Title:

Expanding Exertion Gaming

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Abstract

While exertion games - digital games where the outcome is determined by physical exertion - are of growing interest in HCI, we believe the current health and fitness focus in the research of exertion games limits the opportunities this field has to offer. In order to broaden the agenda on exertion games, we link the existing fields of sports and interactive entertainment (arguing these fields have much to offer) by presenting four of our own designs as case studies. Using our experiences with these designs we highlight three key strategies to guide designers in the creation of richer exertion game experiences: designing a temporal trajectory through games with reference to the way exertion changes over time, designing for the inevitable and not necessarily negative effects of pain in exertion games, and designing for the highly socially situated nature of exertion gaming.

Keywords

Exertion; games; exertion games; sport; entertainment; play

1. Introduction

Exertion gaming – digital gaming where the outcome is determined by physical exertion – is of growing interest in HCI. Exertion games combine elements of physical activity as known from sports with interactive entertainment, particularly computer gaming (Mueller et al., 2011). This article examines the relationship exertion gaming has with both sports and interactive entertainment, exploring what we can learn from both areas in order to broaden the agenda for exertion games.

In our opinion, exertion gaming research has so far rather narrowly focused on health objectives, particularly energy expenditure, often fuelled by grant objectives targeting the obesity epidemic. For example, many papers focus on measuring the energy expenditure of players engaging with the Kinect and Wiimote controllers in order to determine if they are “as good as” traditional sports activities (e.g.(O’Donovan et al., 2012; Whitehead et al., 2010)). We believe that this can set up the expectation that people engage in sports, as well as exertion games, only for energy expenditure reasons. (If this were true, everyone would run marathons and nobody would play golf.)

In contrast, we believe that sports, interactive entertainment and exertion games can complement and learn from each other: after all, they all involve “games” (see Juul (2003) for an overview of definitions of “game"), and all have “play” at their core (using Suits’ (1977) broad definition of play as activities where players voluntarily challenge themselves via unnecessary obstacles). This article sets out to articulate a broader exertion game agenda that goes beyond specific fitness objectives to support a wider range of human activities like bodily play (Márquez Segura et al., 2013). In particular, we believe a broader perspective can a) help exploring the opportunities exertion games have to offer, b) aid in enriching exertion games, c) assist in addressing relevant issues in exertion game research, and d) improve the design of exertion games.

Several prior works offer theoretical accounts on exertion games: these works focus on different views of the human body from an augmenting sensing perspective (Mueller et al., 2011), the experience of engaging in pleasant movements (Márquez Segura et al., 2013), insights from traditional dance applied to movement-based games (Loke and Robertson, 2010), guidelines on how to design movement based games (Mueller and Isbister, 2014), motivations to do more exercise (Yim and Graham, 2007) and applying behaviour change models to motivate exertion (Consolvo et al., 2008). These prior investigations point towards the benefits of taking a wider view of exertion gaming that connects to other disciplines. In this paper, we explore the relationship of exertion games to sports and play, in order to consider the relevance of these disciplines to exertion game design.

While there is a growing body of theoretical work in this field, there is a shortage of research that combines critical perspectives from sports and entertainment. This article aims to bring together and expand these views by synthesizing theoretical perspectives and practical experiences to create a broader agenda for the design of exertion games. We are inspired by previous works that identified a trend towards more body-centric design perspectives, such as Klemmer et al.'s "How Bodies Matter" (Klemmer et al., 2006) and Dourish's "Embodied Interaction" (Dourish, 2004). In this tradition, we first present our critique of the current state of exertion game design and research, followed by a set of strategies for designers to consider when creating new systems, to offer inventors and futurists designer-oriented handles for where to start in contributing to this expanded exertion games agenda.

2. Incorporating Sports and Play into Exertion Games

In this section, we briefly present an overview of the work that we will be referring to throughout the article. Looking at current HCI work on exertion gaming, much of it focuses on in some way on energy expenditure. How much energy expenditure exertion games promote in their players has been studied in many ways, such as by augmenting existing game mechanics with exertion based bonuses or penalties (Berkovsky et al., 2012; Chatta et al., 2015; Hassan et al., 2012), creating games for school physical education classes (Keskinen et al., 2014; Macvean and Robertson, 2013), replacing conventional input devices with exertion based gestural control (Guo and Quarles, 2012), studying how much energy existing exertion games require to play (Chen et al., 2014; O'Donovan et al., 2012; Whitehead et al., 2010), and how one might motivate people to play exertion games more often (Macvean and Robertson, 2013; Nunes et al., 2014; Yim and Graham, 2007).

Further to this, there is literature on exertion as it relates to sports and play, much of it external to HCI. In particular, sports and health sciences have much to say about why people choose to do exercise (Ingledew and Markland, 2008), how people move during exercise and how hard they are able to push themselves (Ben Abdelkrim et al., 2007; Fernandez-Garcia et al., 2000), subjective aspects of exercise such as pain, fear and thrill (Addison et al., 1998; Benedetti et al., 2013; Jirásek and Hurych, 2012; Self et al., 2007), what effect exercise interventions have on people's overall lifestyle (Frémeaux et al., 2011), and also studies of the social aspects of sporting behaviour (Delamont and Petrone, 2010). Health researchers have also presented longer term studies specifically focusing on exertion gaming (Baranowski et al., 2012; Owens et al., 2011). Gaming and play researchers have also discussed much that is relevant to exertion gaming, such as how to effectively create a temporal trajectory in a game (Bleszinski, 2000; Wesołowski, 2009), the purpose of failure in games (Juul, 2009) and broader philosophical questions such as why people choose to play games (Rigby and Ryan, 2011), and what actually defines gaming or play experiences (Juul, 2003; Suits, 1977).

As well as exercise-quantity focused research, there are also examples of exertion game research projects that are driven not by a desire to increase exercise quantity, but more by using exertion primarily as part of game design. For example, Nenonen et al.'s (2007) Pulse Masters Biathlon uses heart rate and synchronised 'skiing' actions to control the action of a two-part skiing then shooting game, the 2nd author's Hanging Off a Bar (Mueller et al., 2012a), creates a game in which players must hang their body weight off a bar for increasing amounts of time, and MobyDick (Choi et al., 2014), which uses swimming strokes as input to a multi-player game where 4 players must collaborate to battle a giant sea creature. There are also commercial exertion games, such as the full body dance game Dance Dance Revolution (Konami, 1998), and the genre of 'rhythm' games which followed that use increasingly fast series of dance moves as input. As well as games sensing body actions direction, pervasive games such as Human Pacman (Cheok et al., 2004) and the Rider Spoke cycling game (Rowland et al., 2009) often involve what Stanley et al. describe as 'exercise as a byproduct of the activity' (Stanley et al., 2010).

In order to explore the synthesis of perspectives from sport and gaming into exertion gaming design we describe below 4 case studies from our own work, which we take as starting points for wider reflections throughout the article.

The case studies were chosen from the work of our two labs because they started from different perspectives while blending different elements of sports and play, from augmenting of conventional sports for social and fitness purposes to a biosensor augmented physical amusement ride and a playful experience around running. By using these disparate case studies we aim to create an agenda for exertion games that is relevant to designers of a wide range of games and experiences.

