Evaluating Exertion Games

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Abstract. Games that demand exertion of the players through bodily movements are experiencing increasing commercial success and have been attributed with many physical, mental and social benefits, thus changing the way we play computer games. However, there is a lack of understanding of how to evaluate such exertion games, mainly because the games' facilitated bodily movements are believed to be responsible for these novel experiences, but are not considered in traditional evaluation methods that primarily assume keyboard and gamepad-style input devices. We do not believe there is a generic approach to evaluating exertion games, and therefore offer an overview of our mixed experiences in using various methods to guide the reader for future evaluations in this domain. We support the presented methods with data from case studies we undertook in order to illustrate their use and what kinds of results to expect. Methods that we have not had experience with, but which also have the potential to address the contribution of bodily involvement to the user experience, are also outlined. By identifying remaining issues in regards to evaluation methods for exertion games, we aim to provide an informed way forward for research in this area. With our work, we hope to contribute towards the advancement of such games, fostering their many benefits towards a more positive user experience

1 Introduction

Gamers have recently seen the explosion of a new gaming genre that has been labeled exergaming or exertion games, which describes the emerging computer game titles that combine exerting bodily movements with computer gaming. Inspired by the success of Dance Dance Revolution, EyeToy and the Wii, computer game companies are excited about the potential of embracing physical activities in their games. Exertion games, defined as computer games that require intense physical effort from their players (Mueller et al. 2003), are believed to be able to work against the prevailing computer gaming image of facilitating the modern world's sedentary lifestyles. The use of the Wiimote and the Wii Fit by gamers to address their personal weight goals has made worldwide headlines (DeLorenzo 2007) and influenced game companies to release more interactive fitness games. Clinicians have discovered the potential of such games to address the obesity epidemic and are conducting studies to test these games' effectiveness in motivating gamers, especially children and teenagers, to incorporate more physical exercise into their daily lives by engaging them through exertion gameplay (Graves et al. 2007). They have also discovered the use of exertion games for rehabilitation purposes to make traditionally repetitive boring exercise tasks more fun (LeBlanc 2008, Powell 2008). These exertion games are also attracting new audiences that have previously not been catered for, offering a transition in the user experience from "highscore-chasing" gaming to "party-fun", especially Nintendo Wii's bowling seems to be attractive to seniors, who organize championships in their nursing homes (Clark 2008). This new trend in gaming might ultimately challenge our understanding of the previously distinct terms of computer game, sports and exercise: the Dance Dance Revolution game, a computer game that requires exhausting jumping on dance pads, has recently been recognized as an official dance sport in Finland (Well-being Field Report), and "Sports over a Distance" applications have enabled sportive exercise between geographically distant locations (Mueller et al. 2007). Several research studies have added weight to anecdotally reported physical, mental and social health benefits (Lieberman 2006, Graves et al. 2007, Wakkary et al. 2008, Bianchi-Berthouze et al. 2007, Eriksson et al. 2007), and their proliferation appears to contribute to an understanding that these exertion games have the ability to introduce a new era in the history of computer gaming that changes the perspective for players, developers, and even spectators in regards to how we see computer gaming, opening doors for new opportunities previously not imaginable.

Being able to understand what makes players engage in such exertion games could result in improved experiences (Bianchi-Berthouze et al. 2007), but also increased energy expenditure, and hence enhanced fitness (Bogost 2005), resulting in a healthier population that also benefits from mental and social benefits facilitated by these games. Studies on recreational physical activity (Wankel 1985) for non-athletes have indeed shown that flow, i.e., a form of optimal experience (Csikszentmihalyi 1990) is an important and relevant factor in maintaining the level of motivation high and reducing drop-out. However, what is currently missing is an understanding of how such games should be evaluated to improve the user experience (Hoysniemi 2006). Traditional approaches to evaluating the user experience in games can fall short in providing a complete story of the user experience when it comes to exertion: exertion games offer opportunities that mouse and gamepad-controlled games lack, and not considering the unique aspects of exertion in such games might result in evaluation work that does not provide a complete picture of the user experience, ultimately failing in contributing towards the advancement of such games. In order to contribute to the success of exertion games, researchers and practitioners need to have an understanding of the opportunities but also challenges that arise when evaluating user experiences in exertion games. The purpose of this chapter is to contribute to this understanding.

We do not believe there is a generic approach to evaluating exertion games, and therefore offer an overview of our experiences in using various methods in order to provide the reader with a personal account that can serve as guide for future evaluations in this domain. We detail specific aspects user experience researchers and practitioners might encounter based on our results of evaluating exertion games using a range of methods. Our stories are based on over five years experience in designing, developing and evaluating exertion games, and we refer back when appropriate to our original work to offer the reader concrete examples, supplemented with empirical evaluation data, to offer insights into our work. The aim is to provide the interested practitioner with guidance based on completed evaluation tasks of exertion games, supplemented with some practical examples of 'lessons-learned'. Furthermore, we hope our work can provide researchers with inspiration for further investigations into this area, by contributing to an understanding of how to approach the task of evaluating such games. We conclude by suggesting a research agenda for future work on the topic of evaluating the user experience of exertion games and provide an outlook on what challenges lie ahead. With our work, we hope to contribute towards the advancement of such games, fostering their many benefits towards a more positive user experience.

