic memos during the coding process as reflective commentaries to form a basis for deeper analysis.

The list of concepts I created from the first pass helped identifying emerging themes, and informed the next coding step when the data was viewed again. In this second iteration, the focus was more on the concepts and the initial codes were reviewed and examined before checked if some of them could be combined.

In a subsequent viewing of the data, the focus was on instances that illustrated concepts. I tried to make comparisons and identify contrasts to support the conceptual coding categories I have developed so far.

Then, the emerged themes were grouped into logical groups and hierarchical categories were created.

5.5.2 Affinity diagramming

I then sorted the generated annotations, memos and codes into logical groups to create categories of important elements. In order to identify links and conceptual levels I placed these concepts in a spatial affinity diagram, looking out for whether they would be specific for Table Tennis for Three or exertion games in general.

5.6 Results

I begin by providing evidence that social play and exertion occurred. What follows is a description of concepts identified from the data. I highlight instances in the game and then discuss their theoretical relevance. Lastly, I explain how these findings contribute towards the research question.

5.6.1 Social play

The players encouraged themselves and each other during the game.

> *"Lets' go for it!" [P3, play]*

> *"P18, come on!" [P20, play]*

They were not shy of engaging in a competitive aspect, often expressed in statements such as:

> *"I really wanted to beat her." [P13, interview]*

If a player snatched away the last brick, I heard statements such as

*"You b***!" [P21, play]*

Although players interacted verbally with their partners during the game, some players also commented that they felt more like they were playing against bricks,

> *"not at each other. When playing, you are more focusing on the blocks than on the other player." [P15, interview]*

When I begun to ask this participant during the interviews if he had a sense of the other players during the game, he completed the sentence

> *"No. I was just trying to get the blocks. (The player next to him nods.) […] Because it's such a fast game, you don't have time to change your strategy."*

P21 described vividly how she recognized that she could have focused on the bricks, but realized that playing against "a person" suited her better. In the interviews she made the following comment to the third player P4 in her group:

> *"…you are playing against yourself, sometimes, because you are very competitive against the screen, whereas I was watching P13, and it was like, when I was telling her off for cheating, then I actually aimed the ball at P13's head, at the screen! (All laughing.)"*

5.6.2 Exertion

Participants were investing physical effort, and as a result, were exhausted. They commented on how quickly the game made them tired, in particular because they never had to wait for their partner, as in conventional table tennis. Participants also showed visible signs of exertion, such as sweat on their foreheads.

Next, an examination follows that investigates what aspects of the design facilitated social play and exertion.

5.6.3 Anticipation

Figure 5-3: During the interview:
"…and you just wait for the third one [crack] and try to get in there quick!"

The participants aimed at hitting bricks that have been hit before (see Figure 5-3):

> *"… and you just wait for the third one [crack] and try to get in there quick (makes a smash arm movement)" [P11, interview]*

> *"…[you] wait for someone to break the blocks and go for it" [P10, interview].*

However, their ability to anticipate which brick will be hit next was limited:

> *"[you do not] get a sense where the other player is … [or] where he is playing" [P12, interview]*

"… so I didn't know this was where you were throwing the ball" [P13, interview]

Anticipating the other players' movements mostly only played a role in initiating the game. P14 said during the interview:

"You are waiting, and as soon as you are ready" [both P14 and P1 initiate a gesture for a serve but stop just before executing it], P1 interrupts: "You are ready to go" [both finishing their movement, both smiling].

5.6.4 Accountability

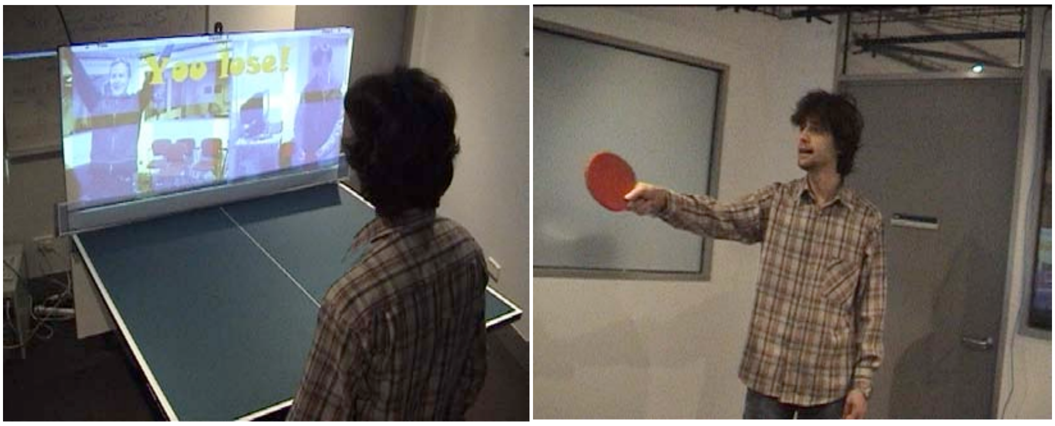


Figure 5-4: One player is excited about winning (left videoconference), the other player is commenting: *"How come I loose? (Very emotional, loud) That's wrong!"*

It was not always clear for the participants if a certain brick was broken because of the hit of the local player, or if another player hit it just shortly beforehand:

"I'm still not sure if I hit it, or you (points at P18) or you (points at 19) or somebody else." [P20, interview]

"You hit it, but actually someone else hit it before you, but you did not realize, because [P19] was such a kick-ass player (points at P19, both laugh)." [P18, interview]

Players had trouble linking their physical actions to particular players, including their own. During the interviews, they expressed that they would have preferred to know who did what, and what their individual progress was, but the system did not always provide this information in an easily comprehensible manner. The players said that they understood that they could have looked at the score, but this would have taken away their attention from the ball:

> *"(Makes shape of block with hands) [I suggest for a future design that] if you have a hit, just have a bold outline [on the screen]. If someone hits it, you get a flash of yellow" [P19]. "Yeah, … like even if it's gone, put a frame around it. And leave it there, because that's easier to check quickly than who has how many" [P18, interview].*

However, the players did look at the score at the end of the game, often commenting on it *("You've got zero [points]!" [P15, play]*), indicating that the score was an important aspect in the game:

> *"This is so exciting! (He then loses.) How come I loose? (Very emotional, loud) That's wrong! (Points at score, emotional) I know, I broke at least 2 glasses [sic], it'd give [sic] me one! These machines, you cannot trust them!" [P3, play].*

P18 wanted a stronger acknowledgement for his physical efforts and suggested that his harder hits should be recognized by the system differently to influence gameplay:

> *"If you hit it hard, you'd make it worth 2 shots. So even if there is only 1 crack, and you give it a good whack, it is all yours, just to piss off the other players even more (P18 and P19 laughing)".*

If players achieved a draw, they did not immediately realize with whom they drew, and if they lost, who won the game, resulting in questions for clarification.

> *"Who won that one? My bat's broken! Did you win again […]? God!" [P5, play].*

This asking of "who won?" was often accompanied by gestures over the video to support answers, such as when players were raising their arms or did a "winning dance".

Although several players showed signs of being irritated at who hit which brick, others were able to establish a direct link between an individual opponent's actions and his/her game outcomes, and used it to enhance their game experience. During the interviews, two players described that they played a "private" competition against each other by starting to aim at the same bricks on one side of the board. This was a decision not negotiated verbally between the players: during the interviews, it was revealed that these two players were aware of this, but the third person was not. The players reported that they decided to concentrate their efforts on beating each other, leaving the third player

> *"to do whatever he wanted to do (laughter)." [P19, interview]*

The two players identified that they had similar skills (superseding the third's), and hence decided to have their "own" competition within the game.

> *"…Cause I usually start with the left ones, cause I assume [P18] is there, he is better. (Realizes what he just said and turns to P20 and touches him on the shoulder.) Sorry!" [P19, interview].*

5.6.5 Secondary Performance

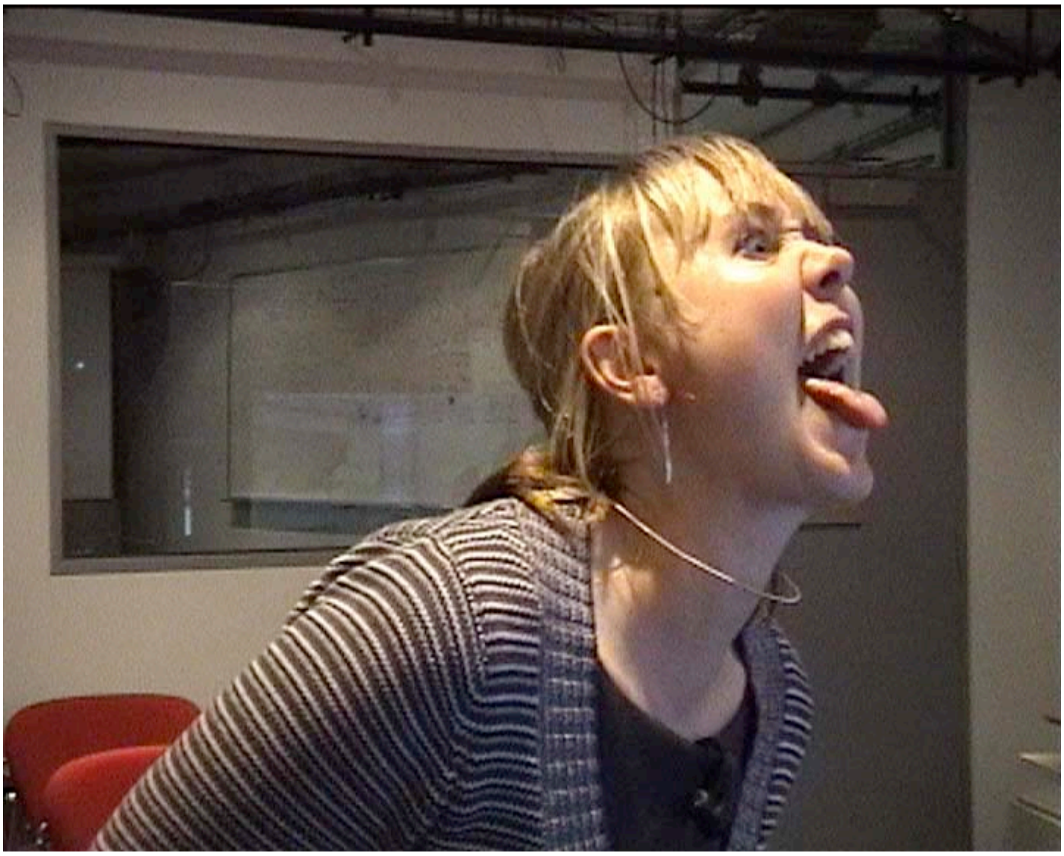


Figure 5-5: Player's reaction from playing against another player

Users demonstrated affective expressions during play, but predominantly outside immediate play: in between points, while having a break, and after the games. Most verbal interactions were of emotional nature and not in relation to play directly, such as swearing, yelling, or dismissing the other player, but sometimes also words of encouragement were exchanged:

> *"You are not trying hard enough!" [P5, play],*
>
> *"I'm going to beat you next time" [P7, play], or*
>
> *"You guys are hysterical!" [P8, play].*

Most of these verbal exchanges were of a joking nature, with elements of mocking, teasing or "fooling around", characteristic of social sports games (Weinberg & Gould, 2006).

Some users chose to supplement their verbal comments with a gesture, such as throwing their hands in the air to indicate they won. A player jokingly made a fist to the other players; another participant put her tongue out. Players often applauded others on their performance, and some performed little winning dances. This was often accompanied by laughter, facilitating a humorous atmosphere.

The exertion activity served as a starting point for social interaction, but it also hindered social interaction when attempted verbally: Players sometimes wanted to say something, but were not able to because they were too exhausted or too involved in their exertion activity. A player made this explicit by saying *"hang on…" [P5, run]* when the beginning of a new game interrupted his dialogue. He continued his verbal exchange in the next break of the game after he recovered from his exhaustion.

5.6.6 Movement Variety

Figure 5-6: Player hiding to try alternative serve

Players adapted rules from traditional table tennis to suit the interactions afforded by Table Tennis for Three. They also referred to table tennis and its rules in the interviews. Even though none of the teams discussed rules amongst each other before the game, they successfully engaged in gameplay by assuming the ball needs to be hit with the bat, cannot be returned volley, etc.

Nevertheless, players changed the way they played when an opportunity arose, such as when a player could not return the ball with her bat, but was able to catch it with her/his hand to increase the chance of winning. They also grabbed spare balls and played them successively, and hid under the table before serving (see Figure 5-6).

The players knew that this was “breaking” the rules, because they pointed it out if they caught someone: a player yelled out loud

"You cheat, you are a cheater!" (accompanied by laughter) [P9, play]

because a remote player was using her hands, but then this player used the hands herself. One player explained that it is hard to play against someone who is better:

"You have to cheat, you know, to win" [P12].

5.6.7 Tangibility

Figure 5-7: Ball flew off the side

Despite the players' best efforts, the ball often went unexpected ways: it hit the edge of the bat, and was diverted in the opposite direction. The ball also often bounced back quicker than expected, but a quick reaction on impulse of the player was able to deflect the ball in a manner that resulted in an unanticipated trajectory of the ball. The ball also often hit the edge of the table, being reflected off it in a surprising angle. Players looked amazed at how some of their hits returned the ball. These surprising situations are characterized by a considerably unexpected behavior of the ball that the player with his/her actions did not intend nor anticipated.

The challenging aspect of controlling the ball with the bat and the associated surprising actions that occurred contributed to the players' enjoyment, which was reflected in their verbal expressions: players often shouted short exclamations such as *"yikes!"* when the ball flew off in the wrong direction, often followed by a smile. This laughter was then answered with laughs by the remote players, and functioned as conversation starters. Players then switched their attention to the remote end if they heard such a surprise expression.

5.7 Discussion

I now discuss the observations in regards to how people played and interacted with one another.

5.7.1 Exertion and social play

Contending for control of shared virtual objects by means of exertion actions can facilitate rich social play – as evident by offensive and defensive tactics – even though participants might be in different geographical locations.

Loosely coupling exertion actions and virtual objects – for example by requiring skilful control of a mediating ball - can conceal technological limitations such as network lags while still support bodily reciprocity to facilitate social play.

On the one hand, participants appreciated being able to play with remote partners. They showed signs of playing together despite the fact that interactions were mediated. On the other hand, players reported that they sometimes felt more like playing against the virtual bricks rather than another person. I also observed incidences where players seemed to experience both, playing against another person and playing against bricks, such as described by the group around P21: they seemed to be able to navigate between these apparently contradicting experiences.

Table Tennis for Three facilitated parallel play in the physical world of the exertion actions, but also non-parallel play in the virtual world of the shared bricks. This explains why players expressed both, that they felt like playing against bricks but also against other players. The virtual bricks enabled a non-parallel game activity, which the players used to challenge each other in order to enrich their social experience. The players used this opportunity to engage with their remote opponents, trying to "outsmart" them to snatch points using tactical decisions to gain an advantage.

The main exertion action of the game, however, is the parallel activity in the physical space. This parallel aspect facilitated a sensation of playing against bricks, not other players, affecting social play. The players described the parallel aspect through expressing they felt like "racing" the computer bricks. When players had such an experience of "playing against bricks" and "not at each other", the mediating design fell short in facilitating a non-parallel experience at that moment.

The affordances of both parallel and non-parallel play were used by some players to enhance their experience. Especially the players who seemed to seamlessly navigate between playing against another person and against virtual bricks demonstrated that the boundaries of the spaces can become fluid in the context of use, and the users made them fit to meet their interactional needs.

It is also interesting to note that the physical ball required skilful control by the participants, which focused their attention on the exertion actions rather than the updates of the virtual bricks: due to limitations in the sensor or network technologies, delays in brick updates (changing from a full brick, to a broken brick, to a disappearing brick) can occur. Network lags in online games can significantly affect the user experience (Linehan, Roche, McLoone, & Ward, 2006), and are a challenge for any online experience. Unlike in button-press computer games, the effects of the delays in Table Tennis for Three appeared to be tempered by the focus on the exertion actions.

In sum, players experienced social play, both parallel and non-parallel, even though the interaction between the participants was mediated. Next, I detail what key aspects of the design led to this social play. This discussion serves as additional puzzle piece towards a framework that grounds an understanding of social play in exertion games.

5.7.2 Anticipation

The continuousness of bodily movements allows anticipating a player's next action, contributing to rich social play.

As previously described, a key characteristic of exertion games is the involvement of bodily movements, and supporting bodily movements is believed to facilitate social interactions (Lindley et al., 2008). For individual activity, this support of bodily movements is often associated with self-awareness of exertion actions (Consolvo et al., 2006; Moen, 2006), however, in a social setting, awareness of the other bodies and their associated movements becomes also important (Fogtmann et al., 2008): an understanding of the activities of others can provide a context for one's own activities (Rettie, 2003), and so called awareness of other bodies can be an important part of how we make sense of the world through our bodies (Dourish, 2001).

Knowing that awareness is an important element in supporting social play, it can now be discussed how anticipation was facilitated by the videoconferencing component. Players were contending for control of the virtual bricks. In order to gain an advantage, participants tried to anticipate their partner's next move. Such anticipation was possible because movement was involved, and this movement was continuous. Participants could sense this continuousness of movement through the videoconference.

Continuousness draws attention to the fact that bodily gross-motor movements as featured extensively in Table Tennis for Three are accompanied by preparatory and follow-through movements, quite different to button-presses. An exertion action involves movements that include a whole set of motions (Moen, 2006): for the Table Tennis for Three players, it was a backswing, a forward swing, the contact with the table tennis ball, and the follow through. Although only the contact with the ball counted towards the game, all elements formed part of play, and players tried to make use of it.

Players were aiming to be aware of their opponents' bodily movements by attempting to "read" these pre- and post-movements to anticipate future play actions. In Table Tennis for Three, the participants made use of the continuousness characteristic of bodily movements in order to enhance their social play experience by utilizing notions of anticipation.

When compared to traditional gamepad controlled games, it can be seen how the notion of continuousness has a particular role in exertion games. Being aware of a player controlling a binary button interaction does not reveal much of that player's intention behind the button pressing action. Anticipating a future move is very difficult with buttons, as they do not require visible sequential movements (a simple flick with the thumb is sufficient) that participants could use as cues to initiate an action.

Usually, this support for continuousness is assumed in co-located experiences, however, the mediation in Table Tennis for Three brought this point to the fore, as the videoconference's technical shortcomings hindered the opportunities for anticipation, as emerged from the data.

Continuousness is a direct result of "movements [being] situated in time and space" (Griffin, 2005). That is why animations representing player actions in computer games such as action fighting games display pre- and post-movements based on a single button-press. For example, a simple button-command in Tekken (Namco, 2010) results in the character to prepare for the kick by leaning backwards and moving the arm back, before propelling forward, hitting the opponent and then getting the arm back into the original position. As a consequence, if designers want to include anticipation in conventional computer games, they need to facilitate it in the virtual world. In exertion games, players can utilize anticipation due to the continuousness characteristic of movement; this means for designers that they have an additional way to support anticipation.

Interesting to note is that players in Table Tennis for Three utilized both, continuousness afforded by bodily movement as well as computer game play elements to anticipate future states of play. The players used the state of the bricks to anticipate which of them will be hit next and adjusted their actions accordingly. The players anticipated future actions not always directly based on movement actions over the videoconference, but on the results of the movements in the virtual space.

The mediating technology significantly affects how anticipation is supported in exertion games. In Table Tennis for Three, the capture area of the camera limited the space in which any continuousness movements could have been captured and hence transmitted, and the videoconferencing quality failed to capture very fast movements and hence anticipation was limited. Also, the conical shape of the camera did not always adequately capture the ball's flight path, hindering any anticipation of future moves based on the location of the ball. However, anticipation was further supported through the virtual objects in the game. In contrast to sports (anticipation occurs based on continuousness in the physical space) and computer games (anticipation occurs based on actions in the virtual space), anticipation in Table Tennis for Three occurred based on continuousness over the videoconference as well as based on actions in the virtual space.

Even though Table Tennis for Three supported anticipation, it did not support bodily reciprocity as, for example, a conventional game of table tennis. Although players in Table Tennis for Three were anticipating their partners' next move, they were also dealing with the task of controlling their own ball, which was acting independent from any other player. In conventional table tennis, every return hit is a response to the other player. Players in Table Tennis for Three could chose to respond to the remote players, but they could also chose to play a parallel play, just aiming to hit bricks in a random fashion. So the ball was not the mediating object between the players, but the bricks, where the ball was the mediator to the bricks. In addition, due to the conical shape of the videoconference, it was difficult to link partners' actions to specific bricks: although one could anticipate when a player is going to execute a hit due to the continuousness of movement, anticipating exactly which brick will be hit was difficult to anticipate once the ball left the capture area of the camera. I call this limited link between exertion actions and virtual objects a loose coupling, as the coupling is not permanent, but rather lose when the player focuses on controlling the ball, acting out parallel play, and tighter when hitting the virtual bricks, engaging in non-parallel play. This loose coupling shaped social play, but it also had advantages in addressing the limitations of the technology, such as network lags.

5.7.3 Secondary performance

Supporting people in expressing themselves using their bodies – in and outside the game – can contribute to rich social interactions and facilitate metagaming

Participants performed using their bodies as a way to communicate, in particular outside the game, as a form of metagaming.

Metagaming is a social play phenomenon that refers to the relationship of a game to elements outside of the game. One way that metagaming occurs "during a game other than the game itself…are social factors such as competition and camaraderie" (Salen & Zimmerman, 2003a). The participants engaged in a metagame experience by socially interacting with one another beyond the immediate game play. In particular, through the exertion nature of the game, they did so by using their bodies to communicate: firstly, exhaustion made verbal exchange more difficult, secondly, the bodily focus of the game lent itself to communication behaviour through the body. The participants embraced this by non-verbally commenting on the other players' performance and turning the game into a bodily spectacle beyond the gameplay itself. Larssen et al. (2004) found the notion of "expressive latitude" particularly fitting in the context of exertion games to describe such behaviour that is not directly influencing the game outcome, but can have communicative aspects. I call this secondary performance.

Interestingly, aspects of secondary performance also appeared in the interviews, in particular when participants were "retelling their experience". The retelling of what happened in a game is an important part of a "lived experience" (McCarthy & Wright, 2004). Players predominantly used their exertion skills in the games, so they drew on these skills again during the reliving of the experience. This reliving of a "pleasurable kinaesthetic stimulation" can re-trigger the associated pleasurable emotions

(Iso-Ahola & Hatfield, 1986). Re-enacting the exertion movements can also support the player's cognitive processes, helping them remembering certain parts of the game (Lindley et al., 2008). Players gave further meaning to these exertion actions by reliving and sharing them with others, the support for secondary performance appeared to contributed towards a social play experience. These exertion actions supporting secondary performance are missing in conventional gamepad-controlled computer games, and their players have to rely on their cognitive skills to remember their lived experience and associated affective responses.

I would also like to draw attention to the second aspect of secondary performance, especially as it usually does not occur in traditional games. Bodily movements can trigger social interactions, but it was also observed that exertion can prevent players from engaging in dialogue, often simply because they are out of breath. This led to a focus of secondary performance "between games" that was unique to exertion games. The players in Table Tennis for Three invested physical effort, which led to muscle fatigue and physical exhaustion. The challenge for the players was to regulate their energy level throughout the game by varying their exertion and using breaks between games to regenerate. Some players extended the breaks created by the game to accommodate their physical recovery needs. These extended breaks then afforded social interactions amongst the players, in which arousal levels were often still high from the exertion activity that preceded them.

Players in non-exertion games also include breaks in their activities. However, I argue that they are not as frequent as in exertion games, and are not motivated by a similar physiological urgency. A computer gamer using a mouse might schedule a break to do some repetitive strain injury-preventing wrist movements, however, its duration and frequency is very different to breaks in exertion games. Players in non-exertion games often *chose* to take a break, these games are not a necessity that their body *demands*. If the players take a break, they want to regenerate from the cognitive demands of the game, in an exertion game, the social interaction is a diversion from the main activity.

5.7.4 Movement variety

The rich variety of movement facilitates to be creative in finding alternative ways - some call it cheating - to reach a game's goal, including the exploitation of technological limitations. This can facilitate rich social interactions ranging from disclosing to showcasing these alternative ways.

The participants explored the many ways of bodily movement to achieve their goals; I consider this a form of self-expression. The participants played with the limitations of technical mediation, using it as resource for "bending the rules". This cheating was used to enhance the experience, a phenomena which has been previously observed in traditional computer game play (Consalvo, 2007). However, the inclusion of exertion in Table Tennis for Three afforded a new approach: players explored their bodily movements within the space of opportunities the sensing technology allowed (or not allowed, as not all actions were sensed), and what was communicated over the videoconference. Benford et al. use the terms "expected, sensed and desired" to differentiate different interactions with sensing systems (2005); using his words I would say that the participants were playing with the various categories that the sensing systems afforded. As the context was a game, the participants explored their movement variety within the sensing space in order to enhance their experience. The players were not so much trying to "break" the rules as to rather "bend" them, exploring alternative ways to achieve the goal in order to catch up with an advanced player, make the other player laugh, and so forth. This has been described as transformative social play, in which players actively engage with the rule system in order to shift or extend their relations with other players (Salen & Zimmerman, 2003a), therefore constituting a form of social play. The mediated aspect appeared to contribute to this, as it enabled a variety of opportunities for bending the rules.

The limitations of the technology enabled these opportunities in three ways:

1. The sensing system of the table tennis table afforded players exploring different ways to execute a hit: if I throw the ball, is the hit also registered? What if I throw it really hard, can I confuse the

sensors so I break two targets? Players were asking these questions in the interviews but also trying the different tactics out during the game.

2. Players realized that they could grab another ball in their other hand to serve as backup if the first ball goes astray. This was difficult to see over the limited video quality, especially in fast-paced games, as the videoconference system communicated only a limited resolution displaying a limited framerate. Communicating subtle details in rapid actions, as often the case in exertion games, is still a challenge for sensing and networking technologies. Players are aware of this and they play with it to their gaming advantage.