2.1 Copy Paste Skate: Augmenting a Street Sport

Copy Paste Skate (referred to henceforth as CPS) (Pijnappel and Mueller, 2013) is an interactive skateboarding experience that supports the trick experience in skateboarding by offering feedback along three modalities that have previously been identified as key to the trick experience (Tholander and Johansson, 2010): visual, aural and haptic.

Visual feedback is provided by a life-size still visualization showing the path of movement of the skateboard during the trick, projected onto a wall just behind the skater. Each subsequent visualization is projected on top of the previous one, with visualizations disappearing after 3 attempts. Directional microphones capture the audio produced during a skater's trick attempt. The audio is then replayed at half the speed through large high-quality speakers to the skater and any bystanders. Right after completing or attempting a trick, custom-built flooring on which the skater performs vibrates based on the motions of the skateboard during the trick attempt. This offers a replay of the haptic experience felt during the trick attempt. Vibrations are produced by an audio transducer that takes the sensor input to create a vibration similar to the haptic experience felt by the skater, however, it is replayed shortly after, so that any by-standers, but also the skater can experience a haptic reminder of the trick again, complementing the original trick. As with the audio, the time of the haptic experience is slightly stretched in order to allow experiencing the haptic sensation over a larger amount of time, responding to the fast duration of a trick. Based on observations and interviews with skateboarders two key design dimensions emerged that highlight how designing for skateboarding means both supporting the execution quality of tricks as well as supporting the trick originality (Pijnappel and Mueller, 2013).

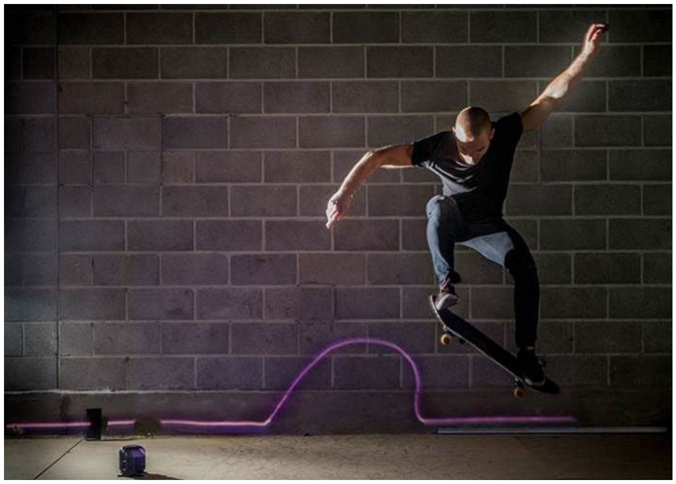

Figure 1. Copy Paste Skate

2.2 Jogging over a Distance: A Networked Social Fitness Activity

In Jogging over a Distance (JoD) (Mueller et al., 2011, 2007), two jogging partners arrange to run at the same time, wearing stereo headphones, a microphone and a heart rate monitor. Before the run, users enter their preferred target heart rate, which stands for the physical effort they plan to invest based on their fitness levels and goals. While participants jog, their heart rate is sent to a server and then to the other jogger. Each jogger can hear the audio of their jogging partner. The participants' heart rate in relation to their target heart rate affects the position of the audio moving round the jogger's head from the front, to side-by-side and to the back depending on the difference of the relative heart rates. If the other jogger is "in front", the sound appears to come from the front. The further "in front" the jogger is, the lower the volume of the audio becomes. When both joggers are at their target heart rate, they hear the audio at full volume as if they were running side-by-side. If one partner's heart rate becomes greater relative to their individual target heart rates, she/he will hear the audio fall behind her/him, and his partner will hear the audio move ahead. This perceived "distance" between the pair increases with the difference in their target-relative heart rates. A study of JoD demonstrated how the system can facilitate a social experience despite the physical distance between the users, bringing together their individual exertion sessions into one shared experience (Mueller et al., 2010).

Figure 2. Jogging Over a Distance

2.3 The Broncomatic: A Whole Body Entertainment Experience

Broncomatic (Marshall et al., 2011b) is a modified bucking bronco ride, which is controlled by the rider's breathing. This creates a feedback loop where the exertion of staying on top of the ride causes people to breathe more heavily, which in turn causes the ride to move faster. To stay on the ride, the rider has to both control his/her balance, and also keep control of the breathing so that they are not thrown around impossibly fast. If she/he fails, she/he is thrown off onto an inflatable mat. Over time the Broncomatic progresses through three difficulty levels, each increasing the intensity of the effect that the breathing has on the ride. Riders score points for how extreme a ride experience they have, based on how long they stay on, and how much they breathe, shown on a large public display next to the ride. Broncomatic is a combination of an existing physical game with digital technology that allows the game to respond to how the rider is experiencing the ride. This creates a new challenge compared to the pre-programmed ride sequences of the original ride.

In studies of the Broncomatic, both first time and repeat riders reported strong levels of enjoyment. The Broncomatic has been shown in various locations since the initial development, and is currently part of a long-term invited installation at the National Videogame Arcade, UK.

Figure 3. The Broncomatic

2.4 I Seek the Nerves: A Playful Running Experience

I Seek the Nerves Under Your Skin (I Seek) (Marshall and Benford, 2011), is a running experience based around a piece of performance poetry in which the performer is getting increasingly excited, energetic and angry throughout the 90 seconds of the poem. It encourages listeners to also act in an increasingly frenetic manner, with the aim of helping them better empathize with the poet; this is done by encouraging them to continually accelerate whilst they listen to the poem through headphones, so that by the end they are sprinting at their maximum speed. This is incredibly hard to do; if the runner slows down, the poem automatically fades out until they start running again when the poem starts from the beginning. The majority of participants never hear the full poem despite multiple attempts. Runners reported that they found the experience exciting, particularly due to the way in which they were encouraged to exert themselves hard whilst surrounded by other people and in complex outdoor environments (Marshall et al., 2011a). Whilst the underlying exercise here is essentially the same as doing sprint interval training, even regular runners who were experienced with that kind of training reported finding it hard when attempting to hear a poem at the same time. The largely unexplained nature of the system led participants decide for themselves whether to interpret the system as a game which was challenging them to run fast enough to beat the system, or as a more open ended form of play around how the sounds produced respond to movement (Marshall et al., 2011a).

