Reflections on Designing Networked Exertion Games

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ABSTRACT

Research in human-computer interaction has begun to acknowledge the benefits of physicality in the way people interact with computers. However, the role of physicality is often understood in terms of the characteristics of physical smart objects and their digital augmentation. We are stressing that the physicality lies within the interaction, not the object, and use a subset of bodily actions, exertion interactions, as an example to demonstrate our point. Emerging game designs have shown that supporting such exertion interactions can enable beneficial experiences between geographically distant participants. Based on several designs from our own work as well as others in this area we articulate reflections for the design of systems that support and facilitate bodily aspects of physicality in networked environments. We believe our work can serve as guidance for designers who are interested in creating future systems that support networked exertion interactions.

Keywords

Exertion Interface, physical, tangible, videoconferencing, sports, physically active, social interaction

Categories and Subject Descriptors

H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous**.**

1. INTRODUCTION

The role of physicality in interactive systems has increasingly gained attention due to a belief in a multitude of benefits to the interaction [32]. Before the first frameworks and theories emerged that aimed to describe physicality in hybrid and virtual interactions, designers had already created systems that made use of this physicality to allow for new kinds of interactions and enhance existing ones [12]. These systems often came from a tangible interface perspective and hence focused on the physicality of objects that were computationally augmented to provide easier access to a divide between the digital and physical world that we humans, in the modern world, simultaneously inhibit [13].

Theories such as embodied interaction [8] follow this approach by placing the body into the center of investigation and call for a more embodied approach to interaction. Humans interact using their bodies, and the result often includes a physical object, however, the physicality lies in the quality of the interaction, not the object. Although tangible interface work can be regarded as a form of embodied interaction [8], providing them as examples puts a focus on the physicality of the object, not on the interaction itself, which is, we believe, situated closer to the core of embodied interactions.

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2. EXERTION GAMES

Our work aims to highlight the physicality of interactions by drawing attention to exertion interactions and their benefits. Exertion interactions are at the extreme end of the range of intensities of physicality interactions our bodies offer. Exertion interactions require intense physical effort and are physically demanding [24]. They can be expected to be physically exhausting when used for an extended period of time; essentially they make the user tired and sweaty. However, they also have the opportunity to offer health benefits [33]. By highlighting exertion interactions, we want to draw attention to the physicality of interactions and create awareness of the benefits providing computer augmentation of such interactions can offer. In particular, we focus on exertion games in this work.

Similar to the field of tangible interactions, exertion interactions were firstly brought to light by the emergence of systems and prototypes created by designers that explored the space. Some of these systems aimed to demonstrate that mediating such exertion interactions computationally could support remote participants in ways not previously possible [24]. We scope our work by focusing on the opportunity networking advances can bring to exertion interactions: traditionally, participants engaged in joint exertion interactions had to be co-located to enjoy the associated benefits [10]. In contrast, we are promoting the use of networking technology so that participants can be located anywhere, while still enjoying the benefits of exertion interactions.

We consider such systems that support networked exertion interactions as within the tradition of a "phenomenological perspective on the interaction experience" [12]. They support an expressive-movement centeredness [12], and, we believe, they can offer valuable examples of how "meaning is created in the interaction" [35].

Research can support designers who want to make use of benefits offered by technology. However, designers who are new to the field of networked exertion interactions but have an interest in creating future systems are faced with a lack of guidance that could support their efforts. In order to promote the utilization of the opportunities and support the creation of future systems we are presenting reflections on designing networked exertion games that

are aimed to guide designers in their practice when creating networked exertion interactions.

3. OVERVIEW

We have outlined our motivation to highlight physicality in interactions and our choice of exertion interactions to stress this point. We described the benefits supporting such interactions can offer, especially in a networked environment. However, designers face a lack of guidance when they want to create systems that support networked exertion interactions. Next, we will describe related work that is aimed at providing an understanding of embodied interactions and offering guidance for designing bodily experiences. We then describe our work in relation to the gap we have identified. We also describe designers' work in supporting such exertion interactions by highlighting some system development. Then, we describe our approach that led to a set of reflections on the design of systems for networked exertion games. We aim to offer practical guidance by highlighting sample applications. We conclude by describing the limitations of our approach and give suggestions for future research.