3. There was a mismatch between the space the player occupied and what the videoconference camera saw. Participants played with this mismatch (for example by hiding below the table), contributing to a joyful atmosphere, but it also affected social play negatively. In co-located exertion games, the physical space and what the other player sees are usually interconnected. In distributed games, however, these spaces might be disparate due to technical limitations. In non-exertion games this mismatch might not be important, as players might not move much. In exertion games on the other hand, players' activities involve many large-scale movements, which might conflict with conventional awareness technologies that are aimed at supporting focused awareness cues such as facial expressions. When one of the participants stepped out of the view of the camera, she became "unsensable" for the camera. By doing so, she also left the "magic circle of play" (Salen & Zimmerman, 2003a). This shows how movement variety in mediated environments can lead to problems, but also opportunities for finding alternative ways to reach the game's goal.

I agree with Salen and Zimmerman that this aspect of rule-breaking is more likely to occur in exertion games; they attribute it to the "athletic nature" of the game (Salen & Zimmerman, 2003a). Salen and Zimmerman compare this effect to a chess game, in which a player will not gain an advantage by having a little corner of his rook peek into an adjacent square. "But in the infinitely granular space of the real world, milliseconds and millimeters can mean the difference between winning and losing" (Salen & Zimmerman, 2003a).

5.7.5 Tangibility

Utilizing the uncertainty that arises when the body interacts with physical objects can level the playing field between participants of different athletic abilities by adding an element of surprise that facilitates engagement.

Unlike other exertion games such as Microsoft's Kinect (Microsoft, 2010) which uses vision analysis to detect exertion actions, Table Tennis for Three exploits the affordances of tangible objects which included the ball, bat and table. For the players, the tangibility of the play objects provided another advantage: it contributed to an uncertainty of play, creating opportunities for surprise. This allowed levelling the playing field between participants, especially of different athletic abilities: a player who was behind in points could all of a sudden receive an advantage due to a surprise event, adding to the excitement of the game. This notion of surprise was appreciated by the players, as it has been previously recognized in physical play (Czajkowski, n.d.) and augmented mixed reality games (Sharp et al., 2007). The results of uncertainty contribute to Gaver's claim that the physical environment can provide affordances for social interaction in games (Gaver, 1996), and Hornecker's suggestion that "the richness of bodily movement" in combination with tangible interfaces is particularly beneficial for social interactions (Hornecker & Buur, 2006). Exertion amplified the chances and outcomes of tangibles' uncertainty: tangibility can support uncertainty without exertion; however, the diverse, fast and forceful movements exhibited in exertion play facilitated these surprising moments for the players. Also, involving the body and the "real world" has been pointed out to add an element of uncertainty in location-based mobile phone games, which designers need to be aware of (Benford et al., 2003).

In non-exertion digital game play, these chance encounters need to be artificially introduced as an element of chance is inherent in most computer games. Game creators have to take special care in finding a balance between believable chance and randomness for the players (Salen & Zimmerman, 2003a). For example, in an exertion game such as the Nintendo Wii Sports Tennis, the ball on the screen might also be controlled by an element of chance; but it will be generic, as the ball will never bounce off the furniture that surrounds the player. The ball will also not bounce off the racquet's frame in much unexpected ways, but if it does, the experience will be "fundamentally different", as players might not believe the probability by which it occurred, but rather assume a bug in the software (Gaver, 1996).

5.8 Contributions

This study has contributed towards an understanding of social play in exertion games through the following contributions. First, the contribution of the design is:

> **Contending for control of shared virtual objects by means of exertion actions can facilitate rich social play – as evident by offensive and defensive tactics – even though participants might be in different geographical locations.**
>
> **Loosely coupling exertion actions and virtual objects – for example by requiring skilful control of a mediating ball - can conceal technological limitations such as network lags while still support bodily reciprocity to facilitate social play.**

Secondly, concepts arising from the analysis led to the following contributions. Again, I begin each with a keyword that later informed the overarching framework:

1. **Contention: The continuousness of bodily movements allows anticipating a player's next action, contributing to rich social play.**

2. **Expression: Supporting people in expressing themselves using their bodies – in and outside the game – can contribute to rich social interactions and facilitate metagaming**

3. **Expression: The rich variety of movement facilitates to be creative in finding alternative ways - some call it cheating - to reach a game's goal, including the exploitation of technological limitations. This can facilitate rich social interactions ranging from disclosing to showcasing these alternative ways.**

4. **Uncertainty: Utilizing the uncertainty that arises when the body interacts with physical objects can level the playing field between participants of different athletic abilities by adding an element of surprise that facilitates engagement.**

5.9 Limitations

I made the assumption that the user data gathered in a university building environment is representative to data that would have been collected in the field. Prior research has investigated the use of exertion games in people's homes in order to investigate the impact of their day-to-day surroundings on the experience, such as the limited space issues when playing Dance Dance Revolution (Sall & Grinter, 2007). The authors found that the living room is an unfamiliar and often unsuitable space for physical exercise, hence the university environment might be just as suitable to investigate an exertion game. Furthermore, I have tried to set up the table tennis tables in ways that resembles spaces in which such tables could be encountered, for example public areas in corporate environments. Also, traditional exercise is usually performed in a gym or on an outdoor field to which the participants generally need to travel to, just as they had to travel to participate in a game of Table Tennis for Three. There are also dedicated spaces in which commercial entities offer exertion game experiences (XRtainment, n.d.), sometimes described as interactive gyms, and these places also require participants to leave their familiar surroundings and travel first before they can participate. These examples demonstrate that a dedicated environment for conducting the study that is unfamiliar for the participants is not very unusual in the context of exertion games.

The participants were located in different parts of the building. This is not the same as being in different locations across the world, separated by significant distance that requires effort to overcome by travel. As the participants knew they were able to join one another physically after the game with ease, their social behavior might have been different than if they would have been geographically very far apart. The social implications that come with simulated distance have been put aside in this study, as “true distance” experiences were explored in Jogging over a Distance.

It is also acknowledged that scaling the system from a two-player version to a three-player system is only offering limited opportunities for investigating scaling effects of mediated social play. Online computer games have pushed the envelope of how massive scaling can be supported in gaming, with some titles supporting millions of players. Supporting three players in Table Tennis for Three seems meager in comparison. However, the system only served as vehicle to investigate social play beyond two players, and represents the first attempt to support player constellations that are otherwise hard to achieve in traditional settings: allowing three players to play together equally while investing physical effort.

5.10 Conclusion

I have presented a qualitative analysis of player observations and interviews from an exertion game to understand the facilitating role of design in the interrelationship between exertion and social play. Firstly, I have found further evidence that exertion games can facilitate social play, even in mediated environments. Secondly, I have identified the salient concepts anticipation, secondary performance, movement variety and tangibility that contribute to the link between exertion and social play and discussed the role of design in facilitating this link, in particular in regards to supporting offensive and defensive tactics as part of rich social play.

In the following study, this knowledge will be extended to include a perspective of differing bodily reciprocity.

6. Remote Impact

Remote Impact – Shadowboxing over a Distance allows distributed participants to box each other's shadow.

Figure 6-1. Remote Impact – Shadowboxing over a Distance

6.1 Introduction

This chapter describes the third exertion game, Remote Impact – Shadowboxing over a Distance (from now on shortened to Remote Impact) and its associated study (see Figure 6-1).

The previous studies resulted in findings that can guide the design of various exertion games: Jogging over a Distance was an example system for games that support a race experience. Table Tennis for Three stood for games that offer richer social play by allowing for offensive and defensive tactics. When looking at the social play continuum, it can be proposed that Table Tennis for Three offers richer social play than Jogging over a Distance because of increased bodily reciprocity. However, one might argue that Table Tennis for Three is a game with a rather particular form of bodily reciprocity: it features a mediating object that makes it exceptionally suitable for mediation, as no "direct" bodily reciprocity occurs. One might argue that table tennis, and hence Table Tennis for Three, separates the players spatially by the net in the middle of the table, preventing any body contact between participants. This represents a particular form of bodily reciprocity, where player's actions depend on one another, but are facilitated by a ball. The existence of such an object, like the ball, can serve as aid for the technical challenges faced by designers when they aim to support distributed participants, as the Table Tennis for Three implementation has demonstrated.

However, not all sports separate its players spatially like in table tennis. Many sports allow their participants to occupy the same space, and some activities even allow body contact, where participants are contending for control of each other's bodies. Boxing is a typical example for this. It should be noted though that although body contact is often associated with a high degree of bodily reciprocity, it is not a necessity: for example, capoeira, an Afro-Brazilian sport, relies heavily on bodily reciprocity, but does not allow bodily contact.

This differentiation between various forms of bodily reciprocity allows framing table tennis as an exertion activity in which participants are contending for control of the ball, whereas in boxing, participants are contending for control of their bodies. This differentiation has been found useful in sports in order to understand implications for the responding body, for example studies have used similar differentiations for specific sports to investigate participation preferences, injury risks, and so forth (Children's Hospital Boston, 2010; Coulomb Cabagno & Rascle, 2006; Keeler, 2007; Schroth, 1995). Here, I demonstrate the usefulness of this differentiation for technological mediation.

The question now is: how does social play unfold when bodily reciprocity is not mediated by an object? How does the lack of such an object affect the experience, and how can design address the technological challenges faced when such games aim to support distributed participants?

Remote Impact aims to contribute to answer these questions. Remote Impact is inspired by boxing, and hence does not feature a facilitating object such as a ball. Nevertheless, it does support distributed participants.

Extending the results from the previous studies, the findings implicate a refined understanding of design insights for exertion games that together form a more comprehensive picture of how design can support social play in exertion games.

This chapter begins with a description of the Remote Impact system. Then the study surrounding Remote Impact is detailed, including how the data was processed and analysed. Lastly, the findings are presented and discussed in relation to implications towards social play in exertion games.

6.2 Aim and approach

The aim of this study is to understand how participants experience social play in an exertion game where participants are contending for control of their bodies.

6.3 Remote Impact

In Remote Impact, two players in two geographically different locations enter the identical interaction spaces (see Figure 6-2). They are facing a vertical sensitive playing area, on which the shadow of the remote person is projected. In addition, their own shadow is also displayed, in a different shade of grey. These shadows appear to be created by a light source behind the players: if the players step closer to the interaction area, their shadows increase in size. If the players face the interaction surface, it appears as if the other person is standing next to them, because the shadows show the silhouettes of two people. The interaction area covers both body shapes from head to toe, spanning a complete surface area of 2.10 x 2.50 meters. The players can also talk to and hear each other through a voice connection between the locations.

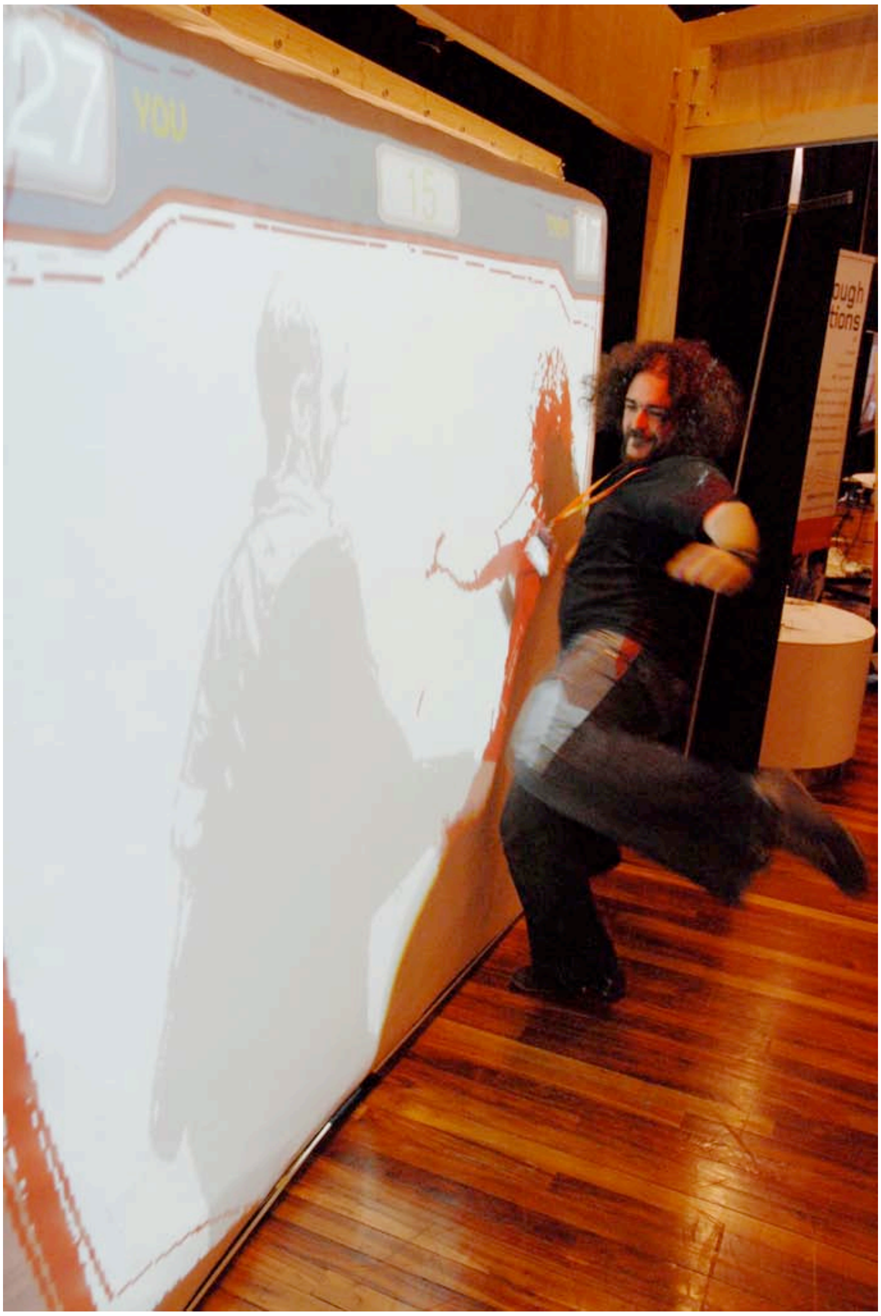


Figure 6-2. Remote Impact

Once the game starts, both players try to execute impacts on each other's shadow. They can target any area of their partner's body, and administer hits with their hands, feet, arms, legs, or their entire body. They can hit with a flat hand or use their fists. Players can punch, kick, or throw their entire bodies against their projected opponent. An impact on the remote person's shadow area is considered a successful hit. Depending on the intensity of their hit, they receive more points, which are displayed at the top of the screen, visible to both parties. If a hit is placed within the shadow area of the remote person, a visual indicator is displayed on the impact spot and a sound effect is played to indicate for both players that a successful hit occurred. Players can dodge hits by ducking or moving out of the way. If the player missed, a different visual appears, indicating that no points were added to the score. Players can execute very strong hits, and punch in quick succession. The player with the most points wins the game.

6.4 Technical implementation

Each station consists of a specially made impact area, consisting of two layers of foam and several layers of fabric. The foam is protected by a silky soft polyester lingerie fabric because its smoothness was required to minimize friction with the impact cover, which is made out of ripstop material, usually used in parachutes and therefore very strong and durable, but soft and lightweight. It is non-stretch, which was a requirement for the detection mechanism. Its white colour also reflects the projection well.

A wooden frame is glued underneath the foam to hold the two surface fabrics in place. To ensure a tight fit, I have sown elastics into the fabric. The impact of the user's body onto the surface is measured by detecting the deformation of the surface area, facilitated by the foam: upon impact, the non-stretch fabric exhibits pulling forces all the way to its sides, where it is held in place by 13 elastic bands, serving as springs. These elastics stretch when an impact occurs, and distribute the force based on the locations of the attachments, forming a grid of 42 impact locations, which I found sufficient considering the size of a fist impact. Attached at either end of the elastic bands are stretch sensors. The sensors behave like variable resistors, the more they are stretched, the higher the resistance. Initially, I had used conventional surface material, which stretched, and therefore did not apply enough forces for the sensors to pick up, hence the decision to use the parachute material.

Each sensor is connected to a data acquisition board that measures change in applied voltage. Peaks above a certain threshold determine the location of the impact, and the height of the peak allows the calculation of the intensity, resulting in a three-dimensional impact plane.

6.4.1 Advantages of the implementation

Other researchers have designed systems to detect impact on large surfaces (for example Paradiso et al. present several (2000)), but they are usually limited to interactions using hands or feet only and do not cover a large area. The Remote Impact system supports very forceful interactions, protecting the user by the use of 15 cm thick foam. Furthermore, the stretch sensor approach allows for the detection of large impact areas, such as when a user throws their entire body onto the surface. If a user has already part of his/her body touching the area, additional hits are still detected, making the system multi-touch capable. Unlike other systems that embed sensors directly into the surface area, Remote Impact's interaction space consists of sturdy fabric and foam that can be hit and kicked ruthlessly.

6.4.2 Design challenges

One major challenge I faced when designing Remote Impact is the cone-shape capture area of any camera that is used in videoconferencing systems. Systems that use videoconferencing components to allow for video interactions between their users, such as demonstrated by Breakout for Two (Mueller et al., 2003), assume the actors stay a certain distance away from the projection screen, which is on the same level as the camera, capturing the local action. In contrast, in Remote Impact, the user wants to, and is encouraged to, come as close as possible to the other person's shadow. However, the conical capturing area of the videoconferencing camera, or in fact any lens-based system, can capture only a limited area of the person once the person gets closer, ultimately resulting in "no capture" once the user blocks all available light coming into the lens. Wide-angle lenses can only partly address the issue of not capturing enough of the interaction area; once a participant wants to touch certain parts on the projection surface, even the widest angle lens will not be able to capture all interactions.

I therefore opted for an alternative approach to visualize the surface actions on the remote end: a camera mounted behind the participant captures the player's actions. This approach captures all body movements, even when interacting with the surface area close-up. However, instead of distributing the video stream of the participant's back to the remote end, I use image analysis to detect the contours of the person and display the participant's silhouette instead. I use a segmentation algorithm and distribute the generated vision analysis result over a network connection to the remote end. The participant is able to determine the other person's bodily interactions in real-size, even when standing close to the projection surface or touching it. However, the silhouette functionality takes away any facial expressions of the participants.

6.5 Study

The goal of the study was to understand qualitatively what it was like for participants to engage with Remote Impact, and how contending for control of the body was supported by the design in terms of facilitating social play as part of the exertion activity.

6.5.1 Participants

First, the system was tested for functioning and durability during an open house event with 49 visitors. The system functioned as envisioned and consequently I initiated the study.

Potential volunteers were invited from personal contacts via word-of-mouth and email, as well as through an internal mailinglist of the larger organization. Participants were also asked if they knew of additional participants who might like to volunteer, and if so, forward the email. This worked well; overall, there were 20 participants.

It was suggested to participants to bring a game partner along. All participants played with someone they knew, most often friends or family members. The participants were all volunteers and were not monetarily compensated for their efforts.

The participants were on average 31 years old. 14 participants were female and 6 were male.

6.6 Procedure

Participants were instructed in pairs how the game was played and how the system worked, before one participant was guided into a separate room that contained the second instance of Remote Impact. The extensity of the Remote Impact system made a "truly" distributed study across continents not practically feasible, hence a simulated approach was chosen where participants were in two separate rooms and could only communicate via the system, as if being far apart.

Participants were invited to interact with the system in any way it suited them and for as long as they wanted.

6.7 Data collection

Observational data recorded with a video camera from the participants playing were the main data source. Participants were also interviewed together after the game, being asked questions about their experience. The questions were open-ended and informed by a checklist I prepared beforehand, but I was also open to any additional comments participants had. I took notes after these interviews to structure my thinking as well as capture any thoughts that arose during the interview.

6.8 Preparing the data

The study generated video observations of the participants, the notes taken after the interviews and the interviews themselves. The approach towards preparing the data was the same as in the previous studies.

6.9 Data Analysis

The general approach towards the analysis was the same as in the Table Tennis for Three study. I handled each participant pair's data individually, looking at the video three times interspersed with re-reading their respective interviews.

6.9.1 Coding

I began the coding process as in the previous studies by looking at social play, exertion, and aspects of technology design. I was also looking for all relevant mention or actions related to the insights I had identified in the previous studies. These instances were marked with the relevant concept description. I was also searching for any instances where the contending for the body characteristic of the game was mentioned or played a role in how participants acted.

I then returned to the data and combed through the previously coded passages for contending for the body, but was now searching for any evidence that might suggest how it affected social play. Then I inspected the data for evidence that related contending for the body back to specific design features, and marked instances accordingly.

In a next step of the coding process, I looked at all codes individually, listing them with their respective data. I also prepared phrases that summarized each and assigned them accordingly. I used these in affinity diagrams again in an attempt to seek out relationships between them and combined related statements into larger clusters. The result was higher-level concepts that became the headings of the findings section.

As in the previous analyses, these concepts were checked with the original data: I was making my way down towards each participant to ensure that there was data that could support these concepts.

6.10 Results

Generally, the participants exhibited social play as well as exertion. As in the previous studies, I begin by providing evidence that social play and exertion occurred despite the distance, before going into detail of specific practices that arose, relating them back to specific design features. The findings lead to implications for technology design that are then discussed.

6.10.1 Social Play

The data indicates that Remote Impact indeed facilitated social play, despite the geographical distance between the participants. Participants were engaged with the system and reported a together experience, however, they also reported that sometimes they were playing against a computer.

6.10.1.1 Participants had a "together" experience

Participants expressed in the interviews that they felt like they were boxing "together". However, it is interesting to note that two types of dominant playing styles emerged that can provide further insights into the together experience.

Most participant pairs started off with a playing style I anticipated: they moved their body extensively, trying not get hit, and, when in a good position, executed a hit. This strategy can be framed as a defensive one, where the main objective was to be hit less often than their partner. However, after a couple of hits, many participants turned their strategy around and played more offensively: they were hitting much more often, and faster, seemingly not being worried about getting hit. The goal changed to hitting the other person more than avoiding getting hit. One pair kept their defensive play style throughout their play, however, all other pairs turned to more offensive play by the end.

Remarkably, participants' actions appeared to become so offensively oriented that it appeared as if they were *"just hitting the mattress as fast as I could"* [P2]. One participant moved left and right while punching aggressively in rapid succession, while his partner was not moving his body at all but applying quick hits. For players such as these, the hitting action became overly dominant over any tactical play.

As a result, it seems not surprising that some participants noted that they were *"playing against the computer" [P3],*

or "just hitting a mattress" [P6].

In other words, Remote Impact facilitated both parallel and non-parallel play, similar to Table Tennis for Three. However, participants noted that there was more to the game than "just" hitting a mattress, as participants enjoyed the sound effects and the resulting score, which allowed them to relate their exertion actions to their partner's:

"Yeah, I win!" [P7]

"[Reads out score]: Not too bad!" [P9]

In sum, participants reported they had a social play experience of playing together, however, as a result of continued play, they turned towards more offensively oriented play that appeared to facilitate less of a "together" play experience than the more balanced play style.

6.10.2 Exertion

Participants exhibited intense hits with their hands and feet in very rapid succession. Most participants kicked as fast as they could, supplemented by using their entire body when their arms or legs became tired. As a result, participants were often very exhausted at the end of the activity:

"It's a lot harder than you think." [P5]

"[Exhaustion noise] I need some water." [P3]

One participant had played an hour of squash before the study, and commented upon leaving that Remote Impact was more exhausting for him than the squash game. He and other participants showed signs of sweat, and removed layers of clothing in between rounds. Participants said they enjoyed the activity, but they also said they had to stop because they were too exhausted.

6.10.3 Intensity

Participants enjoyed trying to hit the interactive surface as hard as they could. Softer hits received a lower score but could be administered more quickly, hence I expected that participants would experiment with different intensities to determine the best strategy. However, the majority of players quickly decided that hitting as hard as they can was more enjoyable for them. Two participants described it independently as

> *"great stress relief." [P3][P9]*

It was difficult for participants to determine the intensity of individual hits: most actions were happening too fast to look at the score, remember it and subtract it from the new score after the hit. In fact, participants did not look at the score during their hitting actions. Therefore individual intensity rewards as expressed through points were not facilitating these actions of high intensity. When asked in the interviews what motivated them, participants said that they simply enjoyed hitting the surface area as hard as they could. Indicators for this enjoyment were smiles on people's faces and laughter when hitting at high intensity. In other words, participants found the ability to hit the mattress engaging:

> *"It just feels great, hitting this mattress." [P14]*

Participants expressed that the interaction surface

> *"just feels good when you push it in, like a mattress." [P6]*

6.11 Discussion

The following is a discussion of the findings that emerged from the data.

6.11.1 Exertion and social play

Contending for control of participants' virtual shadows by means of exertion actions can facilitate rich social play, even though participants might be in different geographical locations.

Tightly coupling the body with a virtual representation – for example by mapping movements to a virtual shadow – supports bodily reciprocity.

Compared to Table Tennis for Three, the body in Remote Impact was coupled tighter to a virtual representation: if the player in Remote Impact moved, the shadow moved as well. In Table Tennis for Three, the body only had an effect on the virtual targets by means of the ball, which can be described as a loser coupling: after the hit, the player has no more direct control of the ball, and suspends him/herself to the fate of the path given to the ball. Table Tennis for Three has shown that such an approach can have advantages: by focusing the player on the mediating object, technological limitations such as network lag faded into the background. With a tight coupling, a lag between movement and virtual representation would be more noticeable (this is an assumption based on early design tests, but as Remote Impact was delivered over a high-speed internal network, the participants experienced no noticeable lag).

A tighter coupling between body and virtual world would suggest heightened bodily reciprocity, which should result in richer social play. However, Remote Impact suggests that other factors, such as bodily risk can impact social play. The next section details how physical risk, and especially the lack thereof, affected social play in Remote Impact.

6.11.2 The body at risk

Reducing physical risk in exertion games affects bodily reciprocity negatively, hindering social play

Participants were not moving their bodies out of the way in order not to be hit, as they preferred concentrating on the offensive hitting movements. Getting hit did not matter for them: participants were punished through the points system, however, this virtual "pain" did not have implications on the way they exerted themselves. If they had experienced physical pain, like in a conventional boxing match, their exertion actions would have certainly been different.

Remote Impact was designed to offer a boxing-like experience, but without the physical risk associated with such an activity. The study showed that removing this element of risk in exertion alters the nature of the experience significantly.

By removing the physical risk, participants engaged in exertion actions they usually would not do. Possibly as a result of this, they enjoyed the stress relief of hitting something. Participants were not concerned about any pain or injury that could have resulted from the exertion. In consequence, they felt free to explore a range of ways to exert their bodies, including highly intense hitting actions, which allowed them to exert themselves extensively.