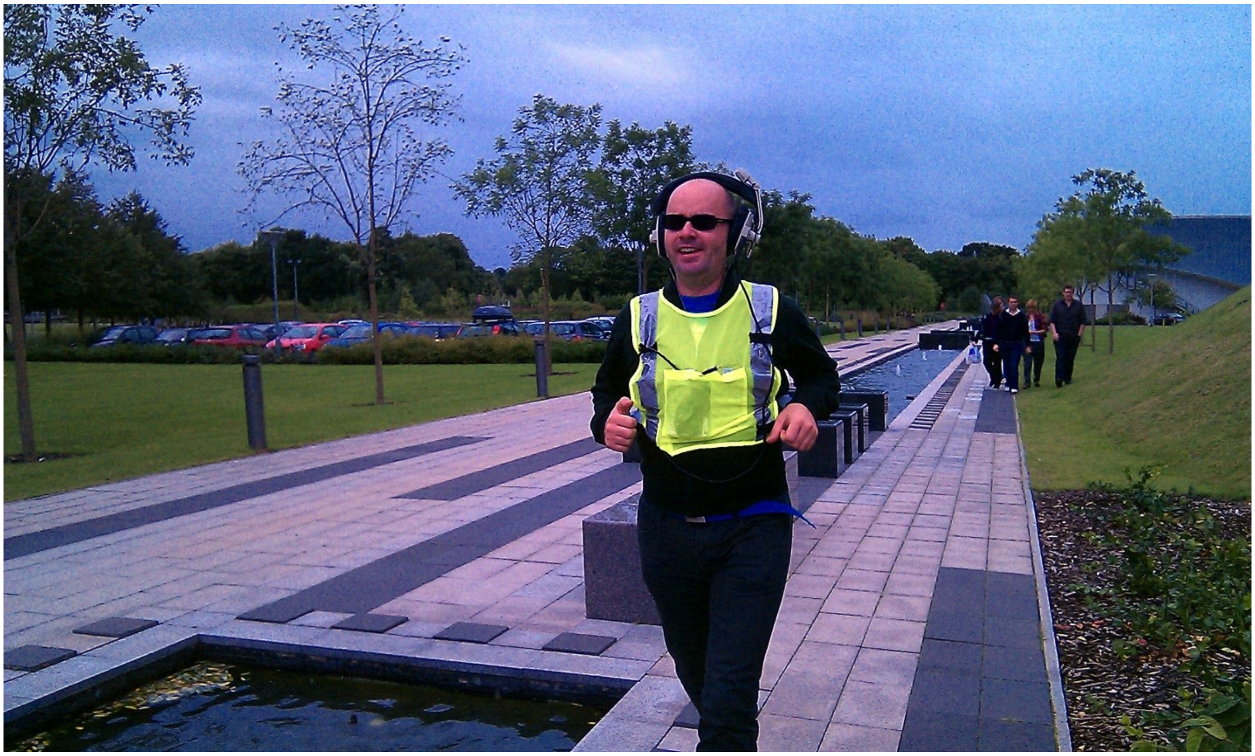

Figure 4. I Seek the Nerves Under Your Skin

3. Critiquing Existing Exertion Games and Frameworks

As exertion game designers, we chose to collaborate due to a shared perspective that:

- Sport and exercise are fulfilling and exciting activities.
- Games and playful experiences are also exciting.
- By using digital technology to combine exercise and games we can create new and exciting playful experiences with physical exercise at their core – perhaps even creating new experiences which could be considered novel digital sports (Mueller et al., 2011).

The work described in the case studies was designed with minimum consideration for health benefits, weight loss or quantification of exertion levels. This is in contrast to much exertion gaming research which sees exertion games as 'serious games' with a focus on player health (Göbel et al., 2010).

In this section, we briefly discuss a range of previous research and commercial exertion gaming works to which we present a set of critiques of the overly health-focused nature of many existing exertion games. We also present systems that we believe deal with these problems in a constructive way. These critiques are not meant to describe the health-focus as a flaw, however we argue that these systems could possibly offer a richer experience by taking into account craft knowledge from sports and entertainment using the design strategies we discuss in Section 4.

3.1 Critique 1: Not considering exertion as an integral part of game design

There has been a recent focus in gaming research in making elements of the game such as the heads up display (Iacovides et al., 2015) and voice commands (Carter et al., 2015) 'diegetic', so that they make sense in the context of the game story and world. We believe that, as with voice commands and player feedback, exertion should also be an integral part of the game design.

Several authors (Berkovsky et al., 2012; Chatta et al., 2015; Hassan et al., 2012; Jung et al., 2010; Wylie and Coulton, 2008) have described the design of exertion games as a process of taking an existing digital game and replacing or augmenting the typically mouse, keyboard or gamepad input with an exertion input mechanism. For example Berkovsky et al. (2012) add a new sensor that is triggered by jumping on the spot a certain number of times which gives bonus time in an existing mouse- and keyboard-controlled maze game. Guo and Quarles (2012) similarly describe taking an existing game and using arbitrary exercises as gestural controls to encourage people to do exercise. Chatta et al. (2015) describe another general approach to exertion gaming, where they take an existing game, and put a flashing overlay over it, which makes it hard to see unless the person constantly exercises. Evaluations of such interfaces generally involve short-term studies in which people play the game, and it is shown either that people move when they are playing the game, or that they move more than they do when playing the original game.

Systems designed in this way could be seen as having the fundamental underlying assumption that game playing is enjoyable, whereas exertion is something that is undesirable, uncomfortable and simply "not fun". Shimada et al. (2007) are very explicit about this, describing exercise as being something "dull, and monotone". By taking the "undesirable" activity of exercise, and adding the fun of digital gaming, these designs aim to divert the user from the fact that "the hidden aim of the game is to increase the physical activity" (Hassan et al., 2012).

This view of exertion ignores sports science research that discusses the positive nature of hard exercise (see Section 4.2 below), and we believe it has two fundamental problems when it comes to the design of exertion gaming:

Firstly, it leads to bad game design, due to the disconnect between the game design and the exertion, where the exertion becomes an arbitrary element of the game, unlinked from the dramatic aspect of play (Fullerton, 2008). For example, we believe there is no meaningful connection between jumping on the spot and a ball rolling around a maze gaining extra time (Berkovsky et al., 2012), or why one might want to 'do 50 running steps' to open a clue in a treasure hunt (Hassan et al., 2012). We acknowledge that these examples were designed to enable quantitative experiments rather than demonstrate complete game designs, however, as they are making arguments for the benefits of these designs for exertion games, the underlying ideas need to be considered as influencing the field.

Secondly, by disconnecting exertion from the game itself, these games highlight the meaningless nature of the exertion involved, and risk promoting the idea that exertion is only worth doing if there is some kind of external reward such as a fun game. This has the potential to be harmful to players in the long term, given the evidence that long term exercise motivation is linked to intrinsic enjoyment of the exercise itself as opposed to extrinsic rewards such as those provided by these games (Ingledew et al., 1998). If we create systems that fail to support the idea that exercise may be intrinsically rewarding, we may actively discourage long-term participation in exercise.

As an example of an exertion game which integrates exertion with the game in a meaningful manner, Pulse Master Biathlon (Nenonen et al., 2007) uses a combination of stepping with alternate feet, and finger presses on ski pole mounted buttons to simulate skiing, with speed in the game relative both to heart rate and hence exertion of the player, and also linked to the synchronisation of their pole movements with the skiing action. In a second section of the game, players have to shoot at targets; in this section, the fact that a heavy beating heart makes it hard to aim a real gun is simulated in the game by wobbling the gun sight more based on a higher heart rate, meaning that players have to balance exertion during skiing with recovery needed to shoot straight. The players' exertion is deeply linked with the design of the game and hence it offers an integrated exertion activity, as opposed to a game with an un-enjoyable exertion activity bolted on.