4. RELATED WORK

Reflections on existing work, often articulated in the form of heuristics have been used to guide designers of interactive computer experiences successfully for many years. Most heuristics are concerned with Internet websites, possibly because of the maturity of this domain. Areas such as embodied interactions and social mediated interactions are still under early investigation in terms of frameworks [1, 2], and heuristics are therefore only recently emerging.

The aforementioned embodied interactions have been investigated by Dourish [8], who developed "foundations of embodied interactions". The examples he quotes are aimed to demonstrate a need for considering the body and social interactions when designing better interfaces, and are coming mostly from a tangible interface research agenda. The main promise of increasing the role of the body and supporting social interactions is also central to our approach, however, our primary concern are practical considerations rather than a "foundation".

Benford et al. [2] created a theoretical framework for sensing-based systems that could support movement-based interactions. The framework focuses on ubiquitous computing applications and provides categorization guidance by differentiating what aspects of a bodily interaction is "sensed" and what is "desired". Our reflections are less abstract and assume the existence of sensed interactions, but the framework could be used to extend our work for designers who want to consider interactions that sit outside this space.

Bellotti et al. [1] provided another framework for physical interaction, highlighting communicative aspects inspired by human-to-human interaction research. This consideration of social interactions has inspired many of our designs, and the support for mediated human-to-human interaction is explored later in this paper. The authors of the framework do not consider augmented physical interactions between humans though.

Larssen et al. [20] have investigated the applicability of the Benford and the Bellotti frameworks by testing them against two EyeToy games. This can aid designers in turning the framework into concrete guidelines, however, Larssen et al. did not come to a conclusion which framework is more suitable.

The "Design Experiences of Networked Exertion Games" [29] share many examples from this paper, and highlights remaining issues in the design of such games, which can inspire designers, but is not on the same practical level as the reflections in this paper.

In terms of networked systems that support exertion interactions, other researchers have designed systems with similar aims, and most were introduced from a sports game perspective. Exertion gaming activities have been merged with computing technology and the term Computer Supported Cooperative Sports [36] has been coined. Within the domain of CSCPlay, designers built networked computer games with a bodily interface such as hang-glider experiences [36].

Research work has previously used physical activity as input to promote and facilitate a healthy lifestyle through exercise, in particular to address weight issues often associated with more traditional sedentary computer work [22]. Consolvo et al. [4] has reported technology recommendations for supporting physical activity. Lin et al. [22] have described guidance when designing technology that is aimed at encouraging users to increase their energy expenditure.

However, users have self-reported "outgrown" experiences with Dance Dance Revolution and other activity-based gaming devices: these games supported their intentions to lose weight, but got "boring" once a certain level of fitness was achieved [19], indicating that although these "exergames" can serve as useful starting points, there is a need for further design advances in this area to support users.

5. APPROACH

We have drawn our insights from experiences designing systems that support networked exertion interactions over several years and reflections on their characteristic features for the purpose of this paper. We also examined other designers' work and included them in our investigations.

6. HIGHLIGHTED APPLICATIONS

In order to aid designers in understanding the practical implications of our work, we have included sample applications. We chose these examples based on our -admittedly biased - belief that they highlight the reflections in an interesting or salient way and hope that these highlights can contribute to a designer's understanding of our reflections.

6.1 Table Tennis for Three

Table Tennis for Three [26, 27] evolved from design lessons learned from previous systems and hence includes features linked to a number of reflections, and we will refer back to it repeatedly.

With Table Tennis for Three, we were interested in the experience beyond the two location-support most other exertion games offered, and therefore designed this game to be playable by three players, in three locations. The gameplay is as follows: each player has a table tennis paddle and a ball and steps up to the table. The table is set up so that the ball can be hit against the vertically positioned opposite half of the table. This setup is familiar to table tennis players who practice on their own by playing the ball against the board. The vertical part of the table is painted white to also serve as projection surface for a videoconference of the other two players. Projected on top of the videoconference are eight semi-transparent bricks shared between the players that players have to hit with their ball before another player hits it. Each hit target scores one point, and once all blocks are cleared, the player with the most points wins the game. The bricks "break" when hit by the ball as a result of the sensors registering the location of the impact. All three players see the same brick layout and the same brick status layered on top of the videoconferencing streams. If a brick is hit once, it cracks a little. If it is hit again (regardless of by which player), it cracks more. The crack appears on all three stations. If hit three times, the brick "breaks" and is removed from play, revealing more of the underlying videoconference: the player "broke" through to the remote player. However, only the player that hits the brick the third and final time receives the point.