In comparison to conventional co-located boxing, the lack of physical risk in Remote Impact led to a reduced degree of bodily reciprocity: participants were less concerned about what their partner did, as the partner's actions did not have any "serious" consequences. By dampening the role of bodily reciprocity, the richness of social play suffered: this became evident through statements such as when participants expressed they felt more like playing against a computer than the other person.

This element of physical risk was not completed removed from the exertion experience, though: two participants proudly showed their bruised knuckles from overexerting themselves. These signs of pain were a way of demonstrating their bodily investment.

Klemmer et al. already pointed out that physical risk is one of the key differentiators between real and virtual (2006). Remote Impact demonstrated the role of physical risk in exertion games, and in particular how its removal can have a negative effect on social play.

6.11.3 Intensity

Understanding: Enticing the exploration of the intensity of movement – for example by reducing the physical risk commonly associated with intensity - facilitates exertion.

Participants found the ability to hit something very engaging. In particular, participants enjoyed exploring maximal intensity of their hitting actions. This was something that they normally would not do in their daily lives. As such, they were playing out a fantasy element often described as one of the key appeals to computer games (Lazzaro, 2008): computers allow players to do things they cannot do outside the game easily. In button-press games, this fantasy occurs in the virtual world, in Remote Impact, it was the opportunity to explore bodily actions such as hitting at maximum intensity.

Unlike in Table Tennis for Three, the game rewarded players if they invested high intensity, but it seemed as if the points did not matter as much to the participants as the sheer pleasure of executing these intense hits.

The design of Remote Impact supported this exploration of bodily intensity: there was no limit to how hard participants could hit the surface area, neither the sensor mapping nor the score were set to constrain the intensity by an upper limit. In other words, the design facilitated exploration of bodily intensity.

Intensity is one element of human movement. Intensity has its equivalent in dance theory with the term weight or strength as used to describe the force behind movements (Luna, n.d.). Unlike in dance, however, intensity in HCI is underdeveloped (Moen, 2006). Not many interfaces differentiate between different movement intensities or allow for maximum intensity. The Remote Impact study suggests that intensity can be a valuable addition to the characteristics of the moving body that technology supports.

6.12 Contributions

The main contributions pertaining to a deeper understanding of how technology design supports social play in exertion games are depicted here again. I begin with the contribution of the design:

> **Contending for control of participants' virtual shadows by means of exertion actions can facilitate rich social play, even though participants might be in different geographical locations.**
>
> **Tightly coupling the body with a virtual representation – for example by mapping movements to a virtual shadow – supports bodily reciprocity.**

Secondly, concepts arising from the analysis led to the following contributions. Again, I begin each with a keyword that later informed the overarching framework:

1. **Risk: Reducing physical risk in exertion games affects bodily reciprocity negatively, hindering social play**

2. **Understanding: Enticing the exploration of the intensity of movement – for example by reducing the physical risk commonly associated with intensity - facilitates exertion.**

6.13 Limitations

As with the previous studies that used novel interactive systems, practicality and feasibility were parameters that shaped the study of Remote Impact. Remote Impact offered new interactions with a novel sensing area, supporting a wide range of bodily actions, hence offering a unique insight into exertion games. However, this required a large, heavy and complex setup that imposed several restrictions on how the study was carried out.

The main limitations of the study were:

- The study was conducted in a lab, not people's everyday environment.
- Participants' contextual goals were only considered to a limited extent.
- Participants were only exposed to the system once rather than long-term.
- The "over a distance" scenario was simulated between different rooms, rather than supporting participants in distant locations.

The size and complexity of the setup of Remote Impact made placing the system into people's everyday environment impractical. As a result, participants were invited into the lab to engage with the system. To reduce the perception of participants partaking in a traditional lab study, two separate rooms were hired and emptied. As a result, the rooms were free of any laboratory “feeling”, only hosting the Remote Impact system, however, the compromise of the study being situated within a larger research environment still remained.

The size of the system along with the need for offering enough interaction space and hosting the same setup twice required that extra floor area needed to be hired. Due to the associated costs, long-term studies were not feasible. Long-term studies might reveal how exertion games unfold in people’s lives, and how they need to be designed for such use. However, it should also be noted that systems such as Remote Impact are not intended to be installed in people’s homes, but rather offer unique event-style experiences, such as many sports do that require specific setups or environments, see for example the opportunities to abseil, kayak, or mountain bike as part of holiday packages.

As previously mentioned, supporting remote participants was not very practical, so an “over a distance” scenario was simulated, with participants situated in different rooms. It was explained to participants that they could be anywhere in the world, and that the intention is to support distributed users, however, they knew that their partner was in the same building.

6.14 Conclusions

This study has led to an even richer understanding of social play in exertion games. The Remote Impact system contributed insights from a perspective of social play where participants are contending for control of their bodies. The findings revealed how certain design features facilitated exertion, but also hindered social play. The conclusions drawn from this complete the understanding gained in this thesis from three studies of novel exertion games.

6.15 A quick map for the road ahead

The next chapter will bring together what was learned from the three studies, compiling a rich understanding of how to design technology to facilitate social play in exertion games.

7. Crossing the finish line: A framework for exertion games

This chapter compiles the insights gained from study one to three. By looking at social play in the three games and examining the results from the three user studies, this chapter proposes design themes that are framed by the body lens as well as a view on computer games. The result is a theoretical framework for exertion games with a particular focus on social play.

7.1 Introduction

This chapter begins with a revisit to the social play continuum, explaining how the insights from the three studies helped to construct a more detailed picture of social play. Then I briefly recapitulating the body lens and explain the value it offers in seeing the three systems from the different perspectives in terms of social play. This will be followed by a discussion how these different perspectives can be valuable when designing future games. Then I explain how the layers of the body lens make up the columns of the design framework. Following this, a set of core elements from a game perspective will be presented. These elements make up the rows of the design framework. Lastly, the findings from the individual studies are folded into this framework by framing them as design themes that span a row of cells. The data collected from the studies as well as the knowledge gained from designing the games are used to justify the construction of the framework.

7.2 The social play continuum revisited

With the knowledge gained from the studies, a refined understanding of social play emerges when revisiting the social play continuum.

Jogging over a Distance looks like parallel play, as the underlying jogging activity is a parallel activity. However, through several design features, Jogging over a Distance facilitated bodily reciprocity beyond parallel play, enabling richer social play. These design features were created around the limitations of technology, but also utilized the advantages technological augmentation offered.

- Firstly, Jogging over a Distance allowed participants to be aware of each other's responding body by means of the voice communication channel. The voice channel allowed participants to hear each other's breathing, which was influenced by the bodily response to the exercise. In particular, the system's design focus on audio – by excluding video – and the placement of the microphone amplified this breathing, making participants aware of each other's body in pain. This facilitated social empathy, which in turn affected participants' physical effort investment.
- Secondly, the voice channel also allowed participants to identify a rhythm in their own and in their partner's exertion actions, by highlighting the breathing and footsteps, which both display a beat. This allowed for synchronicity of bodily actions, fostering another form of bodily reciprocity, supporting enriched social play.
- Thirdly, Jogging over a Distance mapped people's heart rates to a shared virtual world, which allowed participants to compare their effort despite being in two different locations. The ability to compare bodily responses facilitated competition and collaboration. The ability to engage in competition and collaboration offers opportunities for richer social play than simple knowledge of the fact that the partner is also investing exertion.
- Fourthly, the design of Jogging over a Distance facilitated rich social play by encouraging collaboration: the system made awareness of the responding body, the heart rate, only available in a social manner: heart rate was not conveyed in absolute terms, but only relative to the partner's heart rate, encouraging a collaborative approach to jogging.
- Fifthly, the design of Jogging over a Distance facilitated rich social play further by placing the heart rate data into an ambiguous audio space, which discouraged competitive attitudes, encouraging collaborative play. Depending on

> participants' goals towards the exertion activity (more social or more performance oriented), both collaboration and competitive attitudes were therefore attractive approaches for participants, providing participants with choices on how to approach the activity, and hence enriched social play.

So although participants in Jogging over a Distance could not interfere with each other's bodies (they could not push each other out of the way to get in front, for example), they utilized bodily reciprocity as afforded by the system's features on five levels in order to enhance the richness of social play. In other words, each design feature described above allowed the Jogging over a Distance experience to be "pushed" further towards richer social play on the social play continuum. As a result, Jogging over a Distance allows for richer social play experiences than, for example, a simple Bluetooth connection between joggers (O'Brien & Mueller, 2007), however, the experience is not as rich as in Table Tennis for Three: Table Tennis for Three allows for non-parallel play, a different category of rich social play, even further towards the richer end on the social play continuum.

Table Tennis for Three afforded even richer social play than Jogging over a Distance as it allowed for offensive and defensive tactics. Participants engaged in non-parallel play, as they were contending for control of the bricks. The bricks were shared, so if one person hit a brick, the other could person could not hit it anymore. Although the geographical distance between the participants does usually not allow for bodily reciprocity (the players could not engage in contenting for control of the ball, for example), the addition of a virtual world with its shared objects enabled non-parallel play. However, the limitations of the videoconference technology made it not always obvious how the virtual bricks and exertion actions were linked to one another, resulting in a loose coupling that limited bodily reciprocity. As a result, participants engaged in both parallel and non-parallel play: non-parallel play occurred as part of the engagement with the shared bricks, and parallel play around the exertion actions of controlling the physical ball. The support for both parallel and non-parallel play offers new opportunities for designers usually not available in non-technologically augmented exertion experiences.

- One feature that facilitated the engagement with bodily reciprocity was the videoconference that enabled to anticipate bodily actions as demonstrated by the participants who engaged in social play around the idea of "fake starts".
- The videoconference also supported the expressive power of the body, allowing participants to communicate with one another using their bodies.
- The limitations of the videoconference also afforded participants to explore their bodily skills in achieving alternative ways to explore the goal of the game; some of these actions were deliberately hidden from the other players as they were thought of as cheating, a questionable, but nevertheless social form of play.
- The use of a physical ball facilitated uncertainty arising from the body. This uncertainty added suspense to the game that allowed participants with inferior skills to achieve a surprise win, levelling the playing field between participants, which they appreciated: not only did this facilitate laughter, but also social play.
- The use of a physical ball emphasized skill development in the physical world, easing technology requirements such as network lag. Technology limitations, in particular network lag, can hinder engagement with the game (Linehan et al., 2006), and hence social play, therefore easing such requirements set favourable conditions for the emergence of social play.

Remote Impact also allowed for offensive and defensive tactics. As in Table Tennis for Three, the distributed nature would make one assume that non-parallel play is not possible, however, the design of the system enabled it through a tight coupling between exertion and shared virtual world.

- In Remote Impact, participants' bodies were tightly coupled to their digital shadows. These digital shadows were situated in a shared virtual world, which enabled the non-

> parallel play activity: participants were contending for control of their bodies' shadows, engaging in bodily reciprocity, which facilitated rich social play. The difference to Table Tennis for Three is that in Remote Impact, the link between exertion actions and virtual world is a tighter coupling: if the participant's body moves, the shadow moves. In Table Tennis for Three, this coupling is looser: the participant does not control the bricks all the time, and only through a mediating ball, once the ball is hit with the bat, control is ceased until the ball bounces back. This can have advantages, such as addressing network lags. However, by providing a tighter coupling such as in Remote Impact, bodily reciprocity is facilitated continuously: participants were constantly attached to their shadows, and they constantly had to watch what they were doing, as their partner could hit their shadow at any time. This tighter coupling facilitated bodily reciprocity, which fostered richer social play. However, although the coupling was tight in Remote Impact, bodily reciprocity could have been improved: as actions in the shared virtual world did not affect the physical world, physical risk was reduced. One can say that the coupling existed only in one direction, hindering the occurrence of physical risk. This lack of physical feedback has been explored in the research field of haptics (Srinivasan & Basdogan, 1997). This lack affected how participants engaged in social play: the joy of bodily expression via hitting movements often superseded plans to engage in richer social play.

In sum, the studies confirmed that social play lies on a continuum. As in sports, there is no maximum of social play designers should aim for, as each game on the social play continuum has its merits, similar to jogging, table tennis and boxing: none of these activities is more social than the other. However, broad categories do exist, as they facilitate different levels of enriched social play. These categories are helpful in understanding exertion games, in particular in regards to affordances of technological mediation. The studies have shown how different aspects of the design can facilitate or hinder bodily reciprocity, creating conditions that foster the emergence of enriched social play. With an understanding of how these aspects facilitate bodily reciprocity, designers have a conceptual guidance on how to design for social play in exertion games.

Having now revisited the social play continuum, a deeper understanding of how the design features in the three studies facilitated social play exists. With this understanding, I can now begin to construct the exertion framework that aims to provide such an understanding for exertion games in general. This construction begins with a revisit to the body lens.

7.3 The body lens

The body lens allows viewing of the body in exertion experiences from four nested perspectives that then combine together. The body is at the centre, encompassed by four layers:

- The Responding Body
- The Moving Body
- The Sensing Body
- The Relating Body

Together, these layers create a body perspective of four complementary lenses on the exerting body.

In the next section, I briefly detail how each one of them helps understand the three exertion games and serves as language to describe the results from the user studies.

7.3.1 The responding body

The responding body is a view of the body "from the inside", and how the body's internal state changes over time as a result of the exertion it is subjected to.

In Table Tennis for Three, bodily responses were only visible through their external signs such as sweating and panting. For the remote participants, awareness of these signs was facilitated by the videoconference. In Jogging over a Distance on the other hand, the responding body directly affected the mediating system: the heart rate of the body responding to running was utilized in the core game mechanic of spatialized audio. In Remote Impact, this view of the body highlights that participants were very exhausted quickly: as a consequence, games were played in several short sets with resting breaks in between.

Looking at exertion games from a responding body perspective highlights an elemental part of the bodily experience in these games: the studies showed that the body responds to effort investment most often quite drastically, especially when compared to conventional HCI activities that mostly elicit bodily responses only after very prolonged use. Moreover, it also points to opportunities for technology design to exploit these responses, for example by using the responding body as game input or communicating these responses to others to elicit empathy and encouragement. As a result, the responding body forms the first column of the exertion framework.

7.3.2 The moving body

The moving body focuses on participants' muscular repositioning of body parts relative to one another.

In Table Tennis for Three, the preparatory and follow-through movements players made to hit the ball were secondary to the game but communicated directly by the videoconference. In Jogging over a Distance, on the other hand, the jogging movements of the participants were primary to the experience but communicated only indirectly as spatialized audio. In Remote Impact, the differences in moving offensively and defensively were in part explained by how the design facilitated physical risk.

The moving body is the second column of the exertion framework.

7.3.3 The sensing body

The sensing body highlights the interactions between the body and its world.

The joggers in Jogging over a Distance were balancing the risks of running outside with the reward of an ever-changing environment. In Table Tennis for Three, this view points to the interactions with the physical ball (in contrast to a virtual one) and its affordances for uncertainty, and in Remote Impact it highlights the experiential correlation of one's body physically hitting one's shadow and mattress at the same time resulting in a sense of forceful impacts being transferred between physical bodies via virtual shadows.

A digital element is a key characteristic of exertion games, and how to design for this interaction between a physical body and a virtual world is one of the major challenges for exertion game designers. The sensing body highlights this challenge, and as a result this view on the body makes the third row of the exertion framework.

7.3.4 The relating body

The relating body offers a view on the bodily interactions that occur with other bodies as part of the exertion activity. As such, the relating body points to bodily reciprocity and the revisit to the social play continuum in Section 7.2

The view of the relating body highlights that the participants in Jogging over a Distance experienced their heart rate only in relation to their partner's, not to a heart rate monitor that displays an individual number. In Table Tennis for Three, it points to the fact that players were experiencing bodily reciprocity through the virtual bricks that were shared amongst the players. For Remote Impact, this view highlights that the player was relating to a virtual representation of another player, and that this representation resembled the body of the other player, offering a tighter coupling than the videoconference and virtual bricks in Table Tennis for Three.

The relating body points to bodily reciprocity. This is the reason why the relating body forms the fourth and last column of the exertion framework.

7.4 The game lens

The previous section presented four different views of the exerting body. Next, perspectives from a supplementary game lens are presented that are used to group the themes of the framework.

I was looking for a way to structure the themes that emerged from the studies. The solution I opted for borrows from a structured approach to understanding gaming from computer game literature: rules, play, and culture have been suggested as schemas to structure an understanding of computer games (Salen & Zimmerman, 2003a). Similarly, I propose the following to structure the themes of the exertion framework: *rules* refers to themes that deal with the formal structures of the game, *play* refers to themes that look at the experiences of the people involved, and *context* refers to themes that help with seeing the circumstances and environment in which the game takes place. As I focus more on the immediate context rather than culture, I use context instead of Salen and Zimmerman's culture. As with the body lens, the game lens is also layered, with the rules encompassed by play, which is encompassed by context.

7.4.1 Contributions as themes

Each study resulted in a set of contributions that are centred on a particular concept. These concepts were presented at the beginning of each contribution. Taken together, they form a set of themes for exertion games. These concepts can all be seen from one of the game lens perspectives, as they all highlight different aspects of the game experience. The concepts refer to a particular instantiation of an exertion game that often focuses on a specific body lens layer. However, the layered characteristic of the body lens means that exertion game design has multiple "handles" where design can "get a grip" (Hornecker & Buur, 2006), and as a result, I frame the concepts in a way that they are applicable across the range of layers of the body lens, stating them as themes for design. Embraced by the body and games lens, they form the exertion framework, offering a conceptual way to think and talk about exertion games (see Figure 7-1).

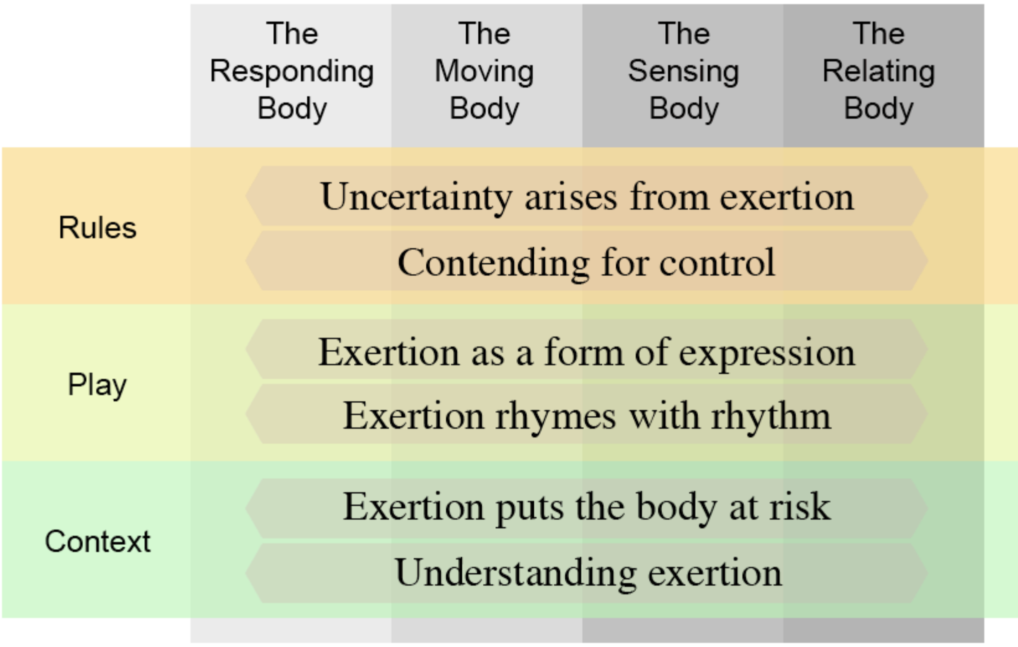


Figure 7-1. The Exertion Framework

7.5 The themes

I now explain each theme in detail, describe how these themes have advantages and disadvantages when considering them in design, make suggestions of how technology can facilitate them, as well as view them from the four body perspectives. I also describe an example for each as viewed from one particular body lens.

7.5.1 Rules: Uncertainty arises from exertion

An important element of many sports games is uncertainty (Salen & Zimmerman, 2003a): the ball dancing on the net before going over in a game of tennis, an adverse weather change in golf affecting some players but not others, and so on. All contribute to an element of suspense, facilitating surprise in games through random or chance events, contributing to what makes a game engaging (Moen, 2006).

In conventional button-press computer games, any chance encounters need to be artificially introduced through explicit program code, as the key presses do not offer a rich set of possibilities for uncertainty in terms of action and effect. In exertion games, on the other hand, uncertainty arises from exertion: the tiring body and its interactions with objects and the environment is a rich source of uncertainty. The body's response to exertion is hard to predict for player and technology alike ("how long can I keep up?"), and the variety of bodily movements can cause even simple actions to go wrong (e.g. missing a free-throw in basketball due to exhaustion).

Research on mobile phone games that have to deal with limited technology such as network coverage and GPS has previously shown how uncertainty can arise from the use of imperfect technology, and encourages designers to utilize this uncertainty, rather than work against it (Benford et al., 2003; Chalmers et al., 2005). The exertion framework suggests to designers to take a similar attitude and utilize the uncertainty of exertion in their designs, extending prior work by detailing how uncertainty can arise from four different perspectives of the body, and hence offer designers four handles from which to grab uncertainty: designers can utilize uncertainty coming from the responding body ("how exhausted am I?"), from movement (the difficulty of repeating and sensing precisely the same movement), from tangible objects (the challenge of controlling a ball) and others ("what is the other person doing next"?).

As a result, this theme guides designers to utilize the uncertainty arising from exertion, possibly augmenting it with uncertainty from the virtual world in order to facilitate more engaging exertion experiences.

7.5.1.1 Uncertainty arises from exertion & the sensing body

The physicality of objects such as balls amplifies the richness of bodily movement and draws on the nonlinearity between physical actions and effects, resulting in an uncertainty that has been exploited in sports (Czajkowski, n.d.) and mixed reality games (Sharp et al., 2007). In Table Tennis for Three, players reacted very emotionally when the ball hit the edge of the table, bouncing off in unexpected ways as a result of "lucky" shots. Such shots can be achieved intentionally with practice, but always carry an inherent risk and “fluke-factor” that heightens suspense for both players and audience, making the outcome of the game less predictable. Moreover, if the ball flies off into a hard to reach spot, it can give another player, who might be behind in points, a new chance to get back into the game, changing the social dynamic of the game in an instant.

7.5.2 Rules: Contending for control

The notion of conflict or struggle is an intrinsic element of all games (Salen & Zimmerman, 2003a). It is a consequence of my definition of games that states that participants engage in activity towards a goal to overcome unnecessary obstacles. Whereas in button-press games these obstacles are virtual, in exertion games these obstacles extend to the body. Through the studies, three broad categories were identified as to how exertion games facilitate obstacles participants are contending with: in Jogging over a Distance, participants were contending for bodily control by wanting to run faster, and not stop. In Table Tennis for Three, participants were contending for control of game objects, the virtual bricks. In Remote Impact, participants were contending for control of their virtual shadows.

The advantage of introducing computers to this bodily contention is that digital technology can selectively hide bodily information from participants as well as reveal it (Salen & Zimmerman, 2003a). The corresponding exertion can benefit both from increasing and decreasing awareness. A person’s awareness of his/her exercise investment can entice them to compare their energy expenditure over time and with others, fostering a competitive element that motivates them to invest even more (Sunny Consolvo et al., 2008).

Furthermore, in Jogging over a Distance participants were being made aware of their partner’s exertion, which facilitated a sense of shared pain. In particular, the location of the microphone amplified the breathing, intensifying the responses from the body, fostering empathy from the partner. On the other hand, the participants also noted that the conversations made them less aware of how much they were contending with their own bodies: it distracted them from the discomfort of exercising.

In sum, there are three broad categories of how participants are contending with their bodies in exertion games: contending for bodily control, contending for control of an object, and contending for control of another body. Making participants more or less aware of bodily information can support this. In addition, design strategies such amplification or transferring data can facilitate specific objectives of the design, such as the fostering of social play.

7.5.2.1 Contending for control & the moving body

In Table Tennis for Three, participants were contending for control of the virtual bricks. They used the movement characteristic of continuousness to anticipate the preparatory movements of their partners in order to be able to play tactically in response to their partners' actions, for example by playing offensively or defensively.

7.5.3 Play: Exertion as a form of expression

Exertion as a form of expression highlights the richness and expressive power of the human body beyond the merely pragmatic (Bianchi-Berthouze et al., 2007; Bowers & Hellstrom, 2000; Larssen et al., 2004; Sheridan & Bryan-Kinns, 2008), affording "performative actions" (Hornecker & Buur, 2006). Expression using the body is common in sports in form of gestures such as "throwing fists" to oneself or to the opponent, and celebratory dances to the audience. Dance Dance Revolution has been found to facilitate self-expression, precisely because it does not care how the dance movements are performed (Behrenshausen, 2007).

Expression can be facilitated by technology through the consideration of metagaming. Exertion game users can draw on a wide range of metagaming strategies that leverage the expressive power of the body. Although such actions require the expenditure of bodily energy and do not make progress towards the goal of the game, they can significantly contribute to the experience (Bianchi-Berthouze et al., 2007; Larssen et al., 2004).

The notion of expression also resonates with the work on interactive performances for an audience (Reeves et al., 2005), however, it extends it by highlighting the various ways expression can be supported by the body: for example, can participants express themselves using their responding body by making heart-rate visible to co-players? Could such performance be rewarded through gameplay, see for example the star-power points given for lifting up the guitar during play in Guitar Hero (Bianchi-Berthouze et al., 2007)?

7.5.3.1 Exertion as a form of expression & the relating body

In Table Tennis for Three, participants hit balls not only to score points, but also to "send a message" to their remote partners, often smashing the ball at their heads on the videoconference. Such actions served a dual expressive role: that the players were "taunting" beaten opponents or "attacking" them after a loss, but only within the playful realm of the game.

7.5.4 Play: Exertion rhymes with rhythm

This theme is about the ability of a system to support a uniform or patterned recurrence of a beat in bodily action. Rhythm in movement can exist within movement itself (Reidsma, Nijholt, Tschacher, & Ramseyer, 2010), reflecting the inner pulse of the user (Moen, 2006), supported by the fact that humans, unlike most animals, can automatically feel a beat (Karageorghis & Priest, 2008). The body lens highlights that rhythm can arise from the responding body, movement, music, and another body, and designers can draw on this in their designs, for example by synchronizing music beat and heart rate delivered during exercise routines (Oliver & Flores-Mangas, 2006).