3.2 Critique 2: Designing exertion gaming for a lone individual

We believe that when designing exertion games, we need to consider people other than the person playing the game. With a standard controller-based game, a player's actions may not be visible to those around him/her, as any fine-motor finger movements are difficult to see and understand for others and can easily be out of view. For example, people playing games on public transport probably appreciate that others cannot see what games they are playing, (and possibly how well as they do not want others to see how "bad" they are in their casual game). Exertion gaming in contrast involves gross-motor movements, something which is hard to hide – therefore we may have to consider attempting not to make people feel uncomfortable in front of onlookers, or feel that they are unfit in comparison to others, aspects that can be a problem for non-exercisers (Yim and Graham, 2007). Unless designing exertion games only for people who deliberately hide and play them in private, exertion games are socially embedded and played amongst other people, and designers should therefore consider the social nature of the activity. This has implications for how we go about teaching the design of exertion games, too: for example, in our teaching practice, we advise students that if they design an exertion game, they should start with a multiplayer version before moving on to a single player version, which is opposite to most traditional game design processes.

As an example of designing for socially situated exertion gaming, Macvean and Robertson (2013) describe several ways in which their single player exertion games for school physical education lessons are essentially social, such as people wanting to play in a separate area of the playground to be near some but out of sight of others. Their findings led them to reconsider earlier designs which largely considered only the single player who was directly interacting with the game (Macvean and Robertson, 2012).

3.3 Critique 3: Keeping it easy

Whitehead et al. (2010) present a detailed review of participants' exertion levels in a large number of exertion games. According to their energy expenditure data, the average exertion measured even in the most active exertion game was 4 times the resting exertion. This puts it into the category the World Health Organisation (2010) describes as moderate intensity, similar to a brisk walk or doing gardening.

This level of exercise is acceptable if users are not used to traditional physical activity, a user group which Whitehead et al. (2010) argue are a key target for exertion gaming as a motivational tool. However, if games are to actually work as a lasting motivation to exercise, they will need to adapt in difficulty and intensity as their players increase in fitness, rather than restricting players to low to medium intensity exercise for reasons appropriate primarily to less fit players, such as to avoid putting players' hearts under "undue strain" (Boyd Davis et al., 2005). Most sport is hard, in that some aspect of pain is understood to be inevitable (Addison et al., 1998), primarily due to pushing oneself to perform at high effort levels. Exertion games similarly should have the potential to be physically difficult.

Clearly, there is a balance to be achieved if one is building a system to target both non-exercisers and exercisers, as non-exercisers may not be motivated to take on hard challenges (Yim and Graham, 2007), and designers do not want to injure participants by pushing them too hard (Boyd Davis et al., 2005), but we believe that the answer cannot be to make everything easy. Overcoming pain and difficulty is an inherent part of physical activity, and as such we advocate designing with this in mind. It is key for lasting exertion game success that we design systems that adapt to people's fitness levels and pain tolerance; Section 4.1 describes ways of dealing with this by creating long and short-term trajectories of exertion intensity. It is important to note that this does not necessarily mean making activities easier for less fit people; sports practice suggests a range of ways of dealing with things that are inherently hard besides reducing the underlying difficulty of the challenge faced, such as coaching, peer support and technical aids (e.g. floats in swimming).

Arguably, I Seek goes somewhat too far in the opposite direction, in that it is extremely hard, which creates serious limitations on how long a game can last, and reduces the ability of less fit players to play for a long time. This is not too bad in its current form, where it is primarily an experience that players will only play at a single event, but the designs would require refinement for longer term replayability.

3.4 Critique 4: Fighting the obesity epidemic

From the earliest exertion games, researchers have argued to funding bodies that by creating engaging exertion games for children and adults who are obese or at risk of obesity, they will become more physically active and less overweight. It is hard to find a paper on exertion gaming which does not contain the words obesity epidemic, or suggestions that exertion gaming may solve obesity – we are not immune from this (e.g. (Chatta et al., 2015; Keskinen et al., 2014; Mueller, 2009; Mueller et al., 2011; Sinclair et al., 2007; Stanley et al., 2010; Whitehead et al., 2010; Yim and Graham, 2007). However, the idea that exertion game research may solve the obesity epidemic is flawed in several ways. Firstly, many researchers use short-term studies and studies in physical education classes or similar situations in order to evaluate their games. These studies demonstrate that when people play a game that enforces movement, they move. What they do not demonstrate is long-term engagement in a naturalistic setting.

This long-term engagement has been argued as lacking in studies of commercial exertion games (Owens et al., 2011), where when given a free choice as to whether to play Wii Fit, player time declined to just 3 minutes a day over 6 weeks. Further to this, even if games are played, the evidence that they increase overall activity is lacking, with studies showing that even if children play active games for 28 minutes a day, their overall levels of physical activity do not increase (Baranowski et al., 2012). This counter-intuitive result is hypothesized to be an effect of a bodily "activity-stat" (Frémeaux et al., 2011), a regulatory mechanism in which the body compensates for activity at one point in the day by being more sedentary at other times. There is further to this evidence that the direction of causality between lack of exercise and obesity may not be as simple as previously thought, with large-scale studies suggesting that lack of exertion is caused by obesity, rather than the other way around (Metcalf et al., 2011).

We also believe approaches that overly focus on energy expenditure or health may in fact have a negative effect on game design, as they encourage design of movements with measurement of exertion as a focus, as opposed to how they fit into the game, and hence encourage approaches with exertion separate from the gameplay as per critique 1 above.

So, we propose that firstly, exertion games are in themselves a positive and interesting gaming and entertainment form. It is true that physical activity afforded by games can have positive benefits for health. However, quantifying their benefits in terms of calories burned, seconds of vigorous activity, or weight lost is simplifying the multifaceted range of benefits that are potentially available to players of exertion games, and neglecting other positive effects from engaging in them, even if it is "just" entertainment. Further to this, as Yim and Graham (2007) point out, even if designing for health, the key to designing a useful game is that people play it. We believe that designing an engaging exertion game is hard in itself, and that by focusing excessively on health benefits, exertion game designers miss the chance to design good exertion games, and risk creating excessively fitness-focused games with poor engagement (Owens et al., 2011).

We believe that a good approach is to present exertion as a positive, exciting and engaging part of the overall experience, and design exertion games as games that involve exertion rather than as disguised Trojan horses for energy expenditure or health. There are some existing commercial examples we would like to highlight that we believe are designed based on the notion that focusing on the positive experiences of sports can achieve significant levels of engagement: Popular exercise tracker Endomondo (2007) uses the slogan "free your endorphins", referring to feelings of exhilaration triggered by hard exercise; similarly online racing app Strava highlights the enjoyable nature of exertion: "Strava provides motivation and camaraderie, and helps us prove that we're out there doing what we love to do*"* (Strava, 2009). Whilst we acknowledge that the quotes are marketing slogans and the associated designs might also not be perfect, they highlight that it is possible to present exertion as being intrinsically enjoyable as opposed to purely necessary for health improvement. We could also include in this list full body rhythm games such as Dance Dance Revolution (Konami, 1998) and Dance Central (Harmonix, 2010), which present the vigorous physical movement of dancing as enjoyable in itself, rather than primarily focusing on fitness or health goals. Even if we do wish to explicitly focus on health improvement, a recent academic study of Dance Central (Chen et al., 2014) suggests that if we do wish to explicitly focus on health outcomes, rather than building games that attempt to hide the existence of exertion and using gamification to encourage people to exert themselves, it may actually be more effective to "healthify" fun games, by framing the game as a form of exertion, something that in their study encouraged players to do exercise for longer.