2 Approach

Prior work has acknowledged that the evaluations of exertion games can benefit from methods that consider and accommodate for the unique characteristics of exertion games in their evaluation task design (Hoysniemi 2006). However, there is a limited understanding of what opportunities exist for the design of evaluation tasks and what shortcomings need to be considered when evaluating user experiences in such games. This lack of a comprehensive understanding of the challenges exertion brings to the evaluation process can hinder the advancement of these games and therefore limit the benefits they can offer to their users. Our work addresses this shortcoming by exploring how the user experience in exertion games can be evaluated based on our experiences of evaluating these games and informed by our results. Our approach begins with detailing our evaluation experiences of a diverse set of existing commercial and prototypal gaming systems. Based on the game under investigation, we have chosen different evaluation approaches, which we subsequently improved and refined. We highlight personal experiences we gained from evaluating these games and provide insights into the shortcomings of some of the methods we used, a summary of which is given in Table 1. We also describe opportunities for further research that arose out of particular instances. Furthermore, we provide an opinioned commentary that is aimed at giving the reader a critical view of what to expect in their evaluation tasks when faced with an exertion game. By also describing our results, we hope to offer guidance when there is a need to choose between several methods.

We acknowledge that our approach cannot and is not intended to result in a comprehensive list of all available methods nor describe every aspect of evaluation specific to exertion games. However, with our approach, we aim to focus on providing an experienced-based account of what opportunities lie ahead in this exciting new field. We believe our experiences on this topic will give the reader an extensive, although not comprehensive, view from various perspectives, contributing to an understanding that can inspire and guide future investigations.

Table 1. Summary of case studies, outcomes and challenges in evaluating post-playing and in-place user experience

Case studies	Approaches	Outcomes	Challenges
Table Tennis for Three: single condition	Semi structured interviews, observations and coding of video data	Exertion facilitates social play in and outside gameplay, e.g. fosters the recollection of the experience through kinesthetic stimulation	a) How to define coding systems b) How to overcome the fact that re-enacting can bring players to reinterpret their experience?
Breakout for Two: exertion vs. non-exertion condition	Prisoner dilemma and questionnaires	Exertion stimulates competition, connectedness	These measures overcome the limitations of self reports but they are indirect.
Donkey Konga: exertion vs. non-exertion conditions	Quantitative comparison of verbal and non-verbal behavior	Exertion facilitates empathic behavior in cooperative games: increase social interaction and emotional experience	How to define coding systems that produce high inter-rater reliability?
Guitar Hero: exertion vs. non-exertion conditions	Quantitative analysis of movement by motion capture system	Exertion facilitates emotional experience and role-taking experience. Amount of movement of the player correlates with engagement	The automatic analysis of complex movements (e.g., pointing, shrugging) is technically challenging.

3 Evaluating user experience post-playing

We begin by describing evaluation methods that are based on the belief that the game experience can be (self-)assessed after it has occurred, for example by interviewing the participants immediately after playing. Such approaches have the advantage that they leave the experience un-altered, as they separate the experience from the evaluation process temporally, but also often physically. We start with interviews, as they are also often used in non-exertion games and are a familiar tool, however, we describe what purpose they serve in contributing to our understanding of exertion games.

3.1 Interviews

For most of our experiments, we conducted semi-structured interviews with the participants after the gaming action. We have also videotaped these interviews, and we now describe our experiences with this method based on one particular case study.

We selected this case study as it offered some unique insights into the social aspects of exertion games, as the players were geographically distant, connected only over a computer network. (We present a collocated exertion game study that also included interviews further below, but report on a different method there).

Case study: Table Tennis for Three. We have conducted semi-structured interviews in an attempt to qualitatively analyze the social play in Table Tennis for Three. Table Tennis for Three is an exertion game that was inspired by table tennis, but can be played by three geographically distant participants. It uses a real bat and ball on a modified table tennis table that detects the ball's impact in order to modify virtual game content, projected onto the playing surface, and augmented with a videoconferencing component to support a social aspect amongst the participants. A detailed description of the system can be read here (Mueller and Gibbs 2007a, Mueller and Gibbs 2007b) and the evaluation process is described here (Mueller and Gibbs 2007b). After having played the game, the participants were interviewed in one room together. The video recordings of the interviews were coded using qualitative analysis software. This approach revealed an interesting aspect specific to exertion games, which we aim to sensitize other researchers to, as it might affect the evaluation process. However, we begin by describing the study design.

Experimental set up. 42 participants were recruited and asked in the advertising material to organize themselves preferably in teams of three. If they were unable to do so, we matched them up randomly with other participants in order to have always three people participating at the same time. We had one last minute cancellation; in this case we replaced the third player with a participant that had played previously, hence we report on 41 distinct participants. The participants were between 21 and 55 years old (arithmetic mean 32 years), whereas 27 were male and 14 female. After each group of three participants played for at least 30 minutes, they were brought together into the same room after the game, where we conducted semi-structured interviews with all three of them together. The interviews lasted from 20 to 60 minutes and included open-ended questions about their experience and their interactions with the other players. We took notes during the interviews as well as videotaped each session. We analyzed the video data using a coding process based on grounded theory (Strauss and Corbin 1998) with the help of a database for all the video data. An iterative coding process was used to identify important themes and ideas. We also used the notes and created affinity diagrams to further refine our concepts.