It has been shown that the rhythm of music during exertion activities can regulate arousal, improve athletic performance, positively impact the acquisition of motor skills, help the attainment of a flow state and abstract from the discomfort of exercise (Karageorghis & Priest, 2008; Waterhouse, Hudson, & Edwards, 2010). Dance Dance Revolution is probably the most widespread example of an exertion game based on rhythm

(Behrenshausen, 2007) next to Guitar Hero and Rock Band (Tanenbaum & Bizzocchi, 2009). Players in Dance Dance Revolution can synchronize their movements to both the music and to their partner (Behrenshausen, 2007).

7.5.4.1 Exertion rhymes with rhythm & the moving body

From a moving body perspective, rhythm is facilitated by the continuousness of movement: an important characteristic of movement is its continuousness (Moen, 2006), especially when compared to a button-press that is contained in an almost single action. In Jogging over a Distance, participants tried to find a rhythm of movement: they referred to their own rhythm of movement, but also used the rhythm they identified through their partner's footsteps and breathing in order to synchronize their movements.

7.5.5 Context: Exertion puts the body at risk

This theme highlights the vulnerability of the body to overexertion and injury as a result of the effort investment. Being injured, recovering from injury, and discussing injuries are prominent elements of the sports experience (Howe, 2004).

Exposure of the body to risk is different to risk-taking in computer games (Salen & Zimmerman, 2003a). In computer games, risk is virtual, as most actions can be undone easily (Klemmer & Hartmann, 2006). Dreyfus says that risk is a key differentiator between virtual and physical experiences (1991). With no real risk (as in virtual worlds), choices become meaningless. Risk means commitment (Dreyfus, 1991; Klemmer & Hartmann, 2006), and exertion is a commitment to physical actions as well as any potential consequences. It might therefore be suggested that choices in computer games could become more meaningful if the physical risk of exertion was introduced to the experience.

Even though a player might experience an affective response when his or her avatar gets hurt, getting injured in an exertion game results in a different bodily response – the feeling of physical pain. This pain can end the game and impact one's life well beyond the magic circle of play: injury can prevent users from participating again, and also affect other activities of daily life. In extreme cases, even death can result from exertion activities that go wrong.

The feeling of putting the body at risk and succeeding contributes to the engagement of sports and exertion games alike. Dreyfus argues that bodily vulnerability can lead to a constant preparedness for danger and surprises, and that this readiness shapes one's life experience (Dreyfus, 1991). Participating in exertion experiences means exposing oneself to a risk, and the realization of this risk can lead to a complex emotional response such as thrill (Schnaedelbach et al., 2008). It is non-trivial, however, to strike the right balance between successful risk-taking "thrills" and the bodily risk of failed "spills", resulting in injury.

The body at risk transcends the "magic circle of play" (Salen & Zimmerman, 2003b), as a severe injury can affect future exertion activities, such as preventing participants from engaging in them again altogether, but also people's life outside the play space of exertion activity. This impact beyond the boundary of the game contrasts with the traditional idea of what makes a game, such as it being a space where actions have no consequence beyond its boundaries, where players are "confident that no harm can come" (Salen & Zimmerman, 2003b). As a result, the risk in exertion games reminds players that this boundary can quickly be transcended. Consequently, exertion games can be discussed as pervasive games (Montola, Stenros, & Waern, 2009, p. 12), as they also expand the magic circle by including an aspect of risk that transcends into everyday life.

The body lens highlights that risk can arise from within the body, such as overexertion, from excessive movement that leads to muscle strain, from interacting with dangerous equipment, and from exertion activities of other participants.

7.5.5.1 Exertion puts the body at risk & the moving body

The design of Remote Impact showed how design facilitated a reduction of risk by not getting the body hurt by the remote partner. The study also showed how this reduced risk affected social play negatively.

7.5.6 Context: Understanding exertion

This theme refers to the potential of a system to support the development of an understanding of the body. For an understanding of the body in exertion two key aspects come to the fore: knowledge and skill (Kretchmar, 2005). Knowledge about the body in exertion is abstract and has an existence apart from the particular situation that it describes or explains. For example, participants in Jogging over a Distance expressed that knowledge about heart rate helps them understand their body better and therefore their effort investment, helping them to plan future runs. As such, bodily knowledge is particularly useful for developing training plans. Technology design can support the acquisition of such knowledge by sensing the information as to how the participants' body responds to exercise and support the sense-making process of this information to the user.

Skill allows us "to do things", and is gained predominantly through training and practice (Kretchmar, 2005, p. 242). Skill can be facilitated by bodily exploration, for example, in Remote Impact participants explored the maximum intensity with which they can move their arms and legs, training their hitting skills.

Supporting this theme means contributing to a bodily understanding. Developing such a bodily understanding has been described as acquiring kinaesthetic literacy (Sheridan & Mueller, 2010). One design strategy to support such bodily understanding is through deliberate mapping between exertion actions and game actions that match players' abilities to the challenge ahead. This facilitates flow, putting the player "into the zone" in a manner thought to be conducive to learning (Csikszentmihalyi, 1990). In this thesis, two approaches were identified as to how technology can support such matching: through the levelling of athletic abilities as demonstrated in Jogging over a Distance and through pairing with similarly skilled partners via networked play as demonstrated in all three games. With these insights, additional ways to facilitate such mappings can be envisioned: exertion games could dynamically manipulate game challenges in response to momentary and long-term changes in a player's body, for example a game system could detect when the player gets tired and adjust the difficulty level accordingly.

7.5.6.1 Understanding exertion & the relating body

In Jogging over a Distance, heart rate was mapped relative to the other person in a game mechanic that contributed to social play, which participants utilized to gain an understanding of their own, but also their partner's body.

7.5.7 Other themes

It should be noted that the exertion framework does not represent a complete list of themes, but consists rather of a selected set that emerged from my empirical investigations most strongly. As a result, other themes are possible and future work might reveal some of them, however, the goal of my investigation was to present an initial set with a strong foundation on empirical data that I believe will offer a valuable starting point for designers.

7.6 Conclusion

This chapter presented the construction of a theoretical framework for exertion games with a particular focus on social play based on the design of a set of games and a series of associated studies of distributed exertion experiences. This framework consists of key themes that are structured around three game elements and can be viewed from four different body views. This theoretical framework extends existing theory on computer games with a dedicated focus on exertion games, merging insights from sports research, human-computer interaction and computer gaming.

In summary, this research program has presented three exertion games that allow for social play even though the participants are geographically distributed. The research also presented three empirical studies that have led to a theoretical framework consisting of a set of themes that contribute to an understanding of exertion games.

In the next chapter, and as a way to bring this thesis to a close, I will demonstrate how the themes of the exertion framework can be translated into a design tool that is useful in the design process of creating exertion games.

I have deployed this design tool in three different workshops conducted across seven sessions, and evaluated its success through a final study. By demonstrating how others used the findings derived in this thesis, I hope to allay some concerns as to whether the understanding of exertion games derived from my design experiences is transferable and useful for others who might not have had the same extensive exposure to the topic, but are nevertheless excited about exertion games. The results show the utility of the design tool, asserting the value of the exertion framework.

8. Passing on the baton: The exertion framework in action

8.1 Introduction

In the previous chapter, I have presented a framework for exertion games. The motivation behind constructing this framework was to offer designers and researchers a conceptual aid that can support them in analysing existing and designing new exertion games. This chapter demonstrates how this framework can support designers in designing new exertion games. Most game designs evolve iteratively, which involves a constant back and forth between analysis and re-design (Pagulayan et al., 2003). As a result, by showing the value of the exertion framework for the design process, its potential for analysis is also suggested.

In order to demonstrate the utility of the framework, I used an instance of it in the form of design cards that supported the ideation process in design workshops, facilitating creative ideas for future exertion games.

The following sections describe the exertion framework in action by discussing the experiences from three workshops held over seven sessions with 134 participants.

8.2 The problem with HCI frameworks

Frameworks in HCI have been used to attain a better understanding of systems, of user experiences and to provide a vocabulary to describe their analysis (Hornecker, 2010). However, many frameworks, and in particular frameworks on embodied interaction, do not offer “step-by-step guidance” or lend themselves easily to support the creative design process due to their abstract nature (Hornecker, 2010). This gap between theoretical frameworks and the practical design process has been an issue for HCI and a source of frustration for many practice-based design researchers (Antle, 2009; Dan R. Olsen, 2007; Landay, 2009). Recent research has investigated how to close this gap in order to support design researchers (Antle, 2009; Hornecker, 2010), and one way suggested was to turn the framework into a design tool (Hornecker, 2010).

8.3 Transforming the framework into a tool

As a way to close the gap between theory and practice, Hornecker proposes to transform the abstract themes of a framework into colloquial questions that designers can relate to (2010). These questions are then framed in a card-based format and introduced to the design process in order to offer guidance from the themes of the framework. As evidence for the utility of this approach, she demonstrated the transformation of a tangible framework into design cards and used it in a series of workshops with positive outcomes in the form of novel design ideas (Hornecker, 2010).

For this final study, I propose a very similar approach to demonstrate the utility of the exertion framework. I opted to lean on Hornecker's approach as the conditions are comparable: Hornecker devised her own framework, which is based on an embodied approach to interaction design, with a specific focus on social aspects (2010). My approach has at least these conditions in common. As her and my framework share the same target group – interaction designers –, and both frameworks were guided by an embodiment agenda with a particular focus on social aspects, it seems reasonable to assume that her approach to turn the framework into a tool could also be of value for the exertion framework. As a result, I build on this work and show the exertion framework in action in a similar way: this involves transforming the framework into design cards and reporting of their use in a series of workshops with a discussion of the results.

8.4 Moving from themes to provocative questions

Hornecker does not describe a generic process of how to turn a framework into questions for designers (2010). I therefore constructed my own process, but I was guided by her examples, my own experiences and insights gained from presenting the results of the studies at conferences and seminars.

The goal was to turn the framework's themes into colloquial, provocative questions that are aimed to provoke creative design thinking. The following section describes this process.

Expanding on Hornecker's work (2010), I added a *dimension* aspect to each question, which highlights that adding themes to a design idea is not a simple yes or no decision. Themes can be considered across a wide spectrum ranging from *a little* to *a lot*. Furthermore, a dimension aspect also highlights that choosing to keep a theme at a minimum (for example, by preventing it from occurring) is also a design decision that can have merit.

The following list of steps describes the process I followed to turn the themes of the exertion framework into design cards:

1. In order to reduce the load on designers, I decided to aim for a relatively low amount of cards: 14.

2. I looked at the themes of the exertion framework, and picked one aspect of each that related to one particular layer of the body lens. For example, for "rhythm", I selected the "relating body". This was informed by the salient contributions from the studies. I deemed them salient if the data brought them out particularly strong.

3. As I wanted to cover the body lens element of the framework stronger than as part of one particular theme as described above, I also picked each layer of the body lens separately. For example, I turned the "responding body" into a question about effort.

4. I transformed the selection into what I considered provocative questions that challenge the creative process. I aimed for questions that can be answered on a dimension, that is, a respondent can answer starting from "a little" to "a lot".

5. To reduce the amount of cards, I only considered contributions where I felt the resulting questions could challenge game designers. In other words, I focused on questions I thought game designers would not think of immediately by themselves.

6. Once I had 14 questions, I stopped, as I wanted to limit the number of cards to a practical number that allowed the workshops to conclude within three hours.

7. I verified the selected questions covered all themes.

8. I wrote the questions on index cards and gave each design card a short and descriptive title.

9. I selected two pictures to represent examples of either end of the dimension. I aimed to use images that offered easy entry into the topic while at the same time did not imply any specific use.

10. I allocated a positive example to each end of the dimension to provoke the reader to consider both ends of the dimension, that is a reader might ask: "If I facilitate a lot of this, I will gain X, but if I facilitate a little, I will gain Y."

11. After having generated all cards, I discussed the results extensively with senior researchers who gave me feedback on how to improve the cards' wording and their presentation. Based on this feedback, I refined the associated examples and the card layouts several times. In addition, I discussed the cards with two fellow researchers in order to verify if the descriptions on the cards were understood even if I was not explaining them.

The most challenging part of this process was the transformation of the contributions into questions (step 4). These questions were meant to work on a more pragmatic level than the theoretical concepts, as suggested by Hornecker (2010). I aimed to make the questions easily accessible in order to support the creative process rather than requiring a deep understanding of the framework. As in Hornecker's (2010) approach, the challenge was to find a balance between abstract concepts and inspiring questions, without falling into the trap of presenting rules that convey they need to be followed. The aim was to create open questions that designers can take as thought-provoking suggestions to guide their creative process.

The end result was a set of cards, which all shared the same layout (see Figure 8-1).

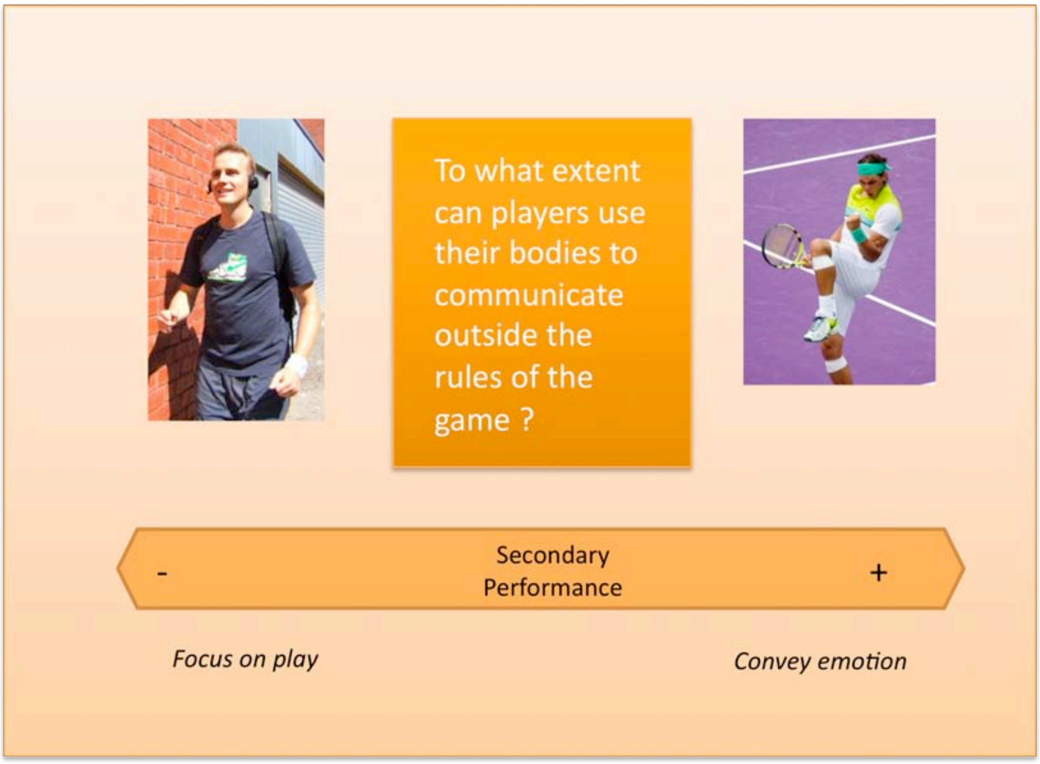


Figure 8-1. One of the design cards

8.5 The transformation result

Table 8-1 depicts the source of each card from the themes and the body lens of the exertion framework, the name of the design card, and the provocative question.

Table 8-1. Transforming the framework into provocative questions

Source	Card	Provocative question
Exertion as a form of expression	Secondary performance	To what extent can players use their bodies to communicate outside the game?
Exertion as a form of expression	Movement variety	To what extent can players explore the many ways of movement to achieve a goal?
Understanding exertion	Intensity interpretation	To what extent is intensity interpreted?
Moving body	Continuousness interpretation	To what extent are pre-movements and follow-throughs interpreted?
Responding body	Effort interpretation	To what extent is physical effort interpreted (in contrast with performance)?
Contending for control	Fidelity of mapping	To what extent are movements mapped from the physical world to the virtual world?
Uncertainty arises from exertion	Tangibility	To what extent can the player master the control of objects (like a ball)?
Sensing body	Haptic feedback	To what extent does the virtual world offer feedback on the body?
Contending for control	Virtual contention	To what extent can players share space, an object or their bodies in the virtual world?
Contending for control	Physical contention	To what extent can players share space, an object or their bodies in the physical world?
Relating body	Integrated communication	To what extent does communication affect the virtual world and vice-versa?
Understanding exertion	Exhaustion management	To what extent is managing exhaustion part of the game?
Exertion rhymes with rhythm	Bodies in harmony	To what extent does the game encourage bodily synchronization?
Exertion puts the body at risk	Physical risk	To what extent is physical risk considered?

8.6 Why cards?

The transformation results were printed on index cards (Figure 8-2).

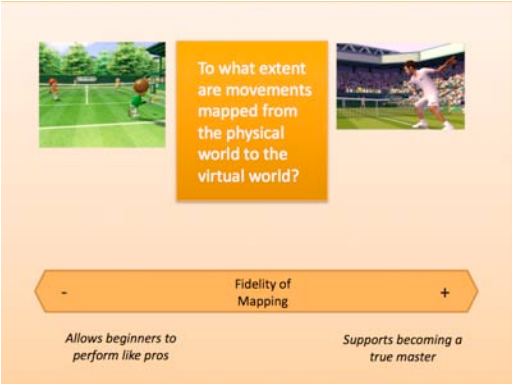
Figure 8-2. Participants discussing a particular design card.

Presenting the results of the transformation in a card format is based on the belief that the physicality of the cards "can help to make arguments tangible in a dialogue" (Hornecker, 2010). Cards are believed to support focus shifts by making it easier to bring in new perspectives, as they can be spread out and distributed amongst participants (Hornecker, 2010).

8.7 The card design

The cards are colour coded with four different colours, one for each layer of the body lens. The centre of the card features the provocative question. The associated design dimension is depicted underneath the question as double-ended arrow, bearing the title of the card. At the extreme ends of the dimension are two short descriptions of what implications answering the question with "a lot" or "a little" could have on the resulting game. For three cards, I opted to provide additional details to clarify what it would mean for participants if they would chose the middle of a dimension that has no obvious medium value: for example, I highlighted that medium intensity can mean that intensity in movement might not be interpreted by the system, but could be communicated to another person.

Each extreme comes with an exemplary photograph, which also serves as visual reference. All 14 cards are depicted in Figure 8-3.

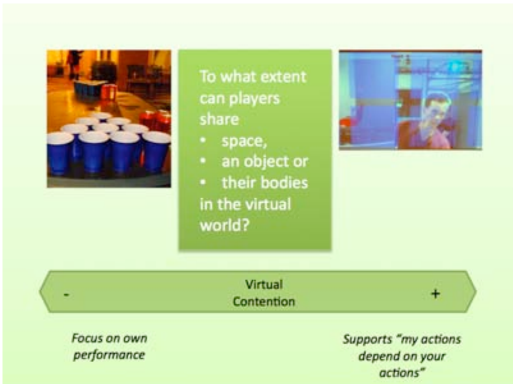

To what extent are movements mapped from the physical world to the virtual world?
-
Fidelity of Mapping
+
Allows beginners to perform like pros
Supports becoming a true master


To what extent is physical effort interpreted (in contrast with performance)?
-
Effort Interpretation
+
Focus on movement efficiency
Communicated: May affect nature of game: competitive-collaborative
Interpreted by the game: Allows comparison between beginner and pro


To what extent can the player master the control of objects (like a ball)?
Tangibility
Adaptability
Direct feedback loop


To what extent does the virtual world offer feedback on the body?
-
Haptic Feedback
+
Adaptability
Direct feedback loop


To what extent can players share
space,
an object, or
their bodies
in the physical world?
-
Physical Contention
+
Low risk of injury
Supports bodily feedback from other player


To what extent can players share
space,
an object or
their bodies
in the virtual world?
-
Virtual Contention
+
Focus on own performance
Supports "my actions depend on your actions"


To what extent does communication affect the virtual world and vice-versa?
-
Integrated Communication
+
Players can always easily communicate
Communication forms part of play


To what extent is managing exhaustion part of the game?
Exhaustion Management
Allows breaks for socializing and tactics negotiation
Focus on fitness, less on tactics

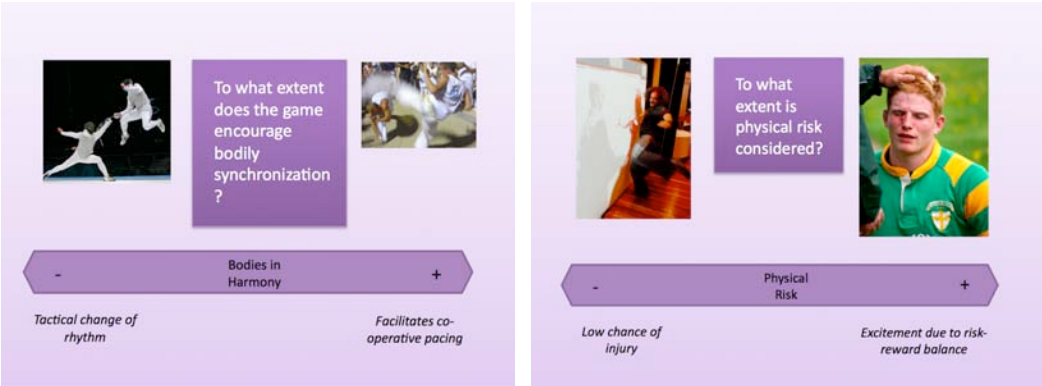


Figure 8-3. The design cards.
Picture credits to flickr users (creative commons licence): sanAago_sa, bass_nroll, ilmv, 91651935@N00, allenjaelee, trioculus, jasmic, oblivion, tomeppy, ben_lawson, teotwawki, mirsasha, romec1, drsam, mirsasha, compose, shawdog.

8.8 The workshops

I decided to test the design cards in workshops with designers to see if they can support the creative process as a way to demonstrate the utility of the framework.

Design cards have been previously used successfully in workshops (2010). Moreover, a workshop with team-based design exercises is similar to the teamwork environment designers are often exposed to. Lastly, workshops provide a tight time-constrained format for creative teamwork, which I found suitable for my intention to study the use of the cards.

8.8.1 The sessions

I conducted three workshops; two of them were conducted multiple times in order to accommodate the large number of participants. Workshop A and B were repeated twice and four times respectively. The workshops were carried out across three different sites, with sessions adapted to the different contexts, number of participants and room layouts. Each participant only attended one session. An overview of the sessions and participant numbers is provided in Table 8-2.

Table 8-2. The workshops summarized

Name	Number of sessions	Number of participants	Participants	Environment	Dur-ation
Workshop A	2	8 + 6=14	Designers and researchers from two major technology companies (both of which develop exertion games)	Conference room	3 h
Workshop B	4	14+14+13+14=55	Design students	Design studio	3 h
Workshop C	1	65	Digital game design students	Classroom	3 h
		Total number of participants: 134			

8.8.2 Structure of the workshops

The three workshops had different constraints and opportunities; however, they all shared the same structure around the cards. The participants were invited with the premise they would learn about designing exertion games, and as a fictitious exercise they were asked to come up with an exertion game idea. I began each workshop with defining the term exertion games in order to have a common understanding of the topic. Then I showed examples of exertion games on video. Next, the design task was explained. The goal of the workshops was to come up in teams with an exertion game. I also presented the idea of social play and showed videos of systems that supported distributed exertion play. Although I was naturally interested in social play, the participants were free to also create solo-player experiences. I did not want to confine the scope of the workshop too much, so participants could make the content applicable for their respective design practices.

Following the introduction, the cards were presented to the participants. The content of the cards was explained, the participants formed teams, and each team received a set of cards. The participants were free to use the cards however they liked.

8.8.3 Participants

In Workshop A, the 14 participants were volunteers from a large software company that had just announced a new exertion games console, and the participants volunteered because they expressed interest in exertion games. The participants' background ranged from computer science to HCI and design, which is representative of the target group of the design cards. Some of them were involved directly in the development of the exertion game project.

The second session was conducted in the same company, but for this session, half of the participants came from a major mobile phone manufacturer's HCI research team that was interested in social play to support their mobile customers.

In Workshop B, 55 design students took part across four sessions that were conducted in a design studio.

In workshop C, 65 participants from a computer games course participated in a classroom setting. This setting was less adaptable to group work, but participants were free to roam during the workshop.

8.8.3.1 Task

Each workshop lasted 3 hours. The participants were asked to form teams of around 5 people. Most sessions had teams of 4-5 members, with the remaining participants (due to the total amount of participants) forming smaller teams down to 2 members.

The exercise task was to design an exertion game. The goal was to come up with an original idea that participants were asked to present to their peers at the end of the workshop.

Each team was asked to write down or sketch out any game ideas they might have. They were free to explore if the design dimensions could support them in their creative process. Once a team decided on a final design, and there was time due to the other teams still working, they were asked to mark on a large sheet of paper which design dimensions (if any) they used and how. It was suggested to align the cards along a spectrum from positive to negative, with neutral in the middle. For example, if the group decided to incorporate “a lot” of “integrated communication”, they attached the card to the “+” side of the paper, if they decided to include only “a little”, they attached it to the “-“ side. Participants were also encouraged to discard cards if they did not think they were useful for their particular task. In the end, each team was asked to present their game idea to the rest of the workshop members.

8.8.3.2 Feedback

After the exercise, the participants were interviewed, and their answers recorded. The posters they used to present their ideas and any other supporting materials they developed were also captured. Due to the size of workshop C, not all participants had a chance to provide feedback, as a result, participants of workshop C were also given the opportunity to post any comments onto a dedicated website. Participants of all workshops were also given a questionnaire at the end that asked them about each card and how useful they thought each one was (see appendix 4).

8.9 Data collection

All sessions were recorded on video. After the exercise, the participants were interviewed as a group, and their answers were video recorded and notes were taken. The final presentations were also videotaped, and any sketch and note materials were photographed. The comments on the website were also captured and analysed. The questionnaires were also digitally captured.

The questionnaires asked the participants about the perceived usefulness of the cards. Furthermore, participants were asked what their favourite card was and why. This question was designed to explore if they preferred a particular card during their design process and why it was relevant to their team’s project.