4. Three Design Strategies for Exertion Games

We now show how a critical reflection across the case studies raises new themes for exertion games. We note that this is not intended to be a comprehensive list, but rather a starting point, based on our design practice, associated craft knowledge and collated reflections. We turn to the literature from sports and interactive entertainment to expand on these themes in order to provide "jumping off" points for designers of future designs. We present 3 design strategies: firstly, we discuss the way in which exertion and time are inextricably interlinked; secondly, we address how pain and discomfort play a positive part in sports and exertion experiences; and finally, our last theme relates to the social nature of exertion experiences. We motivate each strategy based on observations from the case studies, and follow the motivations with a set of specific tactics as stepping stones towards how to implement them.

4.1 Design Strategy 1: Design Exertion Trajectories

Benford et al. (2009) describe the concept of an interactional trajectory, a way of designing for extended experiences involving technology, which move back and forth between physical and digital elements of the experience. In this strategy, we argue that exertion games inherently involve an interplay between the physical and digital over time, and as such designers should consider the trajectory that participants may take during the experience with a particular focus on the way that exertion may change through an experience. We call this the 'exertion trajectory'.

In all our case studies, we found examples of the way that participants' experiences are not constant over time; the effects of both tiredness due to exertion and changes in exertion required by the system meant that how people exerted changed significantly over time, with different system designs creating different exertion trajectories for each system.

The level of exertion required had strong effects on the trajectory of the experience, for example JoD and I Seek both use running as an input. However, the character of the two experiences is very different. The extreme bursts of activity in I Seek are close to the physical limits of participants' bodies, which places a limit on how long people can play, whereas the lower level of constant exertion encouraged by JoD means that people can take part in it for longer.

Exhaustion in JoD developed more slowly over time, even though the joggers engaged in the same action (jogging) throughout their exercise session, their experience of the activity changed significantly as exhaustion developed. Initially, the goal was to find a speed that both joggers were happy with. Once they got tired, the challenge shifted towards "not stopping" as a result of increased exhaustion. This affected the experience and the social interaction, as the more exhausted they got, the less able they were to talk.

In Broncomatic, the management of exhaustion over time is highlighted by the digital scoring system, which uses the idea of "levels" as in computer games in a way that the response of the ride to breathing increases as the player rides for longer. Players score more points on these higher levels, but it is significantly harder to stay on the ride. This creates a trade-off between conserving energy for higher levels and gaining points on lower levels.

Interestingly, the use of JoD did not stop when people stopped jogging: if one jogger arrived at his/her home, while the other jogger was still underway, she/he kept talking in order to keep the other jogger company and support the partner in continuing to run. Even when both joggers arrived simultaneously at their respective homes, they kept using the system to discuss the run, their respective recovery time, etc. There were also moments of low or no exertion before the run, where participants used the system during warm-up exercises to discuss where they would run, for how long, etc.

Where people exert themselves and what environment they move in can change over time, and affects the trajectory they take through an experience, for example in I Seek, participants described various ways terrain and time were related, such as crowded areas making them slow down and actively aiming to run down slopes at particular times in the experience in order to allow them to run faster (Marshall and Benford, 2011).

In CPS, there are multiple layers to the trajectory. At the level of a single practice session, we observed that skaters engaged in a trick, but even if the trick failed, they did not immediately try the trick again. Rather they took a short break to recover and reflected on the trick (which was often accompanied by chatter about the trick, contributing to the social experience), creating a trajectory of periodic exertion with longer gaps in between. Often executing the same trick straight away will not ensure success. CPS supports this reflection by using this recovery time between tricks to offer feedback that might otherwise be disturbing if delivered during the actual trick action. The replay technology also allows people to see their trick replayed after the act. This means that a skater can become part of their own audience. The visibility enabled by this technology can be used to inform their learning processes as they practice and perform tricks. CPS also highlights the longer-term trajectory as people's ability to perform different exertion activities improves and changes while they learn to skate. By promoting reflection on the skater's skills and how they are performing their tricks, it aims to support a long-term skill development trajectory.

As our case studies make clear, when considering the trajectory through an exertion game experience, it is key to consider the temporal aspects of the exertion itself. The following design tactics aim to support designers in this process:

Consider the varying intensity of exertion: Exertion levels during exercise may vary greatly, from rest, through aerobic exercise, where the body is able to supply enough oxygen to continue for some time, into anaerobic exercise, which is either extremely fast exercise, or load bearing exercise such as heavy lifting, where the body is working so hard that it can only continue to do so for a short while. Whilst during training some athletes engage with exercise sessions at relatively constant exertion levels, there are very few events where the challenge level is constant, or even where athletes do the same thing every time. Even in the most 'basic' sports such as running and swimming, athletes will typically pace themselves until near the end, and then put in a spurt of higher power (Noakes, 2007). In addition, designers should also pay attention to the trajectory elements of warm-up and warm-down at either end of an exercise session.

Use exhaustion as an upper limit to exertion trajectories: I Seek uses hard running to push people to find their exertion limits. The exertion game Hanging off a Bar (Mueller et al., 2012a) challenges players to hang on a bar until they can no longer hold on. Both these games use essentially the same mechanic of creating a situation where the level of exertion is limited only by one's ability to fight exhaustion (Mueller et al., 2012a).

Create a trajectory across individual play sessions for skill learning: Csikszentmihalyi's concept of activities which create a feeling or state of flow (Jackson and Csikszentmihalyi, 1999) is heavily cited in both sports and games writings. Flow is described as being created by a situation where the balance between the challenge presented to someone and their skill level is just right – too low and it is boring, too high, and they are unable to deal with the challenge. Both sports and games have longer-term trajectories than a single game level or a single match. Through this longer-term period, people will improve in skill, and thus the challenge must be increased alongside this. In other words, if people are to remain engaged over time, as they develop in skill, the challenges must develop in tandem. Falstein (2005), in his discussion of gaming difficulty, points out how in practice games may vary the rate of difficulty increase over time, rather than use a constant increase in difficulty, in order to give people time to consolidate skills during their learning process, a pattern that has been observed in research into successful existing games (Linehan et al., 2014). With conventional computer games, progression is primarily about skill and tactics; exertion games have a further complication, which is the development of physical ability and fitness. This creates a more complex trajectory of skill development. For example, Sheinin and Gutwin (2015) describe a study of a 'small scale exertion game', which uses repetitive, tiring physical actions on a gamepad; they show how the skill development and tactics for such a game are far more complex than a traditional gamepad controlled version of the same game, due to fatigue and the wider range of skill differences when people have to perform complex physical actions.