Analysis and discussion. The joyful atmosphere of the exertion game carried over to the interviews, which appeared to be facilitated by the use of bodily actions as exhibited during the game by the participants. For example, players used movements not only in relation to play directly, 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 the joyful atmosphere seemed to have carried over into the interviews. Players used their bodies to retell their experiences, and the video recordings were viable tools in capturing this retelling. For example, one team patted on each other's shoulders and slapped each other comradely several times during the interview. Another team initiated a group hug.

In addition to the theoretical concepts we identified as part of the investigation of Table Tennis for Three, we found the aspect of bodily movements facilitated by the exertion game that carried over to a retelling in the interviews particularly intriguing for an understanding of user experiences in games. Such a retelling is an element of metagaming, 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 and Zimmerman 2003). The participants in Table Tennis for Three used this to turn the interview into a metagaming event by verbally and non-verbally commenting on the other players' performance and turning the post-game into a social spectacle. The retelling of what happened in a game is an important part of a "lived experience" (McCarthy and 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 kinesthetic stimulation" has been suggested to re-trigger the associated pleasurable emotions (Iso-Ahola and Hatfield 1986). Re-enacting the exertion movements can also support the player's cognitive processes, helping them to remember certain parts of the game (Lindley and Monk 2008). Players gave further meaning to these exertion actions by sharing them with others, the opportunity for metagaming provided by the interview task therefore contributed towards a meaningful social play experience. In contrast, the exertion actions supporting metagaming are missing in keyboard and gamepad-controlled computer games, and the players have to rely on their cognitive skills to remember their experiences and associated affective responses. Furthermore, Moen (Moen 2006) believes that movement literacy can be improved by physically exploring movement, as our players did during gameplay, but also by verbally reflecting on it, which they did through the interviews. This suggests that the interview task might have contributed to the participants' movement literacy.

Our observations during post-game interviews suggest implications for evaluation methods used in exertion games. Researchers need to be aware that retelling, in particular as part of metagaming, is an important aspect of the user experience, and players will use opportunities to enable such an experience. We believe user experience researchers should be aware of such effects in order to be able to consider them in their experimental designs and be sensitive towards them during the interview process. If the game to be investigated features exertion actions, researchers should anticipate that bodily movements will play a role in the interview process as well. Any capturing should accommodate for this: we valued the use of video, as a traditional audio-only recording and analysis would have neglected the bodily actions we observed that revealed valuable insights into the game experience.

3.2 Prisoner-Dilemma task

We now report on our findings on a distributed soccer-like game called Breakout for Two (Mueller et al. 2003) that allows two participants to engage in a ball sports activity although being apart. In the accompanied study, we were interested in understanding if the required exertion to play the game has an effect on the sense of connectedness between the participants, and hence compared the exertion game with a similar game that is played with a keyboard. We present an element of a larger evaluation study: a Prisoner's Dilemma task.

Measuring social effects between participants based on short periods of gaming activity can be difficult, as many outside factors such as personality types and situational context can affect social behavior. Social interaction is one aspect of it, but even measuring this is not trivial: humans use many cues to express social needs, and a comprehensive account of all social elements within human communication is an almost insurmountable task. The Breakout for Two study consequently focused on investigating whether the system could facilitate a sense of trust between the participants. This sense of trust was probed with a variation of a Prisoner's Dilemma task (Palameta and Brown 1999). A between-subjects experimental design tested the effects of the exertion game on performance in the Prisoner's Dilemma task in comparison with a non-exertion version of the game. There are many interpretations and alteration of the traditional Prisoner's Dilemma task, however, they mostly follow the same principle. The variation used in the study requires to make a decision based on another person's decision, however, their decision is not accessible when the decision needs to be made, because the participants cannot communicate during the process. Such a task is a commonly used measure of trust and cooperation, and multi-round Prisoners' Dilemma tasks have been successfully used to assess levels of trust established between participants in remote locations (Zheng et al. 2002, Zheng et al. 2001, Rocco 1998).

Case study: Breakout for Two. Facilitating exertion as part of a gaming experience is believed to positively influence social factors between the participants. The case study of Breakout for Two was designed to investigate if the positive effects on sociality transfer to mediated communication scenarios, in other words: does the addition of an exertion interface still facilitate social benefits even if the players can only interact with one another over a videoconference? The research answered this by conducting a study that allowed distributed players to exert themselves with a physical ball that was the interface to a shared virtual game: the players had to kick the ball at certain targets before the other player did, and these targets were interconnected over the network. The players could comment on each other's play and see their progress through an integrated large-scale videoconference. The winner was the player who hit the ball the hardest and most accurately, thereby scoring the most points**.**

Experimental set up. 56 volunteers were recruited through flyers and email postings at local universities, sports clubs and youth hostels. The average age of the participants was 26, the youngest being 17 and the oldest 44. 34 volunteers were asked to play the physical game and 22 played the non-exertion, keyboard-controlled game. 77% of the participants were male in the exertion group, 64% in the non-exertion group. This equal distribution was not deliberate, but opportune. After the participants played Breakout for Two, they were escorted to a different area where they could not see nor hear each other. They were faced with written instructions, which explained that their task was to choose if they wanted to put a big X on the back of a sheet of paper or not. If both of the players chose not to put anything down, they would both receive an additional 5 Euros to their payment, in order to ponder their choice seriously. If only one of them would mark an X, this person would receive an additional 10 Euros, but if both of them would draw an X, they would receive nothing.