I was also interested if and how participants used the cards beyond the workshop, and therefore interviewed the participants of the workshop C two months after their workshop. 75 participants of the original workshop were available for this interview.

8.10 Data analysis

The collected data was analysed using a similar process as in the previous chapters. In addition, the data from the questionnaires was analysed and visualized using a spreadsheet program. In session 2 of the first workshop I did not include the contention cards in the questionnaire. As a result, I did not generate graph plots of these two cards from the questionnaire data.

I began the analysis by reading and watching all the material. Then I started the coding process of the data. I began by looking for all relevant mentioning of design cards. This meant identifying instances that described if and how design cards were used. I also looked out for any other instances that related to the cards and any themes from the framework. This included looking for evidence that points to the use of the cards in a way that sparked new ideas or changed existing ones. I also looked for indicators that were concerned with exertion and social play, for example distributed play.

8.11 Results

First, I present a few of the ideas participants came up with during the sessions in order to suggest that the workshops led to creative ideas. The depicted pictures are photographs of the posters presented, with the design cards attached to them by the participants in the way they used them (Figure 8-4, Figure 8-5, Figure 8-6, Figure 8-7, Figure 8-8, Figure 8-9). Next, I will elaborate on the role of the cards on the creative process that led to these ideas.

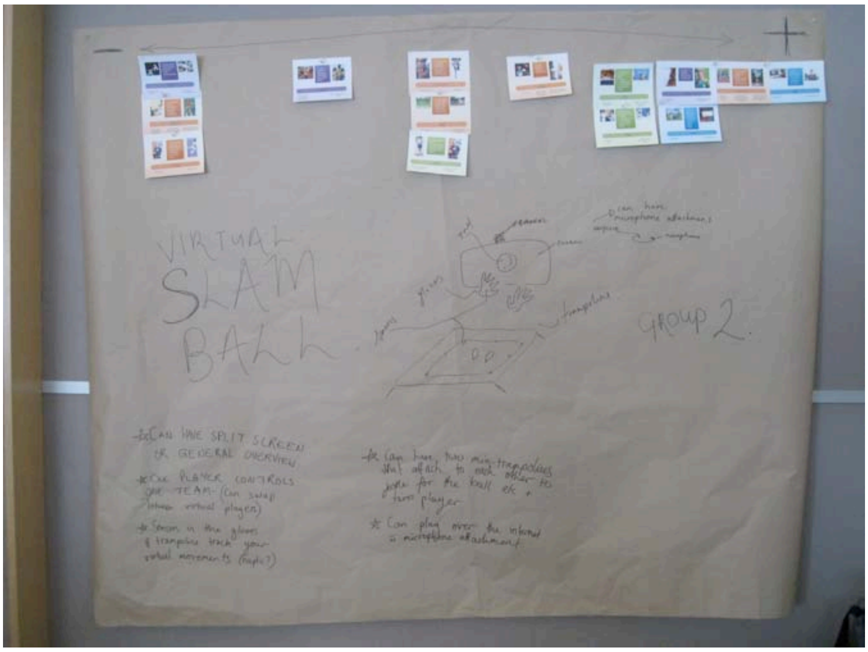


Figure 8-4. Virtual slam ball.

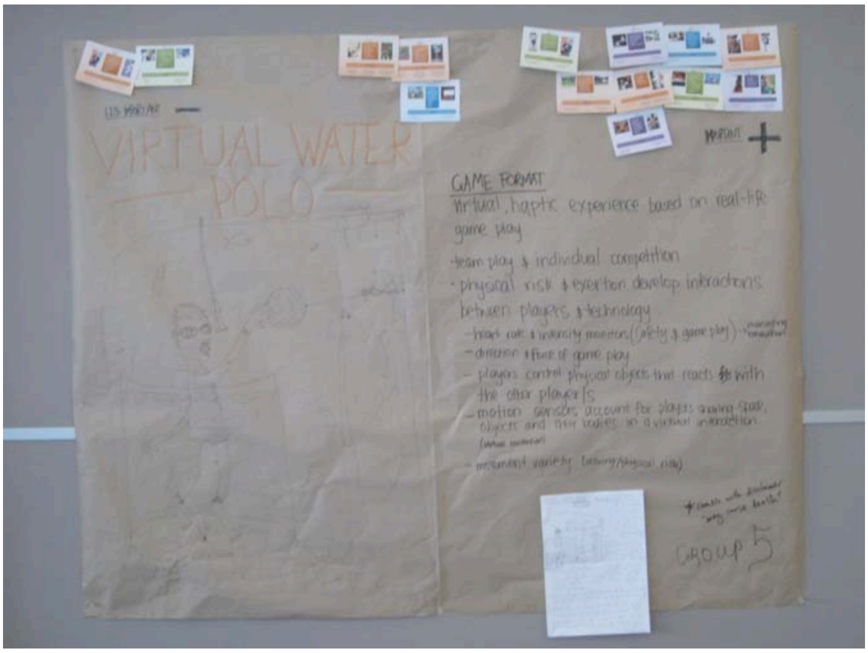


Figure 8-5. Virtual water polo.

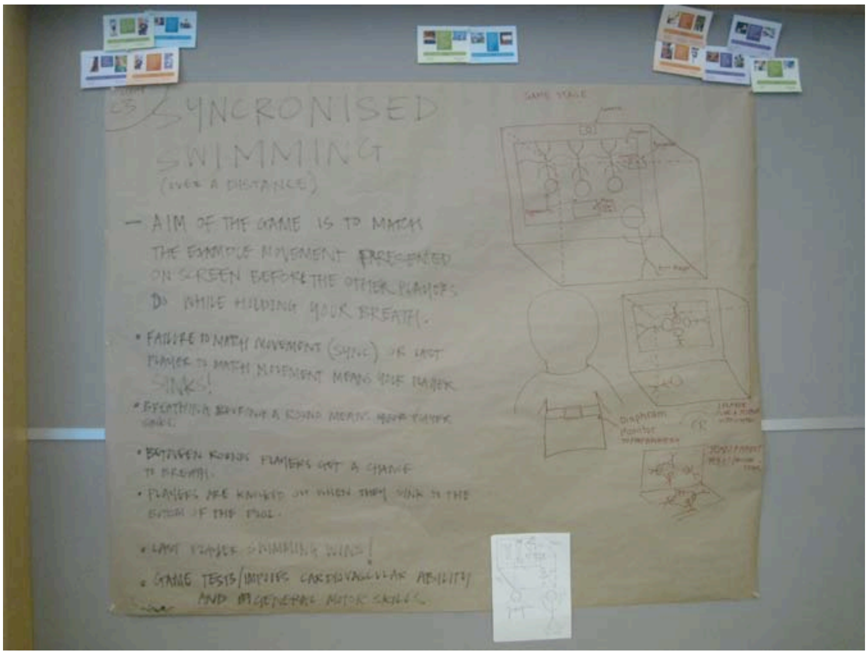


Figure 8-6. Synchronized swimming.

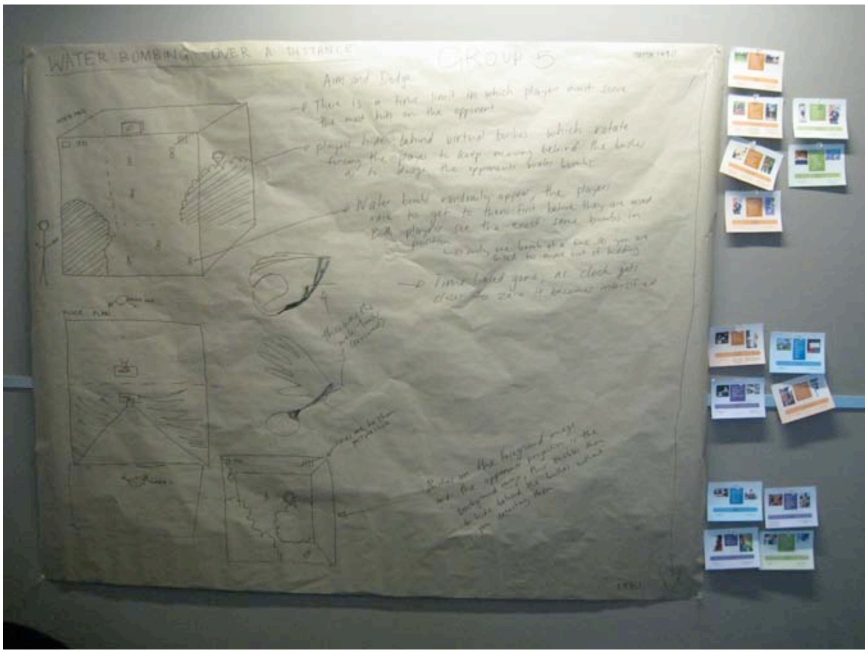


Figure 8-7. Water bombing over a distance.

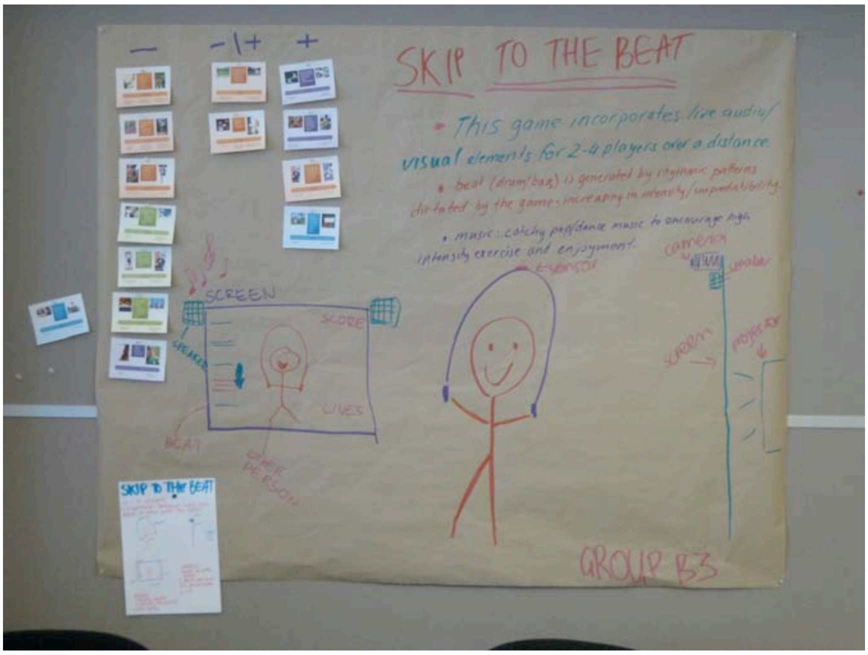


Figure 8-8. Skip to the beat.

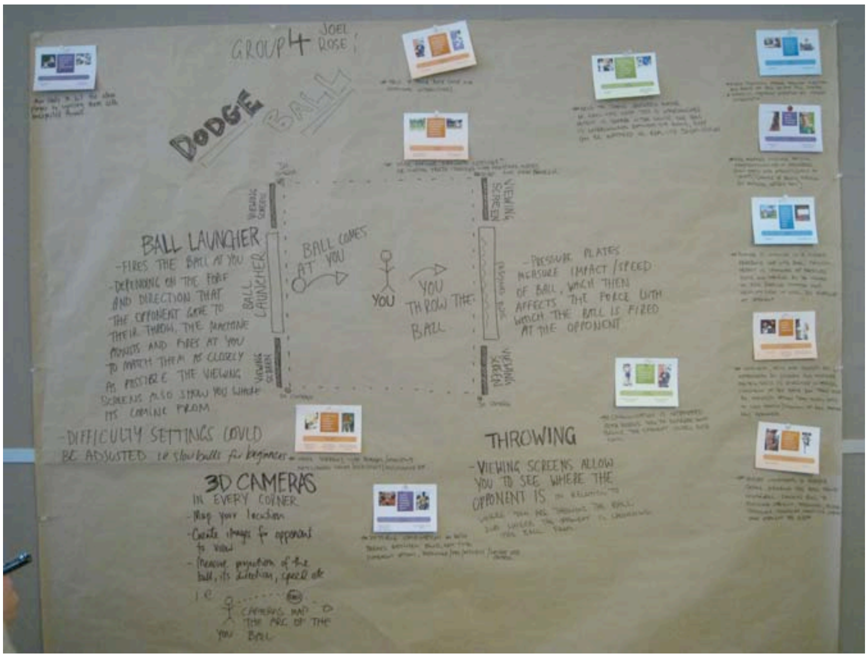


Figure 8-9. Dodge ball.

8.11.1 Perceived usefulness of individual cards

The data from the questionnaires suggests that participants agreed with the statement that each card was useful for their design task.

In particular, a majority of participants either agreed or strongly agreed to this statement in the questionnaire (see Figure 8-10).

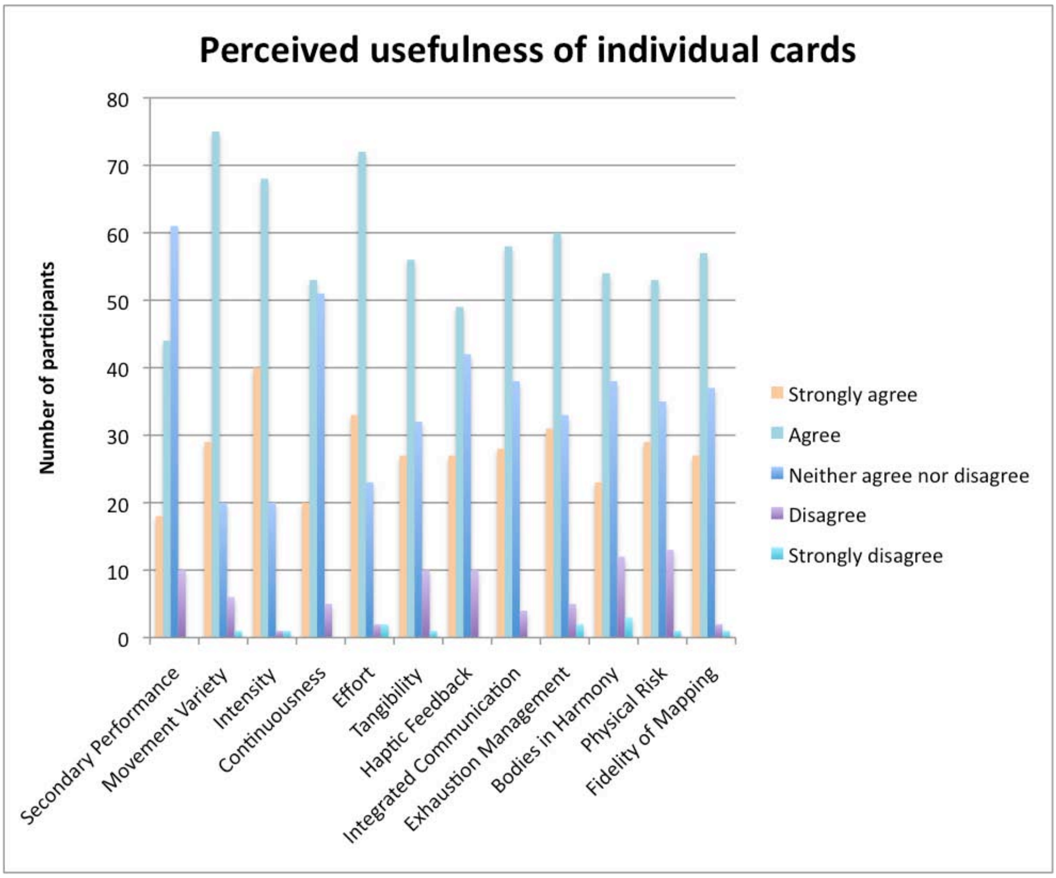


Figure 8-10. Likert-scale results on how useful participants found each card.

8.11.2 Use of individual cards

The next figures display how participants' teams used the cards for their particular design task. First, I display a typical placement of the design cards (see Figure 8-11). When asked to place their cards on a dimension from "a little" to "a lot" in response to how they used a particular card, the following data resulted (see Figure 8-12).

Figure 8-11. The participants placed how they used the cards on a dimension from “a little” to “a lot”.
The card on the bottom indicated that it was “not useful”.

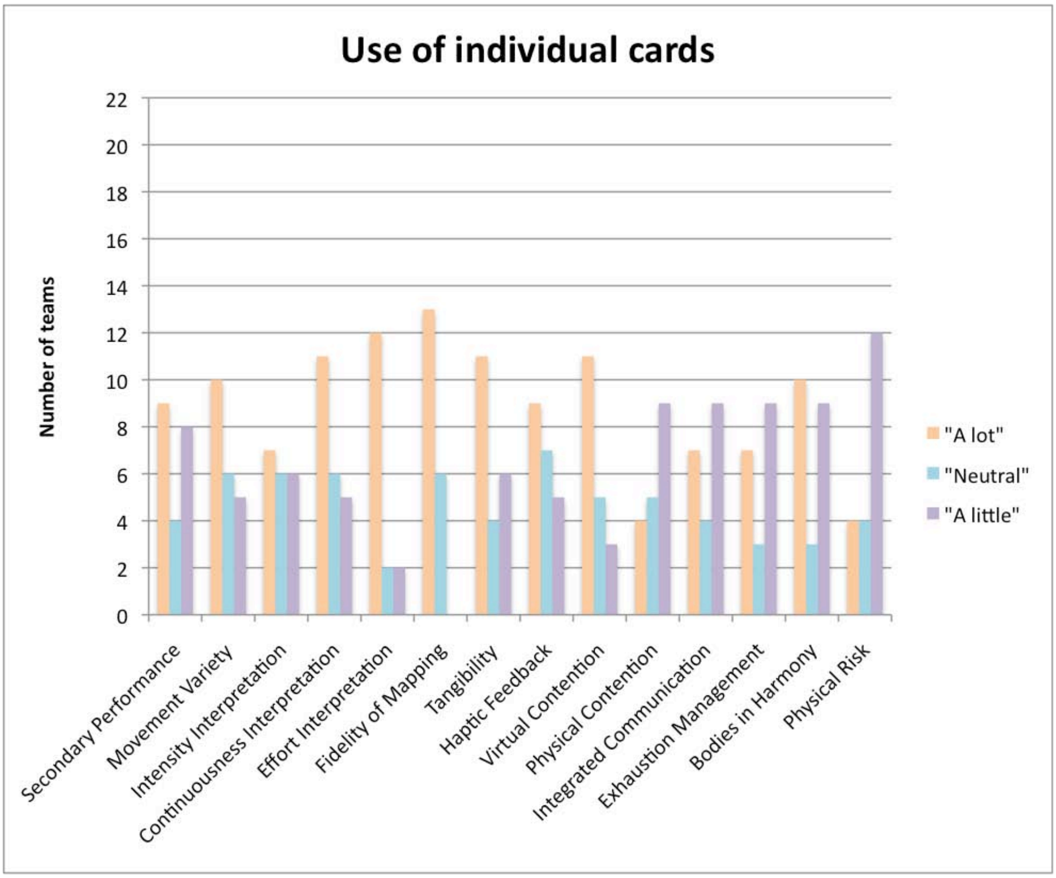


Figure 8-12. The placement of the cards in terms of use.

Participants were also asked to note or discard the cards they did not find useful (see Figure 8-13). There was no card that all teams found "not useful"; this suggests that every card was useful for at least one team. Out of 22 teams who placed their cards, six teams (the highest number) found "effort interpretation" not useful.

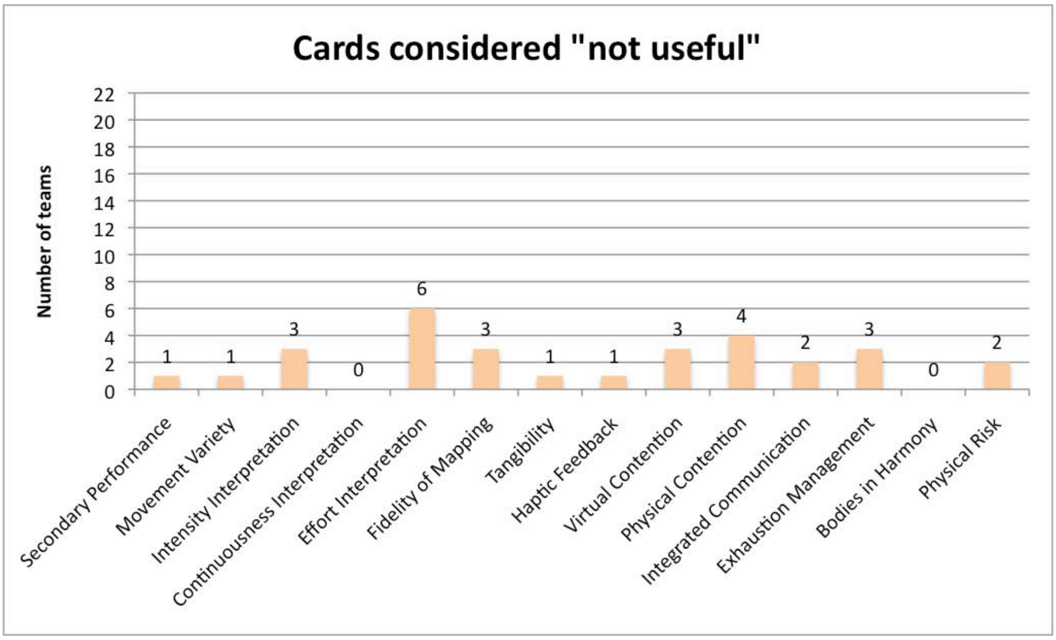


Figure 8-13. Cards not placed on the dimension.

The majority of teams found only one to two cards not useful. The highest number of cards one team did not consider of value was 9 (see Figure 8-14).

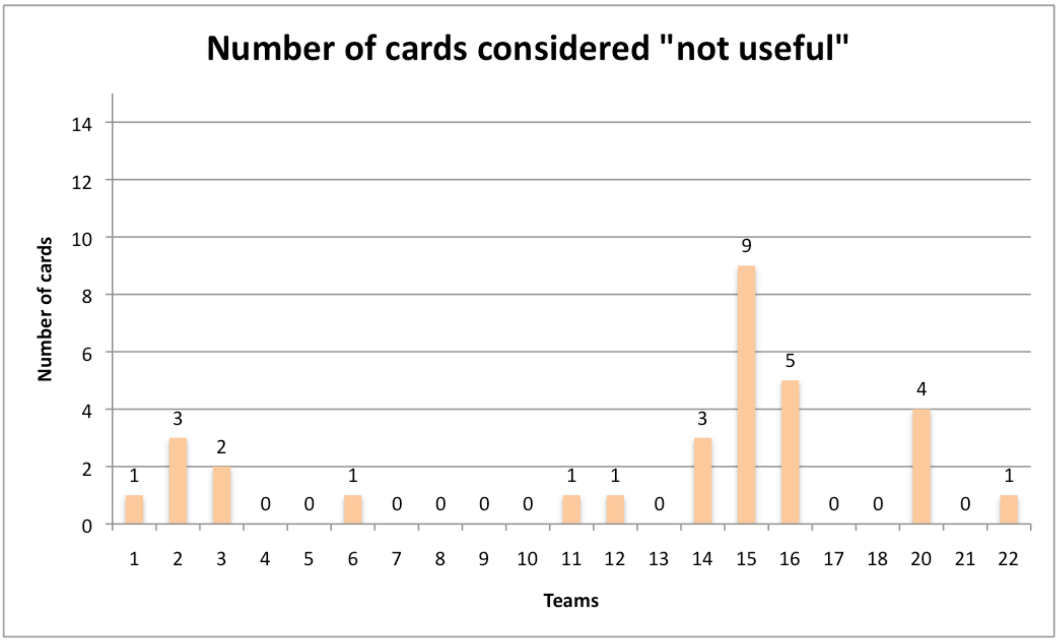


Figure 8-14. The amount of cards not placed on the dimension.

8.11.3 Role of cards

The participants were also asked at the end of the workshop what role the cards played in their design process. The data show that the cards had multiple roles. When combining "Strongly agree" and "Agree", the following list emerges with the top answer listed first. The individual composition can be seen in Figure 8-15.

1. I found the cards useful for generating ideas

2. The cards helped me to improve my ideas

3. The cards helped my team to focus

4. The cards helped me to articulate my ideas

5. The cards helped my team to come to a consensus/agree on items we discussed

6. I had ideas I would not have had without the cards

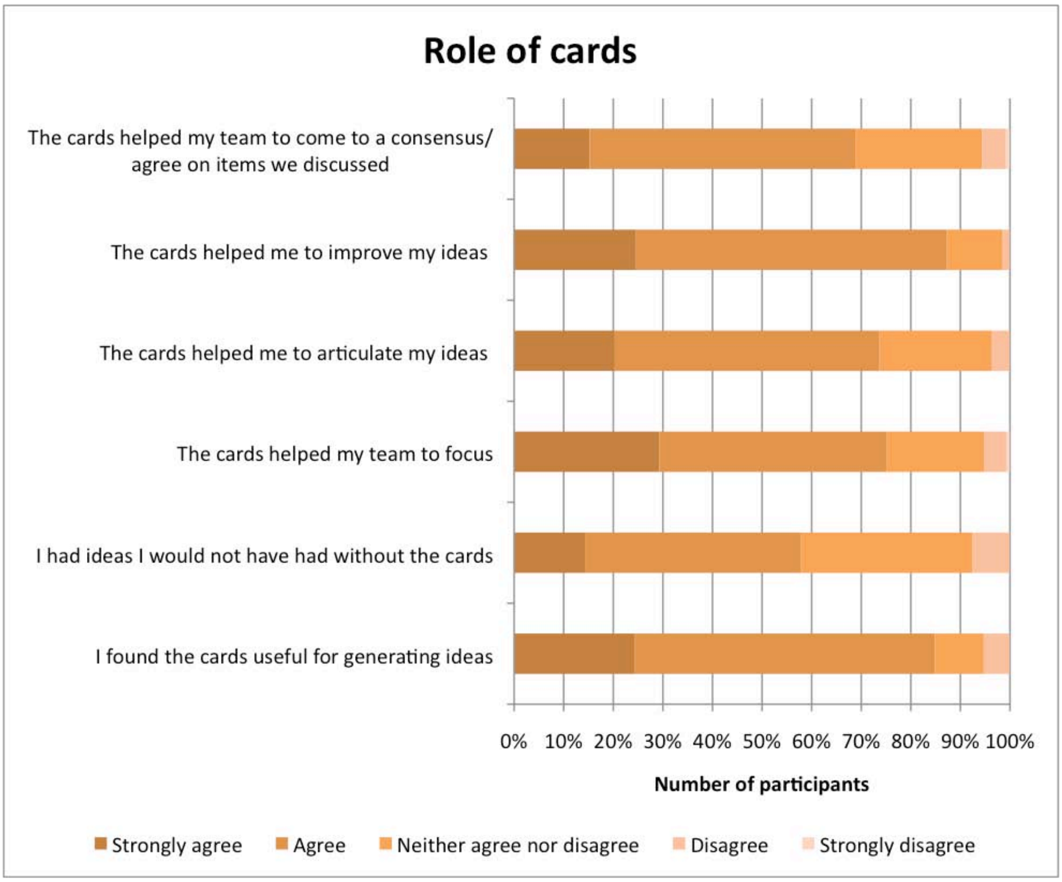


Figure 8-15. How participants assessed the role of cards.