Manipulate time to allow for self-reflection: In sports, audiences have been able to watch actions in a delayed fashion thanks to replays. In CPS, the action replay approach is aimed at the players themselves, by projecting the captured skateboard movement after the trick right into the exertion environment. Manipulating time in this way and providing this to players supports the act of self-spectating as part of the activity and part of the learning process. If self-spectating is used for feedback during a learning process, we can take insight from research into augmented feedback in sports - Care must be taken to provide feedback this in a way that supports skill development whilst reducing the tendency of players to rely on constant feedback (see Magill & Anderson (2012) for a thorough review of augmented feedback). Viewing oneself can also inspire higher levels of performance, new ways of performing, and help people in their self-identification as a skilled performer (Jones, 2011); for example it has been argued that the primary purpose of amateur videos in skateboarding is "*not documentary … but anticipatory: their ability to help skateboarders imagine futures and to contribute to their ongoing symbolic projects of self formation"* (Jones, 2011).

Utilize environment to create exertion trajectories: Designers should also consider utilizing the environment to create exertion trajectories. For example, in rock climbing, the rock face primarily moderates how hard a particular section is; on many sections, people may be able to pause to work out what they will do next, but some parts of a route may require negotiation of overhangs or otherwise require the climber to hang on their arms alone, meaning that a person is undergoing hard exertion during that section.

Utilize game design and narrative to drive exertion trajectories: In gaming, trajectories occur relating to the design of game levels to modulate temporal progress through the game; for example Bleszinski (2000) describes points where one can hide and pause, surrounded by sections where the player has to take a risk of being exposed and has to move quickly to be safe. Wesołowski (2009) suggests that these variations in difficulty be used to give players a break in the intensity of the action, something that is even more important in exertion gaming, where the amount of intense physical activity possible may be limited by people's fitness.

An exertion game example of this tactic is the audio game Zombies, Run (Alderman, 2012), designed to be played while running. It tells the story of a post-apocalyptic future full of zombies. In each level, a slow introductory section encourages the player to warm up, then the player is let out of the safe base and told to run. At key moments of high thrill in the story, the player hears a horde of zombies chasing and has to accelerate to avoid them or else lose vital items. In effect the game excitement drives an exertion trajectory very similar to types of interval training in which people intersperse low effort exercise with bursts of extremely high effort.

Consider cognitive load and the exertion trajectory: When exerting oneself hard, it may be more difficult to concentrate on game elements. Game content may also distract from the exertion activity. When designing exertion trajectories, we need to consider how these conflicts occur, and whether they are desirable or not. For example, in bicycle-based games events may be scheduled to occur at times when riders are not riding hard, to avoid unsafe distractions (Rowland et al., 2009). I Seek in contrast deliberately uses this distraction to alter the participant's perception of the poem, aiming to leave them with an impression of the poem rather than fully hearing every word, making much of the poem only audible while the participant is running hard and having to pay attention to the running.

4.2 Design Strategy 2: Design for, with and around pain

Our second design strategy is concerned with the fact that exertion means that there is a risk of physical discomfort, possibly resulting in pain and even injury. We have previously written about the deliberate use of fatigue as a game challenge (Mueller and Isbister, 2014; Mueller et al., 2012a); in this section we explore a wider range of pain-based design strategies.

Pain (defined as *"*an unpleasant sensory and emotional experience associated with actual or potential tissue damage*"* (Addison et al., 1998)) is known to be a key part of most athletic activities, and despite the negative connotations, pain has many positive functions in sport (Addison et al., 1998), which we discuss below. As designers of exertion games, we should embrace these positive aspects of pain in our designs. Analysis of our case studies revealed a range of ways in which pain and the risk of pain was important to these exertion experiences.

For example, I Seek pushes people to an extreme level of exertion, which can be painful: the heart pumps uncomfortably fast and lactic acid builds up in muscles. This pain also has positive effects, by forcing the participant to stop running and slow down it creates the entire mechanic of the game as people try to overcome the discomfort of such high levels of exertion.

In JoD, the way people expressed pain was a key part of the communication between players. For example a runner reported how hearing the hard breathing of the other runner (emphasized by the close location of the microphone to the jogger's mouth) made them focus on hearing "someone else in pain". This outward signal of painful exhaustion communicated people's exhaustion levels to those they were running with and allowed them to modulate their effort levels in response.

Even fear of pain can have positive effects, for example the Broncomatic uses the rider's fear of falling and hurting themselves as a thrilling part of the ride experience; although the inflatable safety mat means that the risk of injury is low. The fact that the “game over” moment in Broncomatic is to be physically thrown from a large piece of machinery gives it more emotional impact than a simple “game over” display.

CPS takes the idea of risk further, unlike skateboarding video games such as Tony Hawk’s Pro Skater it aims to keep the skateboarding experience true to its nature as an extreme sport. As such CPS involves bodily actions that carry a real risk of physical injury. In particular, a trick is executed correctly if the skater does not fall (the risk of injury is low if the skater does not fall), a trick was not executed correctly when the skater falls (and the risk of injury to the skater is higher). The riskier the trick, the higher the achievement for the skater upon success, as usually assessed by him/herself and other skaters. As such, the level of risk (at least partially) determines the quality of the movement action. This resonates with research in climbing that articulates “risk as a measure of progress” being a key aspect of the climbing experience (Fave et al., 2003).

Pain takes many forms. In our discussion of the tactics that make up this strategy, we highlight 5 forms of pain based loosely on Addison et al.’s (1998) categorization of pain amongst athletes, describing how they could be considered using interactive technologies:

Positive pain is the result of people pushing themselves towards the limits of what they are able to do. Pushing themselves hard is something that many people find thrilling and is key to many sport performances (Addison et al., 1998).

Negative pain such as caused by an injury is unlikely to be a desired outcome, however, the fact that an activity carries potential for negative pain can be thrilling as seen in extreme sports (Breton, 2000; Self et al., 2007).

Potential pain refers not to actual pain as a result of bodily damage, but the perceived potential of pain. Even though no bodily damage occurs, exposing oneself to potential pain can be a significant and thrilling emotional experience (Breton, 2000).

Fatigue can be caused by extended periods of physical activity. Fatigue can occur during one physical activity session, or across many as a result of too many repetitive actions - common in sports such as jogging and swimming, but also seen in gestural input console games (Sparks et al., 2011).

Emotional pain refers to affective responses; a typical example is the negative feeling when just having lost an important game. A typical example of emotional pain in digital games is the loss of a life. Juul (2009) describes 4 successive types of pain in digital games: i) loss of energy, which eventually leads to ii) loss of a life, which may lead to iii) setback punishment, in which a player is forced to replay part of a game, and iv) game termination, which is essentially the ultimate setback punishment. Without any of these types of pain, there would be no challenge in the game. Hence players prefer to fail sometimes, as otherwise the game may be boring and too easy (Juul, 2009).

We propose the following strategies to support exertion game designers to take pain into account:

See pain as a bodily form of feedback: CPS highlights how negative pain as well as potential pain tells the skater something about the quality of the trick. So in addition to providing feedback through audio and visuals, athletes also receive pain as a bodily form of feedback. In our design process, we experimented with pulling the skater off the skateboard by pulling strings attached to the legs in order to understand something about haptic feedback and pain (Pijnappel and Mueller, 2013). We can envision that future versions could support this further such that the level of pain experienced is correlating with movement quality. Interestingly, in skateboarding even a deliberate infliction of negative pain such as knocking people off their board is seen as a positive way to teach people social rules such as turn taking and not dropping in on another skater (Delamont and Petrone, 2010).