Analysis and discussion. In the exertion group, 15 players put an X on the back of their sheet (44%). This comprises 11 pairs where only one person put an X down (resulting in this person receiving an extra 10 Euros), 2 teams where both participants wrote an X (resulting in no extra payment), and 4 teams where both players left the page blank (resulting in an extra 5 Euros for each of them). In the non-exertion group, only 5 players put down an X (23%). In each case, their partner left the page blank, resulting in an extra 10 Euros payment for the first player. Six pairs put nothing down, receiving an additional 5 Euros each and no team had an X on both sheets.

We expected that the participants in the exertion condition would be more likely to cooperate in the Prisoner's Dilemma task than their non-exertion counterparts, based on the higher levels of connectedness that were recorded in the questionnaire survey and interviews within the same setup (Mueller 2002). It seems plausible to anticipate that participants who play a team sport are more likely to cooperate in a Prisoner's Dilemma task. After all, a correlation between sport and trust has been previously studied (Clark and Gronbegh 1987). However, the results showed that players were *less* likely to cooperate if they participated in the exertion game.

Further investigations with larger user numbers are necessary to shed light on this surprising result; however, we have a hunch about what have caused the players' reactions. We believe it could be speculated that the exertion component increased the competitive aspect of the game. The game in both conditions was identical in terms of its competitive element, however, investing bodily actions might have triggered the participants to "take it more seriously" and value the competitive aspect higher. In order to strengthen this claim, we would like to draw attention to the element of competition in traditional exertion sports games: most sports are of a competitive nature, and almost all organized sports have provisions such as overtime or penalty shootouts to determine a winner, if not at the end of a game, at least at the end of the season. It seems competition and exertion go hand in hand, however, this does not imply that physical games cannot foster non-competition: collaborative physical games experienced a high in the 70s as the New Games movement, and augmented derivatives exist (Lantz 2006), however, these games have slowly faded and lack the widespread success of competitive sports.

Reflecting upon the pervasive role of competition in traditional exertion sports, it could be hypothesized that the introduction of exertion activity in a game context amplifies any competitive element. This is underlined by anecdotal incidents observed during gameplay, in which some participants appear to become "more into it" and were more eager to win once they have achieved a certain level of exertion. This would extend the findings that exertion can amplify competiveness by a virtual gameplay component. However, further empirical research is needed to investigate whether augmented exertion can amplify any competitive aspect in games.

We are aware that a Prisoner's Dilemma task does not measure user experience in games per se. However, our investigation demonstrates that using such a task to test for social effects as an outcome of exertion gaming has its caveats. In particular, it leads to the speculation that exertion can amplify competitive notions developed during gameplay. If further research confirms this assumption, this can have implications on how to evaluate competitive games in which the bodies are involved, whether the evaluation includes a Prisoner's Dilemma or any other task, as the investigated concept, here trust, might be skewed by the altered competitiveness that the exertion aspect facilitated.

3.3 Questionnaire

Finally, we conclude this section by discussing the use of questionnaire to gather data for evaluation purposes since this approach is a common practice, and has been increasingly used for an understanding of games as well. As part of our research, we have also used questionnaires, and have acquired experience from using established questions, but also developed our own set of questions to gather data depending on the context, research question and study design we faced. Although questionnaires may seem to be a generic tool for evaluating user experience, and its use for exertion games might not appear to require any specific attention, we have observed, that using questionnaires within the context of exertion games can pose some interesting caveats that we believe researchers should be aware of in order to account for them in their analysis.