Through a free form field, the questionnaire gave participants the option to note any additional roles they thought the cards played. 59 participants thought the cards had additional roles. By structuring them based on logical closeness, I derived three major additional roles. The cards helped participants to fine-tune their ideas, offered guidance for the design process, and supported expanding participants' horizon:

12 Participants stated that an additional use of the cards was to fine-tune their ideas:

> *"The cards helped refine our ideas."*

6 Participants found that the cards offered them some guidance as a group how to proceed with the design task:

> *"They are good guidelines/building blocks."*

> *"It gave our group clear direction and order, something that we sometimes lack."*

The cards provided a

> *"framework for analysis."*

The participants also noted that the cards helped to expand their horizon:

> *"It enabled our group to consider areas that we normally would not consider, like synchronization."*

This resonates with another statement that appeared repeatedly: participants appreciated that the cards helped them to consider "all aspects" of the game, reminding them of perspectives that they otherwise might have overlooked:

> *"[The cards helped] generating and incorporating ideas that weren't thought of before."*

8.11.3.1 Danger of cards

One participant was critical in the comment, saying that the cards have the potential to overcomplicate the process:

> *"They gave a broader outlook of possibilities, however not necessarily 'better' ideas. In perspective of 'easy fun'/'hard fun' stuff, some cards may overcomplicate games for a particular audience."*

8.12 Additional results

The data coming from the video recordings and free form opportunities provided additional insights that are now detailed.

8.12.1 Offering guidance

The cards offered guidance to the creative process. The participants called the design dimensions an

> *"easy to understand guideline for starting and refining games."*

Others found that the cards helped them identify aspects of their design they had overlooked so far, further strengthening the view of the cards as a guide:

> *"I think the dimensions for exertion games work really well to help guide the design of a game. While our group discussed each card in reference to our game I found the dimensions helped us to work out what our game might be lacking, and what could be added to improve it."*

Some participants saw the cards as tools that not only guided existing ideas, but also helped generate new ones:

> *"The flash cards are very useful for people such as myself, because I can never come up with an idea on the spot. The dimensions are perfect for producing further ideas to elaborate on as well as a guide."*

In this sense, people used it as a tool:

> *"the idea of game design [is now] a whole lot deeper. Like most I found the design dimension cards' to be a useful tool in improving a game."*

One participant praised the potential of the cards for industry and academia alike:

> *"I think that as a tool, not only to be used by game companies but also for teaching, the design dimensions are really great."*

Another participant noted how the design dimensions will be useful as a guide for future games and how they will be used in his/her practice:

> *"I found the design dimension cards to be a useful guideline. […] I will be referring to it from time to time, in order to analyse the quality of our next game."*

The cards offered the participants a more efficient way to reach their goals when compared to their existing methods. They praised how they generated results much quicker when using the design dimensions:

"I found the dimensions really helpful, by being aware of the elements that are in games, it makes it so much easier, faster and most likely better to come up with new games and improve existing ones. I found dimensions jump-started my thoughts in a way, that most cards got me thinking of new ideas and/or ways to improve them and got me thinking about different aspects of games that I had not considered before and now seem integral."

"We obtained a lot of fresh ideas and faster than any other method I know my self. But to say that we would have never gotten this ideas without them is another thing, I think it's a time factor more than a possibility factor."

8.12.2 Shifting process

The cards helped the participants to see how they could approach the creative task in a different way. They described the use of the cards

"as an eye opener",

helping to

"view design in a different way", as

"the idea of dimensions helps me think."

One participant explained how the cards helped the group

"to rediscover what it is specifically that we want out of our game. It has given us a ground, or a foundation, from which we can mould and develop our concept".

By having a clear goal, participants found it easier to assess their ideas:

"They're a really useful and clear way of looking at our games for refining and moving beyond 'What can we add to our game?' to 'What could we add to our game to emphasise or draw out more of a certain quality our game has or needs?'"

8.12.3 Factorizing task

The cards helped the participants to break down the creative process into individual elements that were easier to handle. Firstly, the cards enabled the participants to identify that there are several elements that make a successful game:

> *"[it made me] realize that so many factors can affect the games and make it different."*

Secondly, the cards helped the participants to identify these different elements. In other words, the cards supported them in breaking down the task into individual factors:

> *"I did like the break down of the categories."*

> *"Say you have a job to do […] The dimensions would help you define the different aspects of the game and what kind of rules and gameplay to include."*

Equipped with these factors, participants felt empowered to make strategic decisions during the design task:

> *"What made [altering the game] easier was that the cards gave definable characteristics of exertion games, so rather than thinking 'how do I make it more physical?' we could pin point several aspects of the game and the 'player experience', and alter one factor, rather than trying to pull something new out of thin air and risk changing everything."*

8.12.4 Weighing in options

The cards allowed the participants to assign a qualitative weight to certain aspects of their designs:

> *"The cards were really helpful in figuring out where our game's strong points are, or more importantly where they are not."*

Being able to weigh up certain elements gave participants the confidence to focus on specifics, which they used to identify which aspects to improve first:

"It makes us know what we need to do for improving our game"

"I found the cards to be incredibly helpful, especially in regards to tweaking some flaws in our game idea."

8.12.5 Focus aim

The cards helped the participants to focus on the main aim: creating an engaging game.

"This sort of thing is great for someone like me who tends to get caught up in what they're focussing on and slowly becoming more and more tunnel visioned."

The cards helped participants to stay true to the original goal of making an engaging game by diverting from any distraction such as attention to technical implementation too early:

"[...] I believe the dimensions were a great way of allowing us designers to refocus on the essence of the game; the approach to 'fun' if you will. [Without the cards] we tend to concentrate too much on technology and implementation, and less on how the player(s) are enjoying the game. "

8.12.6 Clarity of cards

The study also revealed that turning conceptual frameworks into practical design guides it not an easy undertaking. Several participants expressed difficulty in understanding some card's meanings, noting that the study was undertaken within different cultural contexts and with participants who have different first languages:

"I found myself rereading some cards because I fond them slightly hard to work out."

8.13 Discussion

I now discuss the individual findings in detail, relating them back to the cards and the framework. Briefly, the participants found the cards useful for the creative design process.

8.13.1 Usefulness

The majority of participants considered all cards being of use for their design task. The participants found the cards useful as a whole, and participants did not differ much in their assessment of individual cards. The following sections discuss how participants used the cards during the design process.

8.13.1.1 All cards were useful

Participants used many cards "a lot" or "a little" as indicated by the placement task, and found only a few not useful for their particular design process. No single card was considered "not useful" by all teams, suggesting that each card had found a use in the workshops.

This confirms that each card had its use, and that teams found the set of cards useful. As expected, not all cards were useful for all design processes, but participants found more cards useful than not useful.

"Effort interpretation" and possibly "physical contention" were the cards that received the most (although still modest) count of "not useful", suggesting that in future iterations of the cards, these cards should be investigated first.

8.13.1.2 What cards were useful for

Participants confirmed that the cards were useful for idea generation, idea improvement and articulation. The cards also offered a language to discuss certain aspects of the design, and supported teams in focusing their efforts. In addition to these anticipated roles, the participants also expressed that the cards helped them to fine-tune existing ideas, and helped them to be more concise in their efforts. The participants also appreciated the cards as guide and found their role in the creative process valuable in terms of goal development, efficiency and effectiveness. In sum, the cards offered a framework for the design process that often expanded their range of ideas.

Such an assessment of the roles of the cards is similar to what Hornecker found when she tested her framework (2010). The data suggest that the design cards do not fulfil an isolated role in the design process, but can rather serve multiple roles depending on the stage of the design process and the way participants see fit for them. This finding promotes the design cards as universal tool for the design process.

The cards also helped (re-)focusing participants' aim to the "bigger picture" of creating an engaging game, and diverted from getting caught in details too early. The cards were simultaneously able to support the identification of individual elements while highlighting the bigger picture. So while the cards supported a micro-level view on the task at hand, they also brought a macro-level to the participants' attention.

8.13.1.3 What cards were not useful for

Participants valued the benefits the cards can provide for them, however, it was important for them that the tool does not get into the way of the creative process. The participants criticized that the wording of the design dimensions was sometimes difficult to comprehend, and that some cards were too similar to others. When cards were difficult to comprehend, the participants' focus shifted from the creative process to understanding the cards, reducing the benefits of the cards. The visual examples and the "+" and "-" dimensions helped to clarify any ambiguity, however, future revisions of the cards should refine the wording for easy comprehension. Another solution could be to reduce the amount of cards to reduce ambiguity, however, the participants were in favour of the amount of cards: *"The amount of cards were just right to grab just about every aspect of a game"*.

As with Hornecker's approach (2010), the cards are not a method: the designers still have to sort the cards themselves and find out in which order (if any) they apply them (and which cards to discard). This aims to not restrict the creative process, however, some participants expected more guidance from the cards. This can have two reasons: a) participants wanted a method as they felt this could enhance their creative process, or b) participants expected a method from the instructions given and were dissatisfied that they did not receive one.

8.14 Limitations

As with any investigation that aims to combine theory with practice, there are limitations that are shaped by both theoretical and practical concerns.

One limitation of the study is the use of design cards rather than the framework itself, raising the question if the success of the workshops can be attributed to the cards or the framework. This relates to the challenge of any evaluative work on theoretical frameworks (Benford et al., 2005; Hornecker, 2010), as the gap between theory and practice in HCI is not easy to address (Antle, 2009). In order to bridge this gap, I turned the framework into provocative questions as suggested by prior work (Hornecker, 2010). This process used the framework as the source, creating a strong link between framework and design cards. However, although I followed a structured approach towards the framework's transformation, this structure was devised by me and carried out by me; hence the process was of a subjective nature. However, I devised this process based on examples in the literature that proved to be successful in a similar task (Hornecker, 2010). In order to support other researchers who want to replicate this process, I devised a systematic way to arrive at the design cards, which I documented for others to follow. Some variables chosen, such as the number of cards and the duration of the workshops, were constrained for practical reasons. However, by looking at the process it should be possible for other researchers to adapt the work to other constraints. So although the transformation from framework to design cards was a subjective one by its nature, the leaning on prior work and its systematic approach that is documented adds transparency and credibility to the challenge of bridging theory and practice.

Another limitation of the work is that it was I who presented the design cards during the workshops, adding potentially my own personal bias. However, two of the sessions in workshop B were run by other interaction designers. Although they were instructed by me, this suggests that the design cards can be used in other settings where I am not the main facilitator, hinting at the fact that the knowledge lies in the design cards, not in the person presenting them. However, the utility of the design cards without any personal involvement from me is yet to be demonstrated.

Another limitation of the work is that students were most of the participants, not professional designers. Professional designers, and especially game designers are busy people who have little time to participate in 3-hour long workshops. Moreover, the protection of any of their ideas is of concern, difficult to address in academic environments. However, two workshop sessions were run with professional designers in a commercial environment, suggesting that the design cards indeed have value for people in industry. Furthermore, the students involved in the other workshops will all graduate with a design degree, or a degree in game design, suggesting that their contributions to the workshops were one of future professional designers.

A further limitation of the work is that I did not attempted to demonstrate the quality of the ideas generated. Assessing the quality of a creative process is a difficult endeavour, hence I opted to focus on how the design cards facilitated the creative process, rather than assessing the quality of the generated ideas. To hint at the creative contribution the participants made in the workshops I included a snapshot of some of the ideas in the form of the posters generated that suggest that the design cards can indeed facilitate creative ideas. On the other hand, I acknowledge that assessing the quality of the ideas, for example through an expert panel, might add weight to the argument of the usefulness of the design cards.

Lastly, another limitation was the use of a questionnaire. Questionnaires can only paint a limited picture of complex phenomenon, such as the design task investigated in this study. However, I wanted to give all participants the opportunity to provide feedback, and considering the number of participants in some of the workshops, a questionnaire seemed to me a practical tool to achieve this. In order to minimize the limitations of questionnaires (Neuman, 2006), I always looked for confirming statements for each questionnaire entry in the interview data. It should also be noted that the format of the answer choices on the questionnaire could have been improved: as the rating on the questionnaire occurred at the end of the design task, participants might have been too tired and chose to tick an entire row of "strongly agree". A mixing of answer choices might have avoided this, however, in pilot testing participants found such a mixing too confusing so I opted for a more straightforward presentation of the answer choices.

8.15 Conclusion

The design cards were considered useful by participants in design workshops for the creative task of designing an exertion game. The participants expressed that the cards, which were derived from the exertion framework, supported them in their task, suggesting the utility of the framework. The cards achieved this by, for example, helping the participants factorizing the task into individual elements. This resulted in participants realizing that they would have overlooked an important aspect if they had not used a specific card.

The study also strengthened the framework by adding empirical evidence that the framework can positively affect the design of exertion games, confirming the objective of the framework. The study also highlighted aspects that concern the completeness of the framework: the participants found some cards too similar, possibly indicating that some themes of the framework could be combined, resulting in fewer themes overall. However, on the other hand, the participants found that the design cards covered (almost) the entire spectrum of themes they found practical for their practice, and considered the amount of cards appropriate, which adds weight to the argument that the framework consists of the major themes in exertion games.

In sum, the study demonstrated the exertion framework in action through a set of design cards. The data collected from a range of workshops with an extensive number of participants indicates that the design cards can support the creative process of designing exertion games, and as a result, suggests the utility of the framework.

9. On the podium: Discussion & Conclusion

This chapter presents a recapitulation of the thesis so far, identifies limitations of the approach taken and makes recommendations for addressing them. Before ending with concluding remarks, directions for future work are suggested.

9.1 A brief recapitulation

Interest in gaining an understanding of how to design for the human body, in particular its exertion actions, has grown in HCI and interaction design, as it is believed that such an understanding can contribute to address health issues, such as the obesity epidemic. It has been acknowledged that investigations towards gaining such an understanding can benefit from considering social influences, as philosophical worldviews such as phenomenology and embodied interaction as well as research in sports suggest a tight interrelationship between the body and social play.

In consequence, digital systems have emerged that offer interactive experiences, mostly in the shape of games, which require intense physical effort from its users. Despite the advancements of prototypes and commercial systems, however, there are criticisms in the literature that the understanding of how to design for such exertion games is still limited, in particular in regards to social play. With only a limited understanding, the potential of exertion is difficult to explore, and as a result, an enriched conceptual understanding needs to be developed in order to have guidance for the design of rich social play in exertion games.

The surveyed literature revealed that there are three main reasons why such an understanding of exertion games, and in particular social play in exertion games, is still limited:

1. There is a lack of engagement with the interrelationship between exertion and social play, for example most exertion game studies only investigate single-player games and hence fail to consider this interrelationship.

2. There is a lack of systems that would allow for investigations of rich social play experiences in exertion games.

3. There is a lack of empirical research that provides knowledge about the user experience in exertion games, feeding the desired understanding.

In an effort to address these gaps, I designed three novel exertion games and conducted studies with each to establish an understanding of how to design for social play in exertion games. The three exertion games support distributed participants in order to highlight, but also to investigate, the opportunities and challenges technology can bring to social exertion experiences.

The design process of the three exertion games was influenced by an embodied approach to interaction design. This meant that the game's rules, the interface mechanic, and social communication channels were approached as a whole and hence developed together, rather than seen as separate components of the overall design. Furthermore, this theoretical stance has helped me in selecting my methods and influenced my choice of data gathering techniques. With this, I was able to systematically investigate how design can facilitate social play in exertion games.

An understanding of exertion games benefits from knowledge on how to create more engaging exertion experiences. In order to foster such knowledge, an understanding of the user's experience when engaging with these games is needed, which led me to study the user experience of the three exertion games. The insights gained from my investigations allowed me to establish the first design-informed and empirically derived understanding of how to design exertion games with a particular focus on social play. This understanding was manifested in the exertion framework. Finally, I demonstrated how an instance of the exertion framework supported the creative process of designing exertion games.

9.2 Research question

My review of the research literature led to the research question:

How can design facilitate social play in exertion games, in particular when mediated?

Briefly, social play in exertion games can occur, even in mediated environments. The mediating technology facilitates social play by supporting bodily reciprocity that is fostered by certain design features.

9.2.1 Prototypes

The three exertion games developed throughout this research program have demonstrated that social play can occur in exertion games, even though participants might be in geographically distant locations. Furthermore, the games have also demonstrated that the technology augmentation can offer opportunities, but also challenges for designers who want to support engaging user experiences.

The three games highlighted that there are at least three broad categories for distributed exertion games: games that are centred on contending for control of one's own body, games that are centred on contending for control of an object, and games that are centred on contending for control of each other's bodies. These games offer different levels of richness in regards to social play. This view on different levels of richness originates from perspectives in sports, however, the different levels become even more important when seen in the light of technology mediation, as they pose different challenges for implementation when exertion is distributed.

- Contending for control of the body means parallel play, which features a low degree of bodily reciprocity, and does not require bodily feedback from a remote body. In contrast, games that foster contending for control of each other's bodies can benefit extensively from bodily feedback from a remote body, as Remote Impact has demonstrated. This view on the interaction helps designers determine if their game could benefit from bodily feedback.
- In games that require contending for control of an object, a design tactic to conceal technological limitations such as network delays can be to require the skilful control of a mediating object, as this can support the loose coupling of

the exertion actions with the virtual domain. In Table Tennis for Three, this was achieved by means of a ball that mediated between the participant's body and the virtual objects.

- Games which feature contending for control of each other's bodies benefit from a tighter coupling between exertion and virtual representation in order to support increased bodily reciprocity: participants in Remote Impact act and react to each other's actions at all times, as there is no mediating object like in Table Tennis for Three.

The exertion games developed offered a way to study these different levels of social play, and as their development was an integral part of the overall research process, they were suited to refer the insights gained back to specific design features.

9.2.2 Studies

The studies revealed that participants could experience social play even though they might be geographically distributed. The studies also demonstrated how, for the participants, social play can vary throughout the experience, supporting the seeing of social play as a continuum, confirming the investigations of children's social play by Frost (2008) and the sports education work by Vossen (2004). Moreover, the exertion games studies extended their work by demonstrating that the introduction of a virtual element allows participants to experience different categories of social play within the same game. Participants experienced both parallel and non-parallel play across the physical and the virtual world, which offers opportunities not readily available in co-located play: for example, the ability to engage in both parallel and non-parallel play enables experiences where participants of different physical abilities might not limit each other's engagement with the game. This could facilitate exertion. However, if technology design supports both parallel and non-parallel play, there is also the potential that participants engage in non-parallel play only if the design facilitates both non-equally, as experienced in the study of Remote Impact.

The studies also demonstrated that participants experience engagement with exertion games around six central themes that can be facilitated by design. In terms of social play, these themes are fostered through the relating body by means of bodily reciprocity, but they can also be seen from a responding body, from a moving body, and from a sensing body perspective. The responding body refers to the response of the body to the exercise, the moving body refers to the repositioning of body parts, and the sensing body refers to the body interacting with the world. Together, they offer a set of perspectives that allow seeing the themes through different views from the body.

The themes arising from the studies can be grouped into three categories: rules, play and context, complementing the body lens to embrace the themes in a matrix-like structure. This extends Salen and Zimmerman's work (Salen & Zimmerman, 2003a) by adding an exertion perspective to their "seeing games as …" approach of understanding games: researchers can now see games as players engaging in exertion through the themes.

9.2.2.1 Uncertainty arises from exertion

Uncertainty is an element of every game, and game designers usually program randomness into digital games to foster uncertainty, as it can facilitate excitement and surprise. In exertion games, the body can be another resource for uncertainty. Designers have a handle on this uncertainty from the different perspectives of the body lens. For example, designers can introduce physical objects the body needs to control to add an element of uncertainty, or they can utilize imperfect sensing technology that introduces an element of uncertainty. Furthermore, uncertainty can level the playing field between participants of different physical abilities, thereby facilitating exertion.

If uncertainty arises from the body, and this uncertainty is used to enhance the game experience, it can be said that the body is a resource for the game's design. Such a view highlights that a rethinking might be needed if it comes to facilitating randomness in games: designers have the ability to control the randomness in the digital world, but they also need to match it with the randomness emerging from the body. Computer games require careful tweaking in order to find the right level of randomness for an engaging experience that users do not find boring or random (Salen & Zimmerman, 2003a). If this digital randomness is now mixed with randomness emerging from the body, designers have to find new ways to tweak their designs, and new methods to test and evaluate this mix might need to be devised in order to support this. On the other hand, this mix can offer new opportunities for design, extending the design space to enable novel game experiences, as suggested by the results from the workshops.

The notion of uncertainty arising from the body contributes to the HCI work that promotes the use of ambiguity in interactive systems as a resource for design to enhance the user experience (Gaver, Beaver, & Benford, 2003). Uncertainty arising from the body can support ambiguity, as the studies have shown that participants drew on uncertainty when contending with their opponent, which can create a sense of ambiguity for the opponent that facilitates suspense and fosters engagement.

9.2.2.2 Contending for control

Technology design facilitates social play by supporting participants in contending for control. The studies have highlighted the following design features that designers can utilize to support contending for control:

- By supporting the ability to share pain, the perception of the discomfort of exercise can be decreased for participants. One way to achieve this is by increasing participant's awareness of their partner's responding body: in Jogging over a Distance, the heavy breathing was amplified by the system's design, which facilitated shared pain and resulted in empathy. This empathy led participants to encourage each other to keep going.
- Participants benefit from awareness of their partner's pain, but they also benefit from a disassociation from their own pain: systems can support the exertion activity by distracting from the pain signals of the body, allowing the continuation of the activity despite exhaustion.

- In addition to the game's goal, participants might also pursue their personal goal as part of the activity, striving to achieve objectives such as improving fitness levels. Designers need to consider these additional goals when designing the game's goal. For example, if participants choose to utilize competitive attitudes to achieve their health goals, designers can facilitate competitive behaviour by allowing for comparisons of bodily data. If participants choose to utilize collaborative attitudes, designers can facilitate this by making bodily data ambiguous.

A design strategy to support contending for control is to foster awareness of bodily data. This resonates with Consolvo et al.'s design recommendation to provide personal awareness of the exertion activity (2006), where the authors refer to the moving body layer of the body lens. This thesis refines their recommendation by suggesting to consider awareness of the responding body as well, in particular, to provide awareness of the partner's responding body. My studies also provided evidence that participants can benefit from systems that offer "dis-awareness" of the exertion activity: the joggers in Jogging over a Distance applauded the system's ability to facilitate a distraction from the pain resulting from the activity.

Contention for control also relates to ideas of collaboration and competition. Although sports are often viewed only from a competitive perspective (Hoffman, 2005/2008), my studies have shown that collaboration and competition often occur within the same exertion game. As a result, I viewed a system's ability to support both competition and collaboration as a way to support rich social play, a finding similar to Voida et al.'s conclusion in their study on social play with console games (2010). In their work, they found that participants waited for one another if a player fell too far behind. Such behaviour was also observed in Jogging over a Distance, however, exertion games are also often motivated by external goals, such as improving health, which can be in conflict with social goals: unlike in console game play, joggers sacrificed their personal workout goal when waiting for their partner. To address this, design could level players in a way that allows for social play while also supporting individual exercise goals. In this sense, my work extended Voida et al.'s (2010) findings by adding how design can support such social play behaviour when exertion is involved.

9.2.2.3 Exertion as a form of expression

Technology design can facilitate social play by supporting participants in using their bodies for expression. Expression can be facilitated by not restricting movement, as the example of Dance Dance Revolution demonstrates: the system's design facilitates expression precisely because it does not care how movements are performed (Behrenshausen, 2007). On the other hand, design can actively encourage self-expression, for example Guitar Hero facilitates the movement of the guitar by awarding game points for such movement (Lindley et al., 2008). This resonates with HCI work on performative interaction in arts projects and self-expression as a public interaction (Benford, Crabtree, Reeves et al., 2006; Dalsgaard & Hansen, 2008; Reeves et al., 2005; Sheridan & Bryan-Kinns, 2008). This prior work focused on analysing the interaction between artist or participant and an audience. Such interactions can also occur between an exertion player and an audience, and hence the prior work can be used to analyse these interactions. In contrast, the work in this thesis aids designers in supporting participants' desire for self-expression using their bodies. It guides designers to four different layers of the body lens where mediating self-expression can originate from, which aids the development in terms of technological augmentation, for example by suggesting physiological sensing to enable new forms of mediated expression. This thesis also showed how mediating expression is different when it comes to opponents (an "audience" usually not present in arts projects), as the rich variety of movement exhibited in exertion activities can facilitate self-expression by means of finding alternative ways to reach a game's goal; this was sometimes considered cheating by the participants. This cheating was often done in ways that exploited the limitations of the technology, a practice that designers of sensor technology might consider as "unexpected behaviour" (Benford et al., 2005), and hence deserves attention from the exertion game designer.

9.2.2.4 Exertion rhymes with rhythm

Technology design can facilitate social play by allowing participants to identify and synchronize a uniform or patterned recurrence of a beat in bodily action. The realization of the benefits of supporting the identification of a beat in interactive systems is not new (Reidsma et al., 2010), however, this thesis extends this work by not seeing it as isolated phenomenon, but rather within the context of a particular social activity. Furthermore, this thesis also aims to highlight that the occurrence of a beat can come from sources other than music: rhythm in exertion games can also arise from the movement itself, or the movement from another person.