Celebrate positive pain: Designers can celebrate positive pain through digital means. For example, the joggers in JoD are rewarded with a loud and clear communication channel if they keep running, engaging in positive pain, and the runners in I Seek only hear the full poem if they continue pushing themselves throughout.

Mix pain types: Designers can combine emotional pain known from digital games with the physical pain known from sports to leverage the advantages of each. For example, in I Seek, the users experience emotional pain when they stop running, as the poem stops and they have to start from the beginning, a setback punishment. However, the user probably stops because she/he feels extremely fatigued. The engagement with the experience comes from balancing this multi-pain potential: If avoiding one pain, the other pain will come to the fore, so the player has some form of autonomy as to which pain she/he will succumb to, this balances the inevitable nature of the pain with the sense of autonomy that is usually seen as good game design element (Rigby and Ryan, 2011).

Use pain to facilitate intense experiences: In I Seek, the positive pain resulting from people pushing to their limits resulted in players entering a different bodily state: one of intense exhaustion. This is an example of how deliberately designing discomfort into an interaction can actually lead to a richer participant experience (Benford et al., 2012). As such, we suggest designers consider pain as a design resource to facilitate what we call intense experiences (Marshall and Benford, 2011).

Use management of pain as game mechanic: In JoD, the player has to constantly manage his/her exhaustion level in order to a) not overdo it, and b) know how much reserve is still needed to complete the jog. As in I Seek, the level of pain that a person is able to tolerate is an essential part of the game mechanic.

Use potential of pain as thrill facilitator: The Broncomatic shows how the potential for pain (falling off) can contribute to a thrilling experience, even if no real pain results (thanks to the inflatable mat). Another example of potential pain as thrill facilitator is rollercoasters that use 'head chopper' sections, where the ride appears to be heading for a bar at head height before veering off at the last second.

Be aware of undesirable negative pain: Large amounts of repetitive, low level exercise can lead to overuse injuries. This is common in running and swimming, but has also been seen in commercial exertion games (Sparks et al., 2011). When designing exertion games, care must be taken to consider the biomechanics of any repetitive actions, for example by using predictive models of fatigue effects (Hincapié-Ramos et al., 2014). Even in more extreme exertion games, where we are embracing the risk of negative pain, we should consider what the nature of that pain is. As seen above, pain is a form of feedback as to the quality of actions; thus we argue that pain should not be arbitrary and that players should be able to make an informed choice as to whether they engage in an activity with a risk of pain. For example, in downhill mountain biking it is considered good trail design to make sure that dangerous trail features such as jumps and drops are clearly visible before they are hit, and that alternative lines which bypass jumps exist, so riders can make informed choices about the risk involved in riding a feature (International Mountain Bicycling Association, 2007).

We can also consider providing protective gear in order to allow people to reduce unnecessary negative pain in extreme physical activities. Protective gear can even be used as a space for interactive designs such as the “Lumahelm” bike helmet, which shows a lit display which responds to the rider’s athletic performance (Walmink et al., 2014, 2013). There may be trade-offs involving protective gear, for example many skateboarders deliberately choose not to wear protective gear, seeing wearing protection as a sign of weakness which reduces the perceived extreme (and hence exciting) nature of the sport.

4.3 Design Strategy 3: Design for the Social Nature of Exertion

As Macvean and Robertson (2013) describe, even designers of single player exertion games should consider the social aspects. Exertion experiences are socially oriented in two ways. Firstly, many sports and games involve social structures that are ‘internal’ to the activity, such as competitive and collaborative team structures, and competition events. Secondly, the activity of exertion is itself very visible in comparison to traditional gaming, which means that consideration must be taken as to how the activity fits in within social structures external to the activity such as how it looks to spectators.

As JoD demonstrates, technology can alter the internal social nature of a sporting activity. As well as allowing non-collocated multiplayer running, it also allows very differently skilled participants to have a satisfying experience of running together which would not normally be possible. This is done by tracking effort level, rather than physical performance. One participant who was injured and could not run was even able to take part by cycling.

The social nature of an activity can inspire exertion - in Broncomatic, whilst only one player takes part at a time, players compete amongst each other to get a higher score, something which acts as a strong motivator to try hard to stay on. Riders will also shout and wave and generally make a performance of their riding of the bronco to friends and other onlookers. As JoD demonstrates, cooperation can also motivate people to exertion, people are inspired to run by a desire to enjoy running together, rather than by competing against each other.

As well as sociality that is directly to do with the game itself, exertion activities can also live within wider shared cultures. For example, CPS aims to situate itself within the social culture of skateboarding (Pijnappel and Mueller, 2013). This extreme sport’s culture is not purely about the activity of skating, it is also about the social acts happening around it, such as a social understanding of what clothing is appropriate and social gatherings within which skating occurs (Delamont and Petrone, 2010). The feedback after a trick aims to fit within the culture of skating at skateparks, where it is usual for skaters to take turns on a ramp, and give feedback to other skaters while they await their turn (Delamont and Petrone, 2010).

The bodily actions in exertion games can be exciting to those who are not involved in the game, for example the ride system used in Broncomatic and skateboarding in CPS are in themselves exciting spectator experiences. Broncomatic and CPS both use large displays that are designed to be visible to spectators; in the case of Broncomatic, this is primarily to create an exciting audience dynamic, with the score display visible to those watching the ride; while the bodily spectacle of the ride itself encourages people to try the ride themselves.

I Seek uses high visibility equipment including a fluorescent jacket and large headphones; these serve as a safety feature, making participants visible, but also make participants obvious to spectators, who are potential future participants. The fact that the audio is not audible to spectators offers an element of mystery; they see people sprinting to extreme speeds, but have no idea why. This exploits what Reeves et al. call a “suspenseful” interaction strategy (Reeves et al., 2005): interface manipulations are visible to spectators, but the result is not.

Bystanders can also alter the gameplay, for example in I Seek, participants reported that bystanders had a major effect on them – both physically, as they had to be negotiated without colliding, and socially, as people felt embarrassed or rude about running fast near other people. Similarly, because multiple people play at the same time, there was potential for players to get in the way of each other.

Many of the strategies below have been described in part in previous work, such as designing spectator experiences for bodily games by considering the ‘computer game as performance’ (Hamalainen et al., 2005) and the design of games where the rules are in part socially negotiated between participants (Márquez Segura et al., 2013; Wilson, 2011).