One aspect that makes the use of questionnaires particular in the context of exertion games is related but not identical to the critique of using questionnaires for games in general. The use of questionnaires for evaluating user experience has been criticized for its inadequacy of capturing a user state during the game, as players answer questions regarding their experience after they have played the game, 'outside' their immediate engagement with it, a critique in common with post-interviews. The participants need to divert their focus of attention to the evaluation task, diverting from the experience; the same experience they are now asked to self-assess. This criticism is common amongst questionnaire approaches, whether the game facilitates exertion or not. However, if the players exerted themselves as part of the gameplay, several factors influence their answers in ways different to a keyboard or gamepad experience: firstly, as exertion games are believed to facilitate more emotional play (Bianchi-Berthouze et al. 2007), these affected states of emotions could influence the assessment players give, in particular if the questions are asked immediately after the game. We acknowledge that these altered emotional states could be a desired effect of the game, worth capturing in the evaluation process; however, we want to point out that researchers should be aware that the emotional change could occur from the game content, but also from the physical exertion the game facilitates, which might have different implications for the analysis. Secondly, a possibly lower recovery curve from a heightened state of arousal based on exertion might affect an effective comparison with non-exertion game data. To explain: the emotions facilitated by the involvement of the body interact with the physiological functions of the body in a bidirectional relationship, and it has been suggested that this relationship can affect the emotional engagement with the game for longer than in a traditional non-exertion game, in which the engagement is mainly regulated by cognitive functions (Lehrer 2006). This prolonged engagement with the game is not limited to emotional aspects; for example, in our investigations of Breakout for Two (Mueller et al. 2003), we have observed that players needed a break to physically recover from the activity before they were able to fill out a questionnaire. This suggests that the exertion aspect can affect the time between the game experience and answering questions, possibly altering the recall capability of the experience. Furthermore, research has shown that cognitive functions are improved after exercise (Ratey 2008), which might also impact upon how the subjects answer, independent from the experience under investigation. These potential effects do not eradicate the use of questionnaires as evaluation method for exertion games, but researchers might benefit from being aware of these potential influences that are quite different than what is expected in traditional questionnaire experiences in order to address them in their evaluation design.

4 Evaluating user experience in-place

In the previous sections, we have focused on methods that rely on data gathered after the gaming action. We are now describing our experiences with directly observing exertion actions while they are taking place. We focus on how the analysis of participants' non-verbal behavior can give insights into their experience, in particular, we describe how it helped us to quantify and reason about the effect of a game's design on social and emotional experience.

4.1 Coding body movement

Case study: Donkey Konga. We carried out a study to investigate how the use of whole body game controllers would change the way players engage in a game (Lindley et al. 2008). An experiment was thus designed to observe and compare the behavior of players playing the same game but using different types of controllers: controllers that require only finger movement to control the game and controllers that require larger body movement**.**

Experimental setup. Levels of engagement and the degree of emotional and social interaction between players were explored in a game of Donkey Konga (Lindley et al. 2008). The input devices were bongos and a standard dual-pad controller. When bongos were used players were encouraged to tap the bongos and clap their hands in time with the music; when the dual-pad controller was used these actions were performed through button presses using fingers and thumbs. We are aware that playing augmented bongos does not necessarily result in intense physical exhaustion, however, the involved body movements and their reliance on rhythmic coordinated kinesthetic actions have many characteristics similar to sportive behavior and have been previously compared to exertion games (Bogost 2005), and hence the results should be able to contribute to an understanding of movement-based activities in general.

Ten pairs of participants were asked to play in both conditions, and the order of the two conditions was counterbalanced across the pairs. Being all beginners, the players played in two-player cooperative mode ('Duet') at the easiest skill setting. The playing sessions were videotaped and an existing engagement questionnaire (Chen et al. 2005) was used. The scores for the participants in each pair were summed. To measure the emotional and social engagement of the participants, their verbal and non-verbal behaviors were coded using the Autism Diagnostic Observation Schedule (Lord et al. 2000). We found this scheme particularly useful, however, other researchers seem to prefer Laban's notations, especially when concerned with dance-like movements (Loke et al. 2007). The length of time that each participant spent producing speech and other utterances was measured. Non-verbal behaviors were also classified according to two categories: Instrumental gestures were defined as those in which the action conveyed a clear meaning or directed attention (e.g., pointing, shrugging, and nods of the head); empathic gestures were defined as those in which the action was emotive (e.g., placing the hands to the mouth in shock). These gestures were selected as they indicate the players' social and emotional involvement.

Analysis and discussion: To understand the magnitude of the effect the body movements has on the players, a statistical analysis of the non-verbal and verbal behaviors was performed. Prior to this, scores on the game were compared across the two conditions to ensure that possible effects were not due to variations in performance. A Wilcoxon's two-tailed matched-pairs signed-ranks test showed that the type of controller had no significant effect on performance ($Z = -0.889$, $p = .414$). All further differences were evaluated for statistical significance using Wilcoxon's one-tailed matched-pairs signed-ranks tests, with the pair as the sampling unit. The participants produced more speech ($Z = -1.478$, $p = .08$) and significantly more other utterances ($Z = -2.599$, $p < .01$) when using the bongos. Participants also made significantly more instrumental ($Z = -1.895$, $p < .05$) and empathic ($Z = -2.5273$, $p < .01$) gestures when using the bongos rather than the wireless controller, lending further weight to the idea that there was more social interaction in this condition. The participants rated themselves as experiencing a significantly higher level of engagement ($Z = 2.803$, $p < .01$) when using the bongos (mean = 248.80, max score=336, std. dev. = 23.03) rather than the wireless controller (mean = 198.50, max score=336, std. dev. = 25.33).