Two main strategies were identified as to how design can support rhythm in exertion games:

- Firstly, technology design can help participants identify a rhythm by making the rhythm of the body more accessible, for example by amplifying a rhythm in breathing: the Jogging over a Distance participants reported that the audio-only design amplified the breathing, sensitizing them to become aware of a rhythm in breathing in a way non-augmented breathing does not.
- Secondly, the design facilitated the synchronization of rhythm by making participants aware of each other's breathing. The Jogging over a Distance system amplified the breathing and it also communicated it to the remote end, allowing for the rhythm to take on a social role, as participants adjusted their exertion actions to be in sync. In other words, the design facilitated a form of bodily reciprocity by supporting participants in synchronizing the rhythm in their exertion actions.

However, supporting rhythm is not an easy endeavour for designers: rhythm can also be off, impacting exertion negatively. Supporting the identification of a rhythm that is not suitable for participant's own bodily rhythm can be detrimental to the experience (Karageorghis & Priest, 2008), hence supporting rhythm in exertion games is a design choice that needs to be carefully evaluated.

9.2.2.5 Exertion puts the body at risk

Technology design can facilitate social play by considering the physical risk that is inherent in exertion actions. Although this thesis did not find that more physical risk leads to more social play, Remote Impact has shown that a lack of risk can affect the richness of social play negatively, suggesting a relationship between the risk in exertion games and social play. This physical risk can arise from participants' own bodies, endangering health through overexertion. Risk can also arise from the moving body, causing injury by moving abruptly or extensively. Furthermore, physical risk is also associated with the equipment and environment that the exertion activity engages with, the risk of jogging at night reported by participants in Jogging over a Distance is an example of this. Lastly, risk can arise from body contact with another person in activities which feature contending for each other's bodies.

Conventional computer games are characterized by a lack of physical risk; in fact, it is precisely this lack of physical risk that enables one of the key characteristics that makes computer games so compelling for many players: gamers enjoy being able to delve into a fantasy world where they can do what they cannot do in the real world (Lazzaro, 2004; Salen & Zimmerman, 2003a). This includes being risk free of bodily harm. Exertion games challenge this notion as they introduce physical risk to the game experience, which poses interesting new challenges for the designer of exertion games: if the lack of risk means no commitment (Klemmer & Hartmann, 2006), does the introduction of physical risk means more commitment? If so, does this affect the potential of the fantasy element, that is, will the potential of computer games to support the fantasy element be hindered by the inclusion of physical risk? The insights from this thesis on physical risk suggest that investigations into the role of the fantasy element in exertion games might reveal interesting insights that aid designers by helping them to understand the relationship between fantasy, risk and commitment in interactive experiences.

9.2.2.6 Understanding exertion

Technology design can facilitate social play by fostering conditions that are supportive of gaining an understanding of participants' bodies when engaging in exertion activities. This understanding of the body evolves around two key concepts:

- Knowledge about the body in exertion enables an abstract description or explanation of a particular bodily action.
- Skill allows executing actions during the exertion activity, and is predominantly gained through training and practice.

Design can facilitate both knowledge and skill. For example, Jogging over a Distance demonstrated how design supports participants' understanding of their bodies by making their heart rate easily accessible to them during the activity. This facilitated bodily exploration, as participants were interested to find out how their movements affected their heart rate. The design of the system fostered this gaining of an understanding not on a personal, but on a social level: participants gained an understanding of their bodies only in relation to their partners', which contributed to bodily reciprocity.

The theme of understanding exertion relates to the notion of kinaesthetic literacy (Sheridan & Mueller, 2010). Understanding exertion can be seen as a subset of kinaesthetic literacy, as kinaesthetic literacy also encompasses interactive learning environments that benefit from the moving body. However, both highlight the potential of interactive technology to foster the combination of exertion and learning. One example of how technology can foster this is through the mapping of exertion actions. By mapping bodily data in non-uniform ways, design can invite participants to explore their bodies, as Jogging over a Distance demonstrated.

9.2.3 Summary

This thesis established

- A contribution to design through the design of three novel exertion games that also served as research vehicles for investigations into exertion and social play.

- An exertion framework with six themes that are at the centre of the exertion experience, embraced by a view on games and the body that can serve as handles for design.
- An understanding of how design features informed by these six themes foster bodily reciprocity between participants, and as a result, facilitate enriched social play.

9.3 Contributions

This thesis makes contributions to both practice and theory.

9.3.1 Contributions to practice

This thesis makes a contribution to practice through the design of three exertion games that demonstrated how exertion games could facilitate social play between distributed participants. These games facilitated social play along different levels of richness, answering the call for more systems to expand the design space in this field by de Kort et al. (2008). These games demonstrated additional benefits besides supporting distributed participants that technological augmentation can offer to the players:

- Jogging over a Distance demonstrated how technology could allow participants of different athletic abilities to jog together.
- Table Tennis for Three demonstrated how technology could support a scaling of player numbers to enable three players to fairly play a table tennis-like game together.
- Remote Impact - Shadowboxing over a Distance demonstrated that technology could be used to reduce the risk of physical harm often associated with traditional sports activities without eliminating the exertion aspect.

By offering novel experiences to its users, these exertion games also contribute to design, as they were designed to “make the *right* thing", being “a product that transforms the world from its current state to the preferred state” (Zimmerman et al., 2007, emphasis by the authors). The authors propose to examine the process, invention, relevance and extensibility of the design in order to evaluate any contribution to design. By looking at this list, it becomes apparent how the exertion games made a contribution to design: the design process of the exertion games has been documented in this thesis and in academic peer-reviewed papers, the prototypes constitute significant inventions that advance the current state of the art, the designs have relevance as they allow distributed participants to engage in exertion activity together in a way that they otherwise would not be able to do, and the work is extensible as the designers in the workshops have used the insights gained to design new games.

By demonstrating how participants of computer game experiences can profit from the social and physical health benefits of exertion this research also demonstrated that computer games can serve the community ethically beyond entertainment, fostering the ethical responsibility of the industry, therefore ultimately contributing to the gamer and the game-producing community as a whole.

9.3.2 Contributions to theory

This thesis makes the following contributions to theory:

- This thesis broadens our understanding of computer games to include an emerging area of computer games that require physical effort from the participants. It achieved this by providing insights from empirically grounded studies of exertion games, therefore contributing towards redressing the lamented lack of empirical studies on games that centre on the body (de Kort & Ijsselsteijn, 2008; Moen, 2006). This work provided the first understanding of how designers can design for the experience of playing exertion games, extending prior work that focused primarily on the health effects that occur as a result of playing these games, rather than the actual user experience (Graves et al., 2007; Lanningham-Foster et al., 2006).
- In particular, this work contributed to an understanding of social play in digital games, answering the call for more investigations into the benefits of considering social play when gaming (Isbister, 2010). This work extended current understanding of social play by explicating the role of

bodily reciprocity, which is negligible for social play in button-press games, but gains significance in exertion games. This understanding of bodily reciprocity was elucidated through the investigation of social play in mediated environments.

- This work also contributed to an understanding of exertion. It facilitated this understanding by offering a perspective through computer games, related to the game character of sports. However, unlike sports, the computer can offer advantages to enable exertion experiences that are not possible without the technology mediation, such as supporting distributed participants. By investigating these novel exertion experiences, the understanding of exertion is advanced: this work revealed how exertion is affected by social play, and how design facilitates this relationship. In particular, this work explicated how participants change their exertion investment based on social play experiences.
- This research also contributes to our understanding of computer mediation. It explicated ways how technology can support computer mediated communication if exertion is involved, and it achieved this by detailing how bodily reciprocity can be supported by design. The work presented new ways to understand and categorize bodily reciprocity, proposing three broad categories that aim to help designers in approaching the development of mediated exertion games. These three broad categories, contending for control of the body, contending for control of an object, and contending for control of each other's bodies, refine prior categorizations on parallel and non-parallel play by explicating a continuum of bodily reciprocity.
- This research also contributes to the user experience agenda by demonstrating the use of methods of how to evaluate the user experience of games that involve exertion, extending the current user experience perspectives on games that focus mainly on button-press games (Bernhaupt, 2010a).
- This work also contributed to the embodied interaction agenda in HCI by extending this work to an application

domain that features the body extensively, in particular when compared to traditional HCI application domains that only feature limited bodily actions, such as those which occur in the office workplace. The thesis highlighted notions such as physical risk and pain that do not traditionally occupy a significant role in HCI. By bringing such notions to the fore, this work also aims to make a contribution by facilitating explorations on the idea of how technology can support areas of life where these concepts play a more significant role, such as in sports, and how HCI can contribute to these areas of life.

- This work also contributed an additional explication of how theoretical frameworks can be transformed into design tools by means of the design cards that were used in workshops with designers. Furthermore, it added an experiential account of how this design tool can be evaluated.
- By having drawn from both sports and HCI research, this work also serves as bridge between sports and HCI, offering a language that can mediate between the two, making a contribution to bringing these two fields closer together.

9.4 Limitations and recommendations

Each of the four studies included a detailed critique of the limitations for each. What follows next is a discussion of the limitations of the overall research program and how these limitations could be addressed.

First, I critique the exertion games developed, then the process of how the studies were approached, and lastly I critique the contributions of the thesis.

9.4.1 Critique of exertion systems

I designed three exertion games to serve as a research vehicle to gain an understanding of exertion games. I have already justified the decision as to why I designed three systems, and will hence concentrate on critiquing limitations of the overall approach and how they could be addressed.

9.4.1.1 Designer was evaluator

I designed as well as evaluated all three exertion games, hence my perspective during the studies of the systems was informed by my experience of designing them. This allowed me to have a holistic view on the technology design throughout the entire process.

However, one could argue that studying other people's systems, whether from other research labs or from commercial game companies, could reveal insights that I overlooked, as I was too intimately involved in the system's design to spot high-level issues of design. Firstly, there is a rich history of designers evaluating their own systems in HCI, hence the studying of one's own designs is very common in the field. Secondly, I agree that adding additional systems to study could enrich the set of findings. However, at the time of this project, there were only very few systems available that supported distributed exertion, and if they did support it, richness of social play was limited. More importantly, I did not want to conclude with design recommendations for existing systems, but rather insights that shape the future of the field, hence I opted for designing novel systems that I believed "pushed the envelope" of what is currently possible, in order to inspire other researchers to invent the future of exertion games.

9.4.1.2 Limited multi-user support

The systems presented only make limited use of technology's potential to scale for a large amount of users (Salen & Zimmerman, 2003a). Only Table Tennis for Three was tested with more than two participants at the same time, and although it has been played informally with four players (and so was Remote Impact), no study was undertaken to investigate a larger number of players.

I agree that designing an additional game in the style of massive multiplayer online games (MMOGs) would have allowed the investigation of how scaling exertion to a large group of online participants could have revealed interesting insights. However, this has already been approached with research that combines the Nike+ system with principles of MMOGs (Campbell et al., 2008), although social play is only supported after the exertion activity occurred. Moreover, supporting a large user base usually requires a large set of hardware input devices. One way to address this would be to use existing hardware that people might already possess, such as cameras, to capture exertion input, and collect log data from a large user base. I concur that this would make an interesting avenue for future work.

9.4.1.3 Limited to sports inspirations

All three games were inspired by existing sports, hence borrowed bodily mechanics from sports activities that already exist. In Jogging over a Distance, it is the activity of jogging, in Table Tennis for Three, participants had to control the table tennis ball with a table tennis bat, and in Remote Impact participants had to box one another. By drawing extensively from existing sports activities, one could argue I missed opportunities to invent entirely new games, expanding the range of exertion activities participants can engage in.

Although the presented exertion games were inspired by existing sports, they were not a simulation of the sports in the digital domain, an approach often taken in virtual reality research (see for example the attempt to recreate a table tennis game in a virtual world (Woodward, Honkamaa, Jppinen, & Pykkimies, 2004)). With my systems, I tried to combine bodily mechanics from existing sports with opportunities that the technological augmentation offers. In Jogging over a Distance it is the opportunity to jog with a remote partner of different athletic abilities. In Table Tennis for Three it is the opportunity to play with three players equally, and in Remote Impact it is the opportunity to box without the physical risk involved. In that sense, these are new sports experiences.

Additionally, drawing from existing sports allows participants to quickly engage, as the learning curve to understand the bodily mechanics required to play is minimized. As a result, all participants were quickly able to play without lengthy instructions, leaving more time to engage with the studies. Introducing participants to unfamiliar bodily mechanics might have resulted in more complex instructions, which might have taken time away from playtime, reducing the amount of data I could have collected.

Lastly, I also hoped that borrowing from existing sports gives participants more confidence in their ability to participate in a safe manner, keeping the risk of physical injury to a minimum. For example, the equipment used in table tennis has evolved throughout the sport's history into an ergonomic solution suitable for extensive use. Joggers have shoes that are designed to support running. If participants would have been exposed to activities and equipment they were not familiar with and were not extensively tested to suit a wide range of bodies, it was feared that the risk of physical injury might increase.

I see the presented games as one step towards a richer set of interactive systems that support exertion. Consequently, they can only represent a small set of exertion systems, but are hopefully able to inspire a wide range of new systems that borrow from all sorts of existing sports and also contribute to the invention of new sports activities.

9.4.1.4 Limited to "over a distance"

All three systems utilized a distributed approach to exertion. This was a deliberate design choice, as I believe that studying social play in mediated environments can reveal unique insights into the opportunities of technology mediation. The results are insights into how design can support social interactions that might also be applicable to co-located settings, but would not appear obvious when investigating only co-located play.

Furthermore, by presenting several exertion games that can be played over a distance, I aimed to demonstrate that playing "sports" is possible over a distance, and that technology design can offer advantages, such as supporting distributed participants, when compared to existing sports. This approach also aimed to allay some concerns that exertion games might replace sports; I believe exertion games provide an addition, not a replacement to, existing sports.

9.4.2 Critique of studies

Next, I critique the process of studying the exertion systems and make recommendations about what could be improved in the future.

9.4.2.1 Single coder

Although the outcomes of the data coding process were discussed with my supervisors and fellow researchers, having a second coder during the qualitative data analysis could have added credibility to the findings of the qualitative process. However, acquiring a second coder was not always practically feasible.

My coding themes were checked against two senior researchers during my analysis of Jogging over a Distance. The Table Tennis for Three data was presented to the department's peers in a seminar. The Remote Impact coding process benefited from being performed under the auspices from researchers from another institution. The coding process from the last study was also performed under the auspices from external senior researchers. The data and coding process as well as outcomes of my analysis were also always extensively discussed with my supervisors. They were also presented at departmental seminars where further input was solicited.

Although the coding process benefited from the insights from a wide range of senior researchers from different institutions throughout the analysis process, I do agree that the analysis would have gained more credibility with the input of a second or maybe even third coder.

9.4.2.2 Limited longitudinal investigation

This research did not include a longitudinal study of exertion games for practical reasons. I do acknowledge that such a study could reveal additional insights into the long-term engagement with exertion activities and highlight any evolving health benefits such as weight loss. As longitudinal studies are often carried out within the context of people's lives, such studies might also reveal insights into aspects of why or why not people choose to engage in exertion activities. Such investigations could offer insights into designing for long-term use, creating a more sustainable exertion culture for participants.

For each of the studies, I already described practical reasons that justified the particular lengths of investigations. Moreover, the Jogging over a Distance study already suggests that the systems can facilitate engagement beyond the immediate studies, as one of the participants who was a non-regular jogger noted: *"Listen, this jogging - I've got to thank [the experimenter] - I'm really getting into it." [P12, run]* Furthermore, she added that she went out on her own between the two study runs because she was inspired by the Jogging over a Distance jogs.

I would like to add that, although I agree that longitudinal studies can provide additional insights about exertion games, it is also important to note that a long-term attitude to sports is an evolving one, possibly shaped by the fast-lived world of computer games. In the past, only limited sports facilitates were available, and participants often engaged in the same sport activity for a lifetime. Today, with facilities covering a wide range of activities, and people's mobility allowing them to travel to different sites offering different sports opportunities, people can engage in a wide variety of sports activities, easily switching from one to another. Similarly, computer games are supporting engagement that often only lasts a couple of hours before the next game is purchased, with the exception of a very few titles. This has not diminished the appeal of computer games though. Maybe exertion games will be used in a similar way where participants play only for a short period of time before they move on to the next game. This might mean that exertion games do not need to engage for years, but are suitable short-term activities for today's fast-lived lifestyle. If so, the need for longitudinal studies might fade in the background.

9.4.2.3 Prior relationships between participants

The selection of participants' activity partners was shaped by practical reasons, rather than a structured approach as to how previous relationships inform social play. I acknowledge that the games literature suggests that prior social relationships can shape the game experience (Salen & Zimmerman, 2003a), and that a more structured selection of participants might have resulted in additional insights, for example by looking into how previous sports partners played together compared to participants who did not know each other before.

However, considering such prior social relationships is a difficult task, as social relationships are difficult to categorize and constantly changing, for example when does an acquaintance become a friend? Furthermore, acquiring a rich set of different social relationships would have required a much larger number of participants, adding to the complexity of the task. I therefore decided to let participants decide with whom they would like to partner up with, only if they could not bring partner(s) along, I matched them up myself. For this, I was inspired by existing sports practices, where people enjoy participating in sports activities with their friends, however, due to the practical reasons, often have to partner up with strangers (Weinberg & Gould, 2006).

9.4.2.4 Definition of exertion

My definition of exertion does not include a quantifiable measure of what makes a game an exertion game and what does not. The term “physical effort” was selected to guide designers how to consider the themes on a case-by-case basis: the more physical effort a game requires, the more important the themes become. This depends on the individual experience, too: a professional athlete might not require much physical effort when engaging in a particular game whereas a regular user might require much more. This also means that, for example, games that require intense movements with a joystick might also require physical effort for some users, and could therefore also be seen from an exertion game perspective. However, some suggest a need for a quantifiable measure of what makes an exertion game, and also, how much exertion is needed to play it (Ballas, 2010). The argument is that this will help buyers make informed decisions as to how much these games can contribute to their physical exercise regime, aiding weight loss programs (Ballas, 2010).

I make the claim that the systems investigated here required more physical exertion than most commercial systems available today. However, my goal was not to prove that more exertion is possible, but rather that the field is only touching upon what is possible in terms of supporting physical effort. I believe the focus should be on extending the range of physical effort on the positive end of the spectrum, rather than focusing on establishing a fixed borderline between what a button-press game and exertion game is.

9.4.2.5 Social Play

This investigation examined exertion interactions with a focus on social play. Some of the findings, however, have more of an exertion than a social "feel" to it, for example the exertion framework only focuses in the last column on social play. The first three columns are useful to consider in social play experience, however, can also be applied to solo-player games. I chose to include these insights, as the field is relatively young, and I believe that these new insights can help to grow the research understanding of exertion games, strengthening the field. I acknowledge that there is the chance that these insights might delude the focus of the contributions, however, the data from the workshops did not suggest that this might be the case, as almost all exertion game ideas participants presented had a social component to them.

9.5 Future directions

This research program has contributed to an understanding of exertion games. It focused on social play and how technology design can support it. This focus enabled a thorough understanding of a particular aspect of exertion games, rather than a broad exploration. However, the progress has made a fertile ground for future research.

While the previous section has discussed ways to refine the proposed understanding in this research program, the next section presents directions for future work, arising from reflections on the contributions made.

9.5.1 Designing for social play surrounding the exertion activity

This research investigated social play as part of exertion activities. It differs from prior work on exertion activities by its focus on the social interactions that occur during the activity, in contrast to post-exertion social exchange, such as investigated by Consolvo et al. (Consolvo et al., 2006; Sunny Consolvo et al., 2008). However, social interaction does not stop when the exertion activity stops: social interactions on the sideline, conversations during the half-time break, chit-chat in the locker room, discussions of the game afterwards over a drink and so forth are all part of the social ritual sports. As such, exertion games can probably benefit from social support that encapsulates the activity, rather than uses it as boundary line. For example, the data from the Table Tennis for Three study shows how participants used the videoconference to discuss their performance after the game. The Jogging over a Distance participants utilized the mobile phone connection to keep talking even though they had completed their run. Investigating how to design technology that provides a seamless transition between social interactions arising before, during and after the activity could be a fruitful avenue for future research.

9.5.2 Physical risk in interaction design

This research program has highlighted the role of physical risk in exertion games. As suggested by Klemmer et al. (2006), physical risk has a role in interaction design that is currently underdeveloped. This research contributed to a richer understanding of physical risk by looking at it from a games perspective, but the insights gained might also be helpful in guiding future research on integrating physical risk in an HCI agenda that encompasses the whole gamut of human experiences, including physical risk and the potentially negative implications such as physical pain.

9.5.3 Exertion for non-gamers

This research program investigated exertion games, assuming gamers, defined as people who voluntarily engage in the activity

(Salen & Zimmerman, 2003a), play them. Many definitions of games explicitly state that as soon as the player stops approaching the activity with a playful attitude, not voluntarily engaging anymore, the view of the activity as playing ceases to exist (Salen & Zimmerman, 2003a). In this sense, playing games professionally does not count as gaming. This distinction is interesting in the context of exertion games, as many users might not be gamers by this definition. For example, is playing an exertion game different if a physiotherapist prescribed it? How does design need to change if the user of an exertion game does not approach it with a playful attitude, but one of requirement, in order to meet recommended exercise targets? How is the design task different if designing for professional athletes? With interaction design research for professional athletes gaining increased attention (Chi et al., 2004; M Ludvigsen, Fogtmann, & Gronbek, 2010), these are all interesting questions for future research.

9.5.4 Refining the framework

The resulting exertion framework highlights themes for exertion games as derived from studies of games placed along the social play continuum. The framework is aimed to support all exertion games, however, it could be the case that different games on the social play continuum highlight different themes in the framework, with some themes only being applicable to certain locations on the social play continuum. This could lead to a more refined framework that designers of specific game genres might find useful. Investigating such themes specific to different categories of social play could be an interesting avenue for future research.

9.5.5 Non-human social play

In order to focus my investigation, I restricted my understanding of social play to human-human interactions. However, as prior research has pointed out, human-computer play with non-player characters in games can also be a form of social play (Isbister, 2006; Lazzaro, 2008). It could therefore be an interesting avenue for future research to investigate how participants engage in social play where the participant's body relates to a virtual body: exertion games can feature computer-controlled avatars that try to engage in bodily reciprocity with their human players. This offers opportunities to engage participants in exertion activities when no human partner is available, or engage people who feel more comfortable exercising alone. Designers of such systems need to consider if such non-human players would also need to get tired in order to, for example, facilitate shared pain. However, this would also mean that the avatar might need to stop exercising at some point, possibly before the human player, ending the activity prematurely. Finding optimal ways to utilize non-human players to facilitate exertion benefits might therefore be an interesting area for future work.

9.5.6 Exertion beyond games

The research program focused on exertion games. However, exertion can occur in many other areas of life outside games, and this research program did not consider these. However, the insights gained might be useful for future work that investigates exertion in non-game tasks. Interaction design might also offer benefits to exertion actions that do not occur in a game context.

Furthermore, as many recent HCI systems involve the body more extensively, it might be also beneficial to investigate these systems from an exertion perspective. For example, many mobile location-based systems require users to walk around (Benford, Crabtree, Flintham et al., 2006), which can result in exertion, and investigating such systems from an exertion perspective might reveal new insights into how to design for these bodily experiences.

9.6 Concluding remarks

Exertion is an important part of life, resulting from investing physical effort that people often do for fun, adding to a satisfying life. These exertion experiences are often intertwined with social benefits, suggested by sports as a good example of where exertion and social play experience a tight interrelationship.

However, exertion is a complex phenomenon, where people often have to overcome physical limitations in order to reap the benefits of the activity. This means designing for such experiences requires a delicate balancing between opposing ends of a set of dimensions that deal with the body responding to the exercise, the movements of the body, and the body's interactions with the environment and social others.

A series of novel systems has helped to uncover the opportunities and also challenges for technology to support this interrelationship between exertion and social play. Empirical studies of these systems have revealed guidance for designers on how to design for this interrelationship. Furthermore, this thesis has shown how technology design can facilitate social play in exertion games, and consequently offers a framework for exertion games. The result is an enriched understanding for a relatively unexplored area of HCI: mediated sports experiences. With such an enriched understanding, people's experiences can be positively influenced by technology design, fostering a healthier life. Seen in this light, there is potential for considering the active body in many other areas of life that can be supported by technology, expanding the field where HCI makes a contribution to people's experiences through the use of technology.

While exertion games are not meant to replace existing sports, they can contribute to an exciting new view of what we understand as sports, expanding the range of experiences we have with our bodies. We now have a framework to design for this.

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Appendix 1: Jogging over a Distance

Appendix 1.1: Demonstrating first phase of data analysis

This appendix supplements and expands upon my description of analysis presented for study 1.

In the following sections, I describe and demonstrate how I carried out the coding process through the data. First, the recordings from the runs and the interviews were transcribed and segmented into individual speed bursts. An identifier precedes each speed burst for each participant in the table below.

Below I use a selection of the run as well as the interview data to illustrate the process.

I went through three passes of the data to identify aspects of social play, exertion, and technology design, which I represent as columns added to the right of the quotes. The outcome of the coding is represented in these columns. I was looking for any descriptions or phrases within each instance of the data that corresponds to any of the elements. Then a description of the element was entered into the box on the same row as the data.

In a second pass of the data, I was looking for any mentions of exertion and physical effort. This included trying to look for evidence that points to the role of the body in the interaction. If I identified some, I looked for any indicators pointing towards specific roles of the body as suggested by the body lens. These were entered into the relevant cell along the same row.

In a third pass of the data, I looked for indicators concerned with the design of the system. This meant identifying instances where participants described how their experience was shaped by the system. This included descriptions that point to the distributed nature of the activity, for example instances where participants compared their run to previous co-located experiences.