There are also various exertion gaming designs described in the HCI literature which are explicitly framed as social (Choi et al., 2014; Park et al., 2012; Payton et al., 2011). However, the “social” aspect of these games is primarily the fact that they are multiplayer, as opposed to the wider notion of social gaming that we describe here. The following sections describe tactics for the design of exertion games that take into account the inherently social nature of exertion gaming:

Use technology to reveal the nature of exertion to spectators: Exertion games lend themselves to becoming spectacles that draw audiences due to the bodily movements involved. Designers might consider what they reveal to spectators and what they hide. In an exertion game we have the virtual world of the game, and what Reeves (2005) calls the ‘interface manipulations’ or the bodily movements in the system that can both be appealing to watch. We may also wish to display other aspects relevant to the action, for example videos of players’ facial expressions and sweat on their foreheads as their bodies respond to the activity. Potentially, biometric data could also create interesting enhanced spectator experiences that reveal how hard people are exerting or how thrilled they are (see for example spectator interfaces for amusement rides (Schnädelbach et al., 2008)).

Engage social aspects in the design of exertion trajectories: In JoD, the length of time spent running and hence the exertion trajectory of the run is the result of a negotiation between the participants. Similarly, in many other sports other players also modulate the exertion trajectory. For example in basketball, bursts of very intense activity such as sprinting against opponents are interspersed with periods of lower intensity activity when not actively taking part in a play (Ben Abdelkrim et al., 2007). So the exertion trajectory is very much a social construct, influenced by the co-participants. Another example is competitive cycling: cyclists draft behind others and use this drafting as tactical element which becomes part of their social exertion trajectory (Fernandez-Garcia et al., 2000).

Design the spectator experience to attract participants: Spectators are an inevitable part of public experiences, and even exertion games played in private at home are likely to involve other family members watching (Voida and Greenberg, 2009). Assuming we wish that as many people play our games as possible, we may aim to design transitions between spectating and active participation (Sheridan et al., 2007). For example both I Seek and Broncomatic are deliberately designed to look and sound exciting in order to encourage spectators to play, similar to the way arcade game machines use bright and noisy “attract modes” to encourage people to play.

Interactive technology can also support audience members to quickly engage with existing play activities. For example, in the Xbox game Dance Central, players simply raise their hand to join an existing game. This is unlike in many traditional sports activities, where if one player arrives or leaves, the game needs to be reconfigured or simply ends.

Design for exertion around bystanders: If people are exerting themselves in public, in our experiences we should design interactions with the knowledge that these activities will most likely take place amongst bystanders. The presence of bystanders may be a positive thing, for example participants in I Seek found it thrilling to run through a crowded area, but this can also cause safety issues. I Seek deals with these safety issues by equipping participants with high visibility clothing and being designed to be ‘eyes free’ (Yi et al., 2012), so participants can see where they are running. The bicycle game Rider Spoke (Rowland et al., 2009) also used these techniques, with riders offered high visibility vests, and screen-based interaction only occurring while stopped and not riding. In some situations, designers might need to take a lot of care, for example commercial GPS ride tracking systems have been criticized for the way they encourage people to compete hard as if in a race whilst riding in public, and even been accused of culpability for the deaths of participants and bystanders (Velonews.com, 2013).

Consider parallel and interference play: We believe that exertion games can learn from sports about parallel and interference play. Parallel play is where players are acting physically independently. For example in a 100m race, participants exert to their best of their physical abilities, but they have no influence on the physical abilities of each other (besides through cognitive means). In contrast, in wrestling athletes physically interfering with each other is part of what “makes” wrestling. The actions of one athlete depend on the action of the other (Mueller et al., 2014; Vossen, 2004).

Frost points out the difference between parallel and interference play through the development phases of a child: first, a child engages in play independently, playing in parallel with other children. With more advanced development stages, the child begins to play with other children, sharing toys and interfering with as well as building on each other’s play (Frost et al., 2008). Currently, we observe that many exertion games only support parallel play, where players move their bodies independently of each other. We believe this is mostly due to the technology involved. For example, the Kinect uses vision tracking, which benefits from players standing apart, and similarly Sony Moves and Wiimotes are not focused on sensing body contact. Technologies used for pervasive exertion gaming such as GPS sensors also do not sense body contact well (see (Mueller et al., 2014) for a more detailed discussion of interference play in exertion gaming).

A few existing games do support bodily contact, for example Johann Sebastian Joust (Wilson, 2012) uses motion sensitive controllers held by each player, and players have to try and jostle each other’s controller, whilst keeping their controller steady. Interestingly, facilitating body contact does not necessarily even require technologies that can sense body contact: for example, the game B.U.T.T.O.N. demonstrates that managing body contact can be facilitated with traditional controllers, leaving the managing of body contact to the discretion of the players rather than to the computer (Wilson, 2011);

similarly the classic board game Twister (Foley and Rabens, 1966) instructs players where to place limbs, but does not control what bodily contact occurs.

Consider whether to balance social play: In multiplayer games, players can have different abilities and skills, which can hinder the emergence of an engaging experience (Mueller et al., 2012b). We identify that there are two main approaches to creating more balanced exertion experiences. Firstly, there are effort-based systems such as JoD. These measure effort that participants are putting in, such as measured by normalized heart rate. This to some extent removes fitness differences (although some participants will be able to jog further, so it is not perfect). This kind of balancing is rare in traditional sports. A number of sports such as amateur golf do use a second method of balancing known as handicapping, in which a fixed penalty is given to more able participants.

An alternative option to balancing is taken by the vast majority of both sports and computer games, which is not to balance at all. I Seek takes such a deliberately elitist approach and is designed to be hard: only 30% of participants were able to hear the full poem. The advantage of not balancing is that it gives people the potential to clearly see a progression in skills and fitness over time and allows for easy objective comparisons.

In multiplayer exertion gaming, if we do not balance, we have to rely on people choosing appropriate levels of competitors, often using structures outside the main game itself. In sports, this is often done using leagues, player rankings, age categories, or informal categories such as fast and slow groups during cycle rides. Exertion gaming can potentially also use player matching technology such as used in online multiplayer games, which aims to pit players of similar ability against each other.

One example of an innovative approach to balance social competition is seen in the cycling app Strava (2009). Strava measures times to ride a section of a track and allows riders to see where they rank on a leaderboard. Furthermore, it allows riders to filter the leaderboard so that they see people with similar types of bikes or of similar weight and age, in order to allow for comparisons with others similar to them, rather than the elite riders at the top of a leaderboard.

Consider asynchronous remote participation: As demonstrated by JoD, digital technology offers key opportunities for remote participation in a way that is not common in traditional sport. However, it may not always be possible to find remote players at the same time; because of this, for some exertion games, an asynchronous approach may be appropriate (Nunes et al., 2014; Sheridan and Mueller, 2010). Strava (2009) is again an example of this approach: it features the “king of the mountain” mechanism, where a rider is notified when someone beats her/his time, often encouraging people to go out and ride a segment again in order to regain their leaderboard position.

5. Conclusion

As boundaries between sports and gaming blur, exertion gaming as a concept becomes increasingly important. Whilst there are still a range of embodied experiences that are variously called games and sports, as sports embrace technology and digital games embrace exertion it is becoming harder to tell them apart. Essentially we argue that many sports are becoming exertion games and vice versa. Current designs often work from one viewpoint, for example taking sport and augmenting it with digital technology or taking interactive entertainment and adding exertion. By synthesizing these viewpoints using the strategies described in this article we believe designers may be able to better work with the nuances of both interactive technology and exertion and create better and more varied exertion games.

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