This study has contributed to an understanding of the quality of engagement in the game. Whereas the engagement questionnaire informed us of a statistically significant higher level of engagement in the bongo condition, the players' behavior informed us that the dynamics of the experience differed between the two conditions, an important implication for our understanding of how to evaluate such games. As shown by the number of instrumental gesture and utterances, players in the bongo condition were socially more interactive. It is important to note that the increased number of gestures cannot simply be accounted for by the fact that players have their hands free. They still need to use them to control the game (i.e., clapping and tapping). The fact that the number of emotional expressions (e.g., dancing) and emphatic gestures was statistically higher in the bongo condition compared with the traditional controller condition suggests that playing the bongos facilitated more emotional and social experiences. We believe our results can inform the choice of future evaluations, because they shed light on characteristics unique to exertion. For example, other measuring techniques, such as biosensors, might have captured emotional engagement and increased physical activity, however, we believe it is unlikely that they would have detected how the social and emotional interaction between players unfolded, a very important information for usability purposes. Whilst Mueller et al. (Mueller et al. 2003) have proposed that arousal associated with physical movement might support social interaction, Mandryk and Inkpen (Mandryk and Inkpen 2004) have shown that the presence of a friend results in higher engagement. Lindley and Monk (Lindley and Monk 2008) have argued further that social behavior and experience are intertwined to the extent that measures of conversation can be used to tap into unfolding experience. By affording realistic movements, the bongos may have facilitated a willing suspension of disbelief during gameplay, and their flexibility may have promoted enjoyment by encouraging clapping and dancing.

4.2 Automatically coding body movement

In the previous section, we have shown how the statistical analysis of non-verbal and verbal behavior enabled us to investigate the effect that changes in the design of a game's interface may have on the emotional and social experience of the player. In this section, we discuss how this approach can be improved: we describe how such an analysis could be facilitated by using a motion capture system to obtain a more objective analysis of the behavior and to reduce the amount of time necessary to analyze the captured video footage. To our knowledge, this is the first time such a device has been used to evaluate exertion gaming experiences.

Case study: Guitar Hero. Here, we present a study in which movement actions captured by using an exoskeleton were quantitatively analyzed to understand the relation between movement and the level and quality of player engagement.

Experimental setup. Participants were asked to play Guitar Hero, a guitar simulation game for Sony's PlayStation (Hero). This game sees the player perform a song by pressing in sequence a number of color-coded buttons on a guitar-shaped controller. Twenty players were randomly assigned to two different playing conditions. In one condition (called D hereafter), the guitar-shaped controller was used as a dual-pad controller, i.e., the participants were taught all of those features that are controlled solely with the hands (i.e., fret buttons, strut bar and whammy bar). In the second condition (called G hereafter), instead, the participants were informed that to gain "star power" they could make use of a tilt sensor in the neck of the guitar, i.e., by raising the guitar upward. The participants were fitted with a lightweight exoskeleton so as to provide angular measurements for each of the upper-body joints. In addition, a video camera was placed in front of them to record their body movements during play. After playing two rock songs (for about 10 minutes) at the beginner level, the player's engagement level was assessed using the previously mentioned engagement questionnaire.

The engagement scores were analyzed using a t-test revealing that the G condition returned significantly higher engagement scores ($t=5.123$, $p<.001$) thus suggesting that body movement imposed in the G condition affected the player's engagement level. To further clarify this finding, we correlated the engagement scores with the amount of motion measured with the motion capture system. We identified a negative correlation in the D condition and a positive correlation in the G condition.

Analysis and discussion. The results seem to indicate that the amount of movement could be a measure of engagement, at least for certain types of movement-based games. However, the amount of movement alone is not sufficient as specific types of movements, e.g., fidgeting, could be an indication of boredom as reported in (Bianchi-Berthouze et al. 2006). By analyzing the video footage of this experiment, we observed that in condition G, players displayed more, even if briefly, guitar-like player movements (e.g., dancing) showing a tendency to take over the role-play offered by the game (e.g., being a rock-star). They also showed expressions of higher levels of arousal and positive experience, such as expressions of excitement. In condition D, players seemed more driven by a desire to win the game (hard fun), leading to an increased focus on the display and to emotional expressions of frustration when a mistake was made. They displayed more still behavior and some rhythm-keeping foot behavior that may have facilitated control of the game. The amount of movement that possibly contributed to a different type of engagement could be identified in more positive emotional expressions and movements that reflect the role the player assumes in the game. Even though in this study we were yet unable to automatically perform such an analysis, new tools for gesture and affective movements detection are becoming available, and a motion capture system could facilitate the capturing of these different types of behavior automatically. Berthouze and colleagues (Bianchi-Berthouze and Kleinsmith 2003) proposed a low-level description of body posture and movement that enable the mapping of bodily expressions into emotion categories or emotion dimensions. By using low-level descriptions of posture, motion capture, and connectionist or statistical modeling techniques to these descriptions, they have suggested that mapping models can easily be adapted to detect different types of expressions irrespective of the context in which these expressions are displayed. Using this approach, they explored whether the style of play of the players could be a factor affecting the players' experience.

Although this study has only shown the use of simple measures of movement, the use of a motion capture system paves the way for more complex analyses of bodily movement. Furthermore, it might enhance our understanding of how the type of movements that the game either imposes or affords can affect the strategies adopted by players and hence the emotional and social experience. The use of an exoskeleton could in fact facilitate the analysis of movement strategies (e.g., smooth and long movement vs. jerky and fast movement) (Pasch et al. 2008) and help produce movement measures that can be indicators of user experience. This approach is thus promising as it offers a more objective way to measure movement. The use of motion capture devices to measure non-verbal behavior is increasingly becoming available but given the challenge gesture recognition technology still faces when dealing with unpredictable scenarios whereby the set of movements and gestures cannot be predefined, we believe this approach still needs to be used in connection with other measures such as video analysis when the meaning of movement needs to be interpreted.