Excerpt from run data

Participant	*Data*	Social Play	Exertion	Design	Other
P25	*I am jogging*	Activity			
P24	*Do I sound better?*	Activity			
P25	*This is kinda neat*	Enjoyment		Spatialization	
P24	*It's weird because you catch up*	Surprised		Spatialization	
P24	*I can hear you panting*	Awareness of other's body state	Intensity of breathing		
P24	*[Laughing]*	Affective-enjoyment			
P25	*I mean what do I sound like?*	How am I perceived?	Breathing		
P24	*[Laughing]*	Affective-enjoyment			
…					
P27	*Go faster*	Encouragement, Instruction			
P26	*You are too far ahead*	Complaining		Spatialization	
P26	*Yeah, that is better*	Encouragement			
P27	*I can't go very fast*		Body capability		
P27	*I've had enough already*		Exhaustion, desire to stop		
P26	*Slow down – I'll slow down as well*	Negotiating, Waiting	Exhaustion management		
P27	*You are still mostly in the middle though, you must be going fast*	Checking activity of other		Awareness of other	

P27	*I think I used up my energy […]*		Exhaustion		
P26	*Talk to me*	Instruction		Talking->Awareness of other	
P27	*I love you long time*	Affective			
P26	*I better speed up*		Speeding up		
P27	*I wonder if I can I cut through the park*				Contextual: sharing co-located information
P26	*You are doing really well*	Encouragement			
P27	*I haven't stopped jogging, I've slowed down a bit*	Communicating body state		Communicating body state (overcoming lack of visual information)	
P26	*You are doing so well*	Encouragement			
…					
P21	*You okay?*	Checking body state	Exhaustion		
P21	*You got the pregnant breathing going on in the microphone*	Breathing	Exhaustion	Audio	
P21	*Do you want the big hill?*	Challenge	Increase exertion		Context: environment
P21	*You either run that or run that way and run up the big hill*	Challenge, Coordinating	Close effort		
P21	*You lazy bitch*	Goading	Close effort		
P20	*See you halfway round*	Goading		Co-located	
P21	*They laughed at me. This is terrible*	Public performance		Microphone	Context: perception by others

P21	*Can you hear anything?*			Status	
P21	*I can sort of hear you but you are breaking up*	Communi-cating		Status: breaking up	
P21	*Maybe I'm not running fast enough*	Negotiating		Speed	
P21	*Are you there?*			Status	
P21	*Ah, I can hear you now*			Status	
P21	*Big horrible hill*	Negotiating	Challenge		Context: envi-ronment creates challenge
P21	*You're getting now run-ning up the hill*	Communi-cate bodily state	Challenge		Context: envi-ronmental condition
P20	*[Panting]*	Awareness of bodily state	Exhaustion	Breathing	
P21	*Come on! Faster!*	Encourage-ment, goad-ing			
P20	*Shut up!*	Goading			

Data from interviews

Parti-cipant	*Data*	Social Play	Exertion	Design	Other
P13 (2nd)	You are kind of using all your senses to do a similar thing, so you can turn around to see where am	Together, perception		spatializa-tion	
P13	Even though we didn't go into any description of where we were running,	Negotiation			Context: location

	it automatically doubles the feeling of where you are running-emphasizes it	Affect, awareness		Amplifica-tion	Context: location
P14	You are not describing where you are or what you are doing	Communi-cating con-text			Context: envirom-ment
	and that kind of removes that idea of separation	Together			
P14	The only time I felt we were in different places	Together			Context: envi-ronment
	is if I came to a stop in my run and I had to indi-cate to [partner] to slow down, I have a light or something	Instruction, Communi-cating bodily state	Interruption		Context: envi-ronment
P14	If they were with you they'd be stopped too	Unlike co-located	Interruption		Context: envi-ronment
P13	It makes you realise you are jogging in different paths	Awareness, unlike co-located	Movement		
P13	It breaks that feeling that you are in the same place	Awareness, unlike co-located, af-fect: disrupt			
	[…]				
P14	I could hear [partner's name] quite clearly at times,			Voice quality	
	if he started to move further away I would just slow down my running a bit and then I hear	Waiting, in-centive to talk	Slowing down		
P14	It felt like it was running with someone	Together, Affect	Movement		
P13	You are there talking and trying to catch up or slow down for each other	Together, shared goal			

P14	When you are running with someone you don't really look them in the face-it's really just their presence	Awareness	Character of jogging	Lack of video	Parallel activity
P14	You can hear them	Perception			
P14	You can hear them breathing	Breathing	Exhaustion		
P14	You don't really get that visual which is fine as you don't really have that anyway	Co-located, awareness		Lack of video	
…					
P17	I just felt like she was near me	Awareness, together			
P17	It was like I was running with her but she was not beside me	Together, co-located	Movement		
	[Where was she?]				
P17	It felt like we were running together but we were not touching […]	Together, body contact (lack of)	Movement		
P16	I wanted to actually pace it		Exhaustion management		
	because that is my game plan to beat him but that didn't work	Competition, affect: disappointment		Contending challenge	
…					
P26	You sort of play with your heart rate		Heart rate	Gaming	
P26	There is genuine exercise benefits out of the heart rate monitor-that's a crucial part of it		Health, heart rate	Heart rate belt	Goal
P27	I think if you just gave us headphones and we were just having a phone call-	Conversation		Spatialization (lack of)	
	if that phone had the		Speed?	Spatializa-	

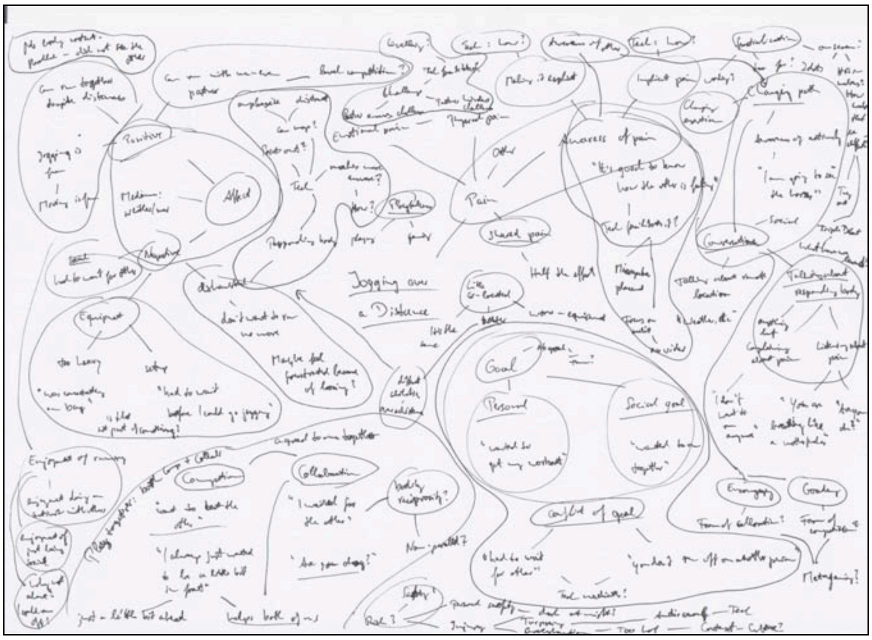
	ability to do the modulation, there wouldn't be any difference			tion	
P26	The interest, engagement, fun and challenge	Engagement, fun	challenge		
	it’s a competition between us to meet the expectations of the game- it's not a competition between us	Competition		Game	
	[But earlier on you said it was not a game?]				
P27	That's true!			Game	
P27	I think there are elements of game play in there	Gameplay		Game	
P26	There's playfulness to try and get the match but intrinsically it's about the running	Playfulness	Close effort	Game	Intrinsic motivation: running Extrinsic: game
P27	When we were running around I observed a couple of guys who were jogging along and talking having a full on conversation side by side and	Co-located	Movement		Context: other runners
	I was talking into the headpiece to [partner] and I was effectively doing the same thing as those guys were doing	Conversation, co-located			Context: other runners
	but they were able fitness wise to jog together but I'm not able fitness wise to jog with X at X's chosen pace but we were still having that interaction	Co-located, together	Close effort, different capabilities		
P26	It is really hard to find the right jogging partner-it's		Close effort, different		

	really hard		capabilities		
P26	The fitness level is probably the biggest thing because if you're with somebody too fast or too slow I think it frustrates everybody to a degree	Affect: frustration	Different capabilities		
	[What did you like the best and the least?]				
P26	My favourite thing was running with [partner's name], that was really nice	Together, affect: affection	Movement		
P26	I didn't really have any least favourite thing - I was conscious of the equipment coming out - I didn't want to wreck it but that didn't bother me in the end			Hardware	Risk of breaking hardware
P27	My favourite thing was being able to sing the rocky theme song to [partner] and he could sing it back and laugh while we were running	Affect: joy, together, reciprocate	Movement		
P26	I thought I sang it				
P27	Yeah but I got on the bandwagon as well	Goading			
P27	My least favourite thing was probably not being at a fitness level where I could exercise more control about balancing the sound - [partner] had to back off rather than me being able to …	Affect: negative	Close effort, different capabilities, slowing down		
P26	[Interrupts] it's all heart rate - you are getting it mixed up		Heart rate		

P27	Maybe my least favourite thing was being tired and feeling like - you know, being tired and jogging	Affect: negative	Exhaustion, Movement

Appendix 1.2: Demonstrating second phase of data analysis

Below is a picture of some of the affinity diagrams I constructed in order to investigate any links and overarching themes out of the results from the analysis in the first phase. Overall, I created over 80 affinity diagrams, refining them in each step.



Groupings done on paper during the coding process

Appendix 1.3: Demonstrating third phase of data analysis

The following is an excerpt of the high level summaries of the concepts derived from the second phase of the data analysis. I began by collecting all data belonging to each concept and created a short description or phrase for each, depicted here above one or two selected samples of the data that illustrates the summary.

As with the previous appendices, I only present an excerpt; here I focus on “Shared pain”.

Communicating pain: to other

“Ah, I've got tummy cramp.”

Complaining about pain

“[…] and also because I could bitch about it to you […] once I got over it, it was gone and I could have done it for longer.”

Hearing/feeling pain of other: from other

“Jeez, you are breathing like a motherfucker.”

Talking through it

“You know, just keep going talking through it.”

Distraction from pain

“Yeah, ‘cos it distracted me and also ‘cos I could bitch about it to you.”

Temporal aspect of pain

“Once I got over it, it was gone and I could have done it for longer.”

Exertion as distraction from pain

“I worked harder than I usually would, so I wasn't thinking about the pain as much.”

Sympathize with pain

“You've got the giving-birth breathing going, are you alright?”

Shared pain affecting exertion

"Because I could hear that [he] is going through the same pain with me, it made me keep going."

Sharing affects responding body

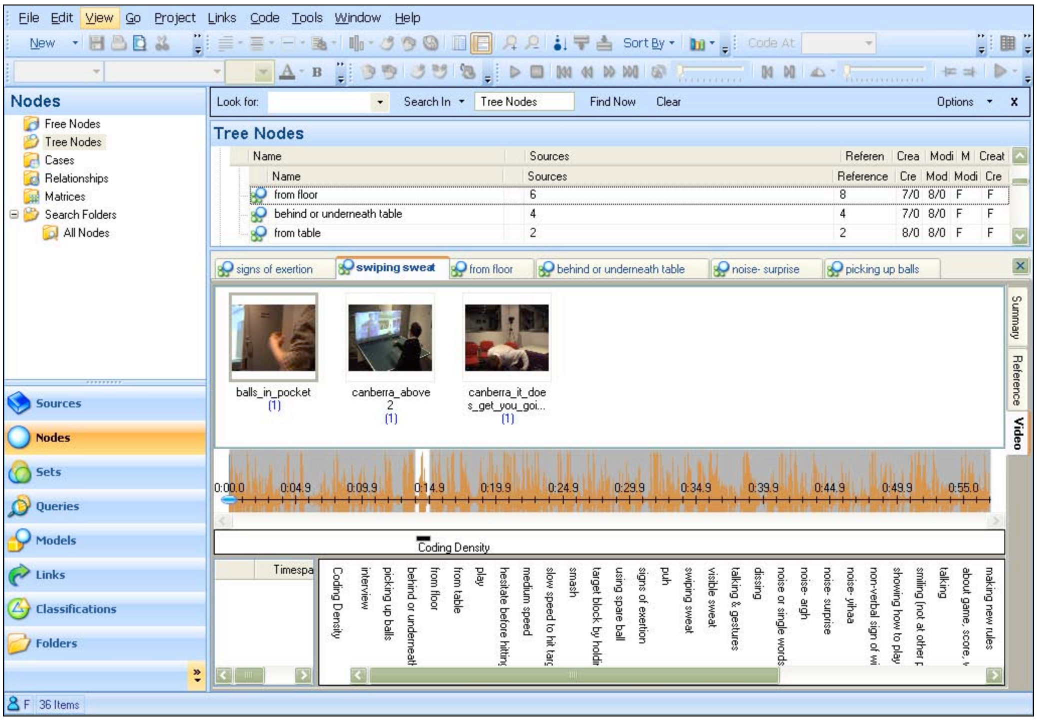
"The idea of doing it together so therefore half the effort."

"Just knowing that someone else is going through the same pain right now makes it more endurable"

Appendix 2: Table Tennis for Three

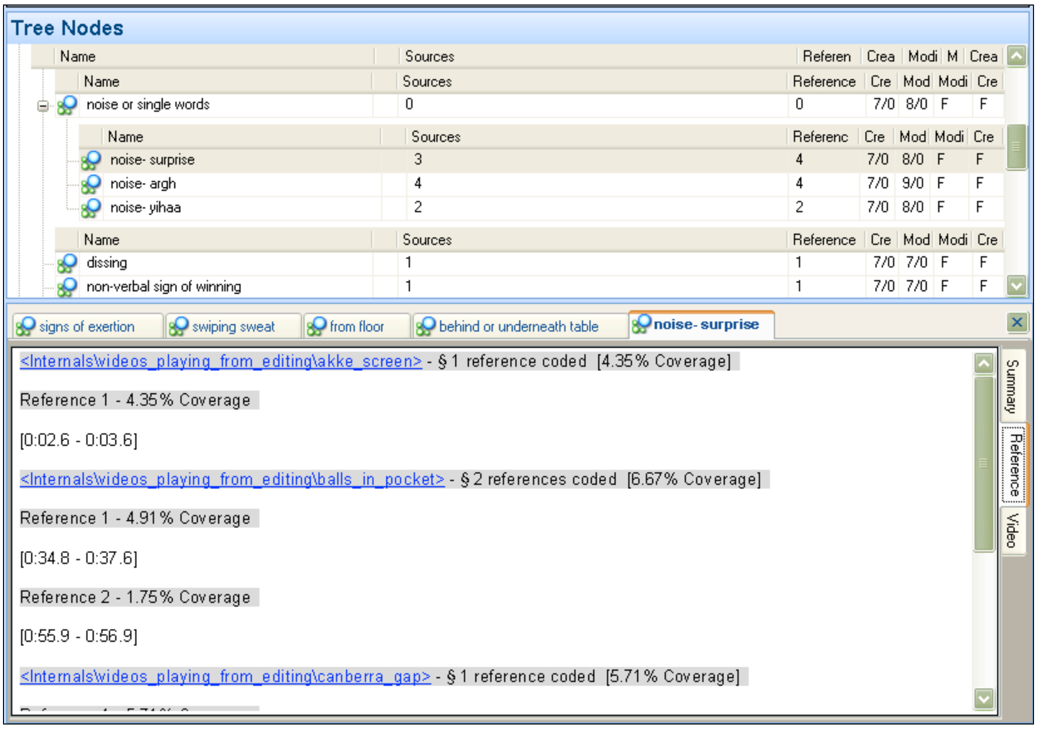
Appendix 2.1: Excerpts from the coding process

Below is a screenshot taken during the coding process of the data collected from the Table Tennis for Three study. It shows one snipped of video that was extracted in order to have sizeable chunks of video to code at a time. The screenshot depicts how I used the video as well as the audio data to look for patterns that characterize the phenomenon.



Screenshot taken during the coding process

This cropped area of another screenshot taken during the coding process highlights the codes organized in a tree-like fashion. It also shows how one particular code, any noise participants made that expressed surprise, was represented in particular parts of a video snippet, including the location in the video and its length.



Selected area of another screenshot, depicting the representation of codes in a tree-like fashion

The following screenshot depicts an excerpt of the codes, arranged in a tree-like fashion, developed as part of the coding process for one particular snipped of video.

Tree Nodes

Name	Sources	References	Created On	Modified On	Modified By	Created By

Name	Sources	References	Cre	Mod	Mo	Cre
to themselves	3	3	7/	8/0	F	F
remote player talking	6	8	7/	8/0	F	F
player asks beg your pardon	2	3	7/	8/0	F	F
talking (i could not understand what was sa	1	1	7/	7/0	F	F
talking hindered (because of play)	1	1	7/	7/0	F	F
about game, score, who won,	3	4	7/	8/0	F	F

Name	Sources	Referenc	Cre	M	Modi	Crea
making new rules	1	1	8/0	8/	F	F

Name	Sources	References	Cre	Mo	Modif	Cre
showing how to play	2	2	8/0	9/	F	F

Name	Sources	References	Created On	Modified On	Modified By	Created By
waiting	0	0	7/07/2008	7/07/2008 1	F	F

Name	Sources	References	Cre	Mo	Modif	Cre
normal (not awkward)	4	4	7/0	8/	F	F
akward pause	3	4	7/0	9/	F	F

Name	Sources	References	Created On	Modified On	Modified By	Created By
signs of exertion	0	0	8/07/2008	8/07/2008 5:	F	F

Name	Sources	References	Cre	Mo	Modif	Cre
swiping sweat	3	3	8/0	9/	F	F
visible sweat	1	1	8/0	8/	F	F
puh	1	1	9/0	9/	F	F

Name	Sources	References	Created On	Modified On	Modified By	Created By
interview	1	1	9/07/2008	9/07/2008 5:	F	F

Name	Sources	References	Created On	Modified On	Modified By	Created By
play	0	0	7/07/2008	7/07/2008 1	F	F

Name	Sources	References	Cre	Mo	Modif	Cre
smash	5	6	7/0	8/	F	F
medium speed	9	15	7/0	9/	F	F
slow speed to hit target	4	4	7/0	8/	F	F
target block by holding ball in hands	4	7	7/0	8/	F	F
hesitate before hitting	2	4	7/0	8/	F	F
using spare ball	1	2	7/0	7/	F	F

Name	Sources	References	Created On	Modified On	Modified By	Created By
picking up balls	0	0	7/07/2008	7/07/2008 1	F	F

Name	Sources	References	Cre	Mo	Modif	Cre
from floor	6	8	7/0	8/	F	F
behind or underneath table	4	4	7/0	8/	F	F
from table	2	2	8/0	8/	F	F

Name	Sources	References	Created On	Modified On	Modified By	Created By
talking & gestures	0	0	7/07/2008	7/07/2008 1	F	F

Name	Sources	References	Cre	Mo	Modif	Cre
smiling (not at other person)	2	2	7/0	7/	F	F
noise or single words	0	0	7/0	8/	F	F

Name	Sources	References	Cre	Mod	Mo	Cre
noise- surprise	3	4	7/	8/0	F	F
noise- argh	4	4	7/	9/0	F	F
noise- yihaa	2	2	7/	8/0	F	F

Name	Sources	References	Cre	Mo	Modif	Cre
dissing	1	1	7/0	7/	F	F
non-verbal sign of winning	1	1	7/0	7/	F	F
talking	0	0	8/0	8/	F	F

Excerpt of the codes used for Table Tennis for Three

Appendix 3: Remote Impact

Appendix 3.1: Excerpts from the coding categories

The following table is an excerpt from the coding categories developed as part of the Remote Impact study. It shows how I developed categories as well as subcategories, which I assigned to verbal and non-verbal groups.

Excerpt from coding categories with examples

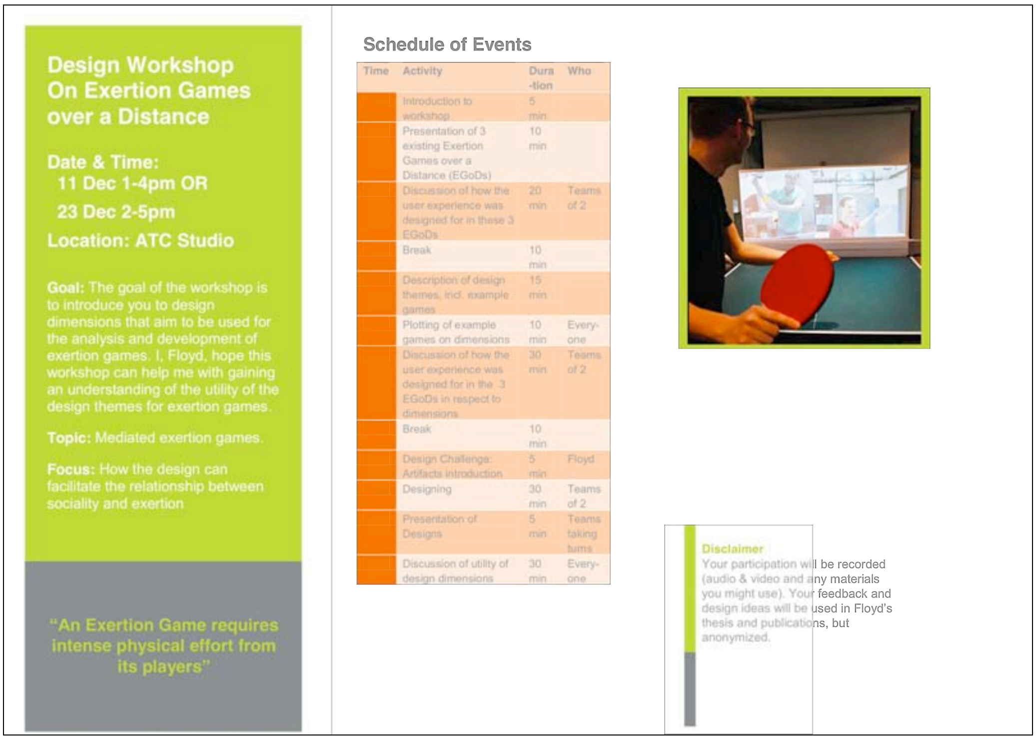
Coding category	Verbal/Non-verbal	Subcategory	Definition	Example
Affect	Verbal	Positive affect	Positive emotional response	I like this!
		Negative affect	Negative emotio-nal response	I don't like this
		Positive re-inforcement	Gives compliment	Good job!
		Negative re-inforcement	Critical of other player	You are wrong/ Loser!
	Non-verbal	Positive affect	Expresses positive affect using the body	Attempted hug, smile, air-kiss
		Negative affect	Expresses nega-tive affect using the body	Frowning, audible sighing, dirty looks
Engage-ment	Verbal	Prompting en-gagement	Player tries to (re-)engage partner	One more round?
		Off-task	Asks an off-task question	What does your room look like?
	Non-verbal	Prompting en-gagement	Bodily gesture	Signals player to continue playing
		Disengaged, off-task, percentage	Approx. % of time where player does not seem to en-	Looks somewhere else

			gage socially	
Reciprocity	Verbal	Commenting on other body	Verbal expression which depends on other body	Got you!
		Verbally reacting to other body	Verbal expression as response to other body	Ouch, I am hit
		Commenting about not caring about other body	Verbal expression of not being affected by other body	You can hit me, it does not hurt!
	Nonverbal	Acting on other body	Nonverbal expression which depends on other body	Hitting other body
		Reacting on other body	Nonverbal expression as response to other body	Ducking away from other body
		Ignoring other body	Nonverbal expression of not being affected by other body	Not ducking when getting hit

Appendix 4: The exertion framework in action

Appendix 4.1: Design workshop structure

The following graphic is the invite to the workshop that was sent out to the participants of workshop A. It contains the structure of the schedule of events as well as details on goals and focus of the particular workshop.



Design Workshop On Exertion Games over a Distance

Date & Time:
11 Dec 1-4pm OR
23 Dec 2-5pm
Location: ATC Studio

Goal: The goal of the workshop is to introduce you to design dimensions that aim to be used for the analysis and development of exertion games. I, Floyd, hope this workshop can help me with gaining an understanding of the utility of the design themes for exertion games.

Topic: Mediated exertion games.

Focus: How the design can facilitate the relationship between sociality and exertion

"An Exertion Game requires intense physical effort from its players"

Schedule of Events

Time	Activity	Dura-tion	Who
	Introduction to workshop	5 min	
	Presentation of 3 existing Exertion Games over a Distance (EGoDs)	10 min	
	Discussion of how the user experience was designed for in these 3 EGoDs	20 min	Teams of 2
	Break	10 min	
	Description of design themes, incl. example games	15 min	
	Plotting of example games on dimensions	10 min	Every-one
	Discussion of how the user experience was designed for in the 3 EGoDs in respect to dimensions	30 min	Teams of 2
	Break	10 min	
	Design Challenge: Artifacts introduction	5 min	Floyd
	Designing	30 min	Teams of 2
	Presentation of Designs	5 min	Teams taking turns
	Discussion of utility of design dimensions	30 min	Every-one

Disclaimer
Your participation will be recorded (audio & video and any materials you might use). Your feedback and design ideas will be used in Floyd's thesis and publications, but anonymized.

Invite for the design workshop

The following page depicts the questionnaire that was distributed amongst the participants of all workshops.

I am: ☐ female, ☐ male

Age: ☐

Reason for attending today:

Cards	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree	If disagree, please explain why: did you decide not to use this card, or was there another reason?
I found the cards useful for generating ideas	☐	☐	☐	☐	☐	
I had ideas I would not have had without the cards	☐	☐	☐	☐	☐	
The cards helped my team to focus	☐	☐	☐	☐	☐	
The cards helped me to articulate my ideas	☐	☐	☐	☐	☐	
The cards helped me to improve my ideas	☐	☐	☐	☐	☐	
The cards helped my team to come to a consensus/agree on items we discussed	☐	☐	☐	☐	☐	
The cards were useful for something else, namely:						
I found the following cards useful for generating ideas						
Secondary Performance	☐	☐	☐	☐	☐	
Movement Variety	☐	☐	☐	☐	☐	
Intensity	☐	☐	☐	☐	☐	
Continuousness	☐	☐	☐	☐	☐	
Effort	☐	☐	☐	☐	☐	
Tangibility	☐	☐	☐	☐	☐	
Haptic Feedback	☐	☐	☐	☐	☐	
Integrated Communication	☐	☐	☐	☐	☐	
Exhaustion Management	☐	☐	☐	☐	☐	
Bodies in Harmony	☐	☐	☐	☐	☐	
Physical Risk	☐	☐	☐	☐	☐	
Fidelity of Mapping	☐	☐	☐	☐	☐	

The cards shifted my ideas

from ______________________________

to ______________________________

My favorite card was:

Why?

Comments to improve the usefulness of the cards and circles:

Thank you!