5 Other approaches of evaluating exertion games

Other researchers have also been concerned with investigating user experience when evaluating interactive technology that involves exertion. However, most of the work evolved from a physiological perspective, primarily concerned with the physical health outcomes that result from participating in such experiences. When applied to gaming applications, these investigations mainly focus on any physical health effects that the game can facilitate, for example whether an exertion game can lead to weight loss (Graves et al. 2007, Tan et al. 2002). In order to shed light on the contribution the game makes to a physiological benefit, the exertion level of the player has been measured. We now describe a few approaches that are derived from these studies, but have potential to be useful and practical for evaluating user experience. Although mostly new to the context of games, we believe they hold promise for exertion games due to their special characteristics. The following outline is by no means comprehensive, but should give the reader a starting point for thought. We believe future investigations will shed light on our understanding of such approaches in the context of games, in particular when combined with more traditional methods.

5.1 Physiological measurements

So far, we have highlighted how our work suggests that movement and engagement can be intertwined in exertion games. However, capturing objective movement might only tell one story: different people exert themselves differently when performing the same physical movement, depending on their fitness level and bodily capabilities. Physiological measurements could create a more objective measure as to how much exertion players invested into the game, possibly contributing to a more complete understanding of engagement and user experience. One cost-effective way of measuring a participant's exertion intensity is to use a heart rate monitor. Heart rate monitors are widely available, and a few models allow interfacing with a PC for subsequent analysis. Athletes and hobby sportspeople often use heart rate monitors in their training, hence study subjects can often already be familiar with such devices and knowledge about their advantages and shortcomings is widely available. Human-computer interaction research has previously used heart rate monitors not only for measuring, but also for controlling games (Nenonen et al. 2007, Mandryk et al. 2006), furthering acceptance in the community through its pervasive use. Heart rate monitors are also small, lightweight and battery powered, making them suitable for mobile use (Mueller et al. 2007). They can provide physiological user data for little cost and are easy to administer, however, the type of exertion activity that is involved during the gameplay can determine its utility, as heart rate monitors are best utilized in aerobic activities. It should also be noted that a player's heart rate can be affected by other factors outside the game environment, too. Hart gives a few examples: outside temperature, too much clothing or caffeine drinking can affect heart rate data (Hart 2003). If such data is not useable, researchers have suggested to use performance measurements to evaluate exertion activities, for example through measurement devices in the participants' shoes or by using GPS data to track a player's movements (Mueller et al. 2007). We believe these approaches can, if supplemented with body data from the user, give insights into the energy expenditure during gameplay, contributing to a wider picture of game experience.

5.2 Borg's perceived exertion scale

Another way of measuring a participant's exertion level is by using Borg's scale (Borg 1998), which aims to acquire the rate of perceived physical exertion by the participant. It is a simple scale, requiring no technical equipment, which was designed for athletes and sports coaches to be used to assess the intensity of training and competition. The Borg scale, or often referred to as 'Rating of Perceived Exertion', is presented to the participant in form of a chart. The participant then has to select how hard she/he feels she/he is working by giving a rating such as "Light" or "Maximal". The original scale has 21 points of exertion, but variations with less points exist (Hart 2003). The Borg scale has the advantage that it is easy to administer and understand by participants. It has also been demonstrated that the scale correlates well with more reliable indicators of exercise intensity such as blood lactate, VO2, ventilation and respiration rates, and it is also not affected by the environmental factors associated with skewed heart rate monitor data (see above). The results are subjective, however, and the players need to give their rating during or right after the exertion activity. For example, asking a subject during a treadmill-based game to rate their exertion level seems doable, however, chasing a player on a football pitch to acquire an intensity rating might seem impractical.

It should be noted, however, that such a focus on the outcome of the game experience, whether through heart rate monitors or Borg's scale, might aid in offering recommendations as to which exertion games support the most intense workout, however, they fall short in contributing to an understanding of whether and how the game facilitates an intrinsic motivation for the participants to play in the first place. Hence we believe such approaches should not be used exclusively, but rather complement the methods we described in more detail above. By doing so, they might be able to contribute to a more complete story of the user experience in exertion games.

5.3 Evaluating exertion games based on user groups

We also would like to point the reader to the work by Höysniemi (Hoysniemi 2006), who describes the design and evaluation of physically interactive games she has been involved in designing herself. The author argues that different user groups can benefit from different evaluation methods, and that the unique characteristics of exertion games demand a critical reflection on which method to choose. Next to interviews and questionnaires, she has used observational as well as Wizard-of-Oz and peer tutoring methods to evaluate exertion games. Similar to Loke et al. (Loke et al. 2007), she has also attempted to describe the bodily movements exhibited in a game using dance-derived movement analysis. She selected specific methods depending on the user group, children, dancers or martial art athletes, and argues that each has potential for unique insights.

5.4 Evaluating using blogs

As users have appropriated exertion games for their personal weight loss goals, it might be possible to use their self-reported progress reports to evaluate such games: for example, upon its release the Nintendo Wii inspired many avid gamers who described themselves as reluctant exercisers to use the accompanied exertion games to increase their energy expenditure through gaming. Many of these gamers reported their progress in blogs (see for example (DeLorenzo 2007)), and used the social support they gained from comments and page-view statistics as motivational tools. Although this data needs to be trusted, the sheer amount of user data and worldwide availability could make such an approach an intriguing tool to evaluate games in terms of their effectiveness to reduce players' waistlines, but also to investigate any long-term effects to engage players, based on their dedication to report about it.

6 Future challenges

Parts of our work involve affective notions of user experience and their relationships with exertion activity. Most often, emotional engagement with games is associated with increased bodily activity. An additional way forward to understanding this inter-relationship could be a view from the opposite direction: by examining the exertion component, researchers might be able to infer affective aspects from the gaming experience. This appears to be a valid approach, as bodily expressions are an important index of emotional experience. For example, past research has shown that body movement and posture can be an important modality in the human judgment of behavioral displays including affective states and moods (Argyle 1988, Bernhardt and Robinson 2008). Although most work in this area has focused on facial expressions (Ambady and Rosenthal 1992, Ekman and Rosenberg 2005), recent studies embraced a more body-centric approach and found that the perception of emotion is often biased towards the emotion expressed by the body (Meeren et al. 2005), meaning the inference of affective states through body posture in exertion games could yield improved results compared to facial-expression approaches. It should be noted, however, that unlike the recognition of facial expressions, which has been generally based on quantitative models that map pattern of muscle activation into emotions (e.g., (Ekman and Rosenberg 2005)), recognition of bodily expressions of emotions has long been mostly qualitative. Recent advances make the process of identifying emotions from basic movement and posture units more objective and measurable. For example Berthouze et al. (Bianchi-Berthouze and Kleinsmith 2003, De Silva and Bianchi-Berthouze 2004) proposed a general description of posture based on angles and distances between body joints to support the mapping of body postures into emotions. Although such approaches might suffer from the general limitations of any automatic recognition systems, their ability to mature through a demand of supporting the creation of technology that can adapt to the affective states of the user can make them a powerful new avenue for evaluation.

7 Final thoughts

We have described our work on the topic of evaluating user experiences of exertion games. We do not believe there is a generic approach to evaluating exertion games, and therefore we offered a diverse set of results with the intention to contribute towards an understanding of this new emerging area from varied viewpoints. By supporting our experience reports with concrete data from case studies, we hoped to be able to provide the reader with practical guidance on what kind of effects one can expect that are unique to evaluating exertion games. Our aim was to provide a lively account in order to inspire researchers to further investigations into this area, and present them with opportunities for future work encouraged by our results.

We have presented methods known from traditional evaluation tasks, and described their different use in an exertion game setup. We found that whether asking a participant interview or questionnaire-style questions, any post-experience evaluation should take into account that the player will be exhausted after the game. The exertion activity demanded the investment of physical effort, and players can be expected to be out of breath, tired and in an altered emotional state. This altered state can show in many ways, and although mostly beneficial when it comes to the well-being of the player, it can also affect the evaluation task, an issue we believe researchers should be aware of in future studies. Evaluators should also be aware that motivation to play these exertion games can not only be facilitated through the gameplay, but also by an intrinsic drive to improve one's health: many players have subscribed to a weight-loss goal, and use their game as a more "fun" way to achieve this goal, instead of exercising in a traditional gym. The user experience might be affected if such an internal motivation is dampened by the weight scale not responding in the expected direction: it could be that the game facilitated increased energy-expenditure, however, environmental factors outside the magic circle of the game (Salen and Zimmerman 2003) might have caused a weight gain. Gyms that use such exertion games to combine the advantages of engaging gameplay with the social aspects of working out in a dedicated space are emerging (XRtainment), and evaluating exertion games in such contexts is a new and exciting area that provides novel opportunities to understand these games with a holistic view on health and social aspects. Measuring physiological or bodily performance data might not only enhance our understanding of physical health implications, it might also supplement results from other methods to help paint a more complete picture of the user experience. Making such data available to the user, for example through displaying the heart rate, could also contribute to the experience itself, as the users' intrinsic motivation might benefit from an immediate feedback showing the game 'works' for their goals.

Using the body's actions to not only facilitate, but also understand affective experience is an exciting new area. Technological advances will contribute towards rapid evolvement of this field. Using the inter-relationship between affect and body movements for evaluation purposes might provide new opportunities for understanding how exertion games engage players, but also be used in other areas of human-computer interaction to create more affective-aware technology. Combining some of the other methods with their individual advantages will also contribute to being able to tell a story that gives justice to the many benefits exertion can offer to its players. By learning from past experiences and appreciating perspectives from various research views, an understanding of exertion games will unfold that, in turn, can offer an exciting new outlook on how we play and interact with technology. We hope with our work, we have contributed towards such advancement, and we were able to excite other researchers to explore this emerging new field further.

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