6.2 Breakout for Two

Breakout for Two is a networked game in which two players, facing a large-scale videoconference projected onto a wall, have a ball each [24]. The goal is to hit virtual targets overlaid on top of the videoconference with the ball before the remote player does.

6.3 Airhockey over a Distance

Airhockey over a Distance [25] is a networked airhockey table that is split in half: a videoconference attached at the half-way line extends the table to a separate location. The player shoots the puck towards the videoconference across the table where it disappears in a small slot between the video screen and the table, but gets shot out at the remote end via rotating puck cannons.

6.4 Dogfight

Dogfight utilizes pedaling and steering efforts as known from bike-riding to control a computer game [9]. The faster the participant pedals, the faster the plane in the game flies.

6.5 Push'n'Pull

Push'N'Pull [28] is a networked exercise machine, which the players use as interface for a cooperative game played on a screen in front of them that also includes a videoconference.

6.6 Tug-of-War

Tug-of-War exists in a networked version, in which sturdy mechanics transmit the pulling power to a motor. At the New York Hall of Science two teams of high-school students were involved in a tug-of-war 13 miles apart from each other, pulling on a rope that seemed to extend through the network [23].

7. LIMITATIONS

We are aware that our reflections rely solely on systems that support networked exertion interactions in a game context, hence our work is biased towards game design. However, we do not solely consider competitive games, but have included examples that support cooperative games.

8. REFLECTIONS

In the following section, we describe our reflections for the design of networked exertion interactions. We acknowledge that not every reflection will find a space in an application due to various limitations, often of technical nature, however, our aim is to present all reflections we identified so far that, we believe, should allow designers to make informed decisions when designing their own systems.

8.1 Utilize an exertion interface to elicit emotions and engage users

Traditional collocated exertion that is believed to facilitate social interactions, such as soccer, football etc., often requires a physically demanding full-body interaction as part of the activity. Exertion is often intertwined with body coordination, reflex and, notably, skill. The definition of "exertion interface" states that it "is an interface that deliberately requires intense physical effort. [It] can be expected to be physically exhausting when used for an extended period of time." It requires skill, which "might take a short time to pick up, but a long time to master" [24].

We believe the exertion interactions as known from traditional physical sport play an important part in facilitating an engaging social experience between the participants involved in the activity. By displaying not only cognitive, but also bodily skills to their partners, players expose and open themselves up in a different fashion than they would in non-exertion interactions. An experiment has shown that an exertion interaction can facilitate a sense of connectedness better between geographically distant participants in a mediated environment than an interaction that does not feature an exertion interface [24].

Furthermore, we believe the bodily interactions can facilitate an emotional engagement with the game, because an emotion begins as the perception of the bodily change, and moving around in an exertion task that increases heart rate and produces sweat due to the intense physical activity can probably facilitate this perception [21].

Damasio [6] describes that in order to prepare a player for an upcoming exertion interaction, the brain triggers a wave of changes in our physical viscera, such as quickening the pulse and releasing adrenaline. Once the game has started, these effects are exaggerated, because the muscles need oxygenated blood [21]. Supporting this constant interaction or loop between brain and body is believed to create a more emotionally engaging experience [21]. Exertion behaviors are also considered to loosen cultural display rules [16]. We believe this decreased impact of social influences can also positively affect the bonding between the participants.

One could argue that moving game pieces on a tabletop game also requires physical skill. In order to differentiate our approach, we would like to draw attention to two points: a) the definition of an exertion interface demands *intense* physical effort and b) the exertion exhibited by the player should be clearly associated with the player's physical skills. We base the second point on work by Vossen [34] who describes the difference between moving chess pieces and hitting a tennis ball by explaining that both players could be instructed over the telephone how to perform their particular move, however, in the chess example, the person on the remote end would be considered the player, in the tennis example, the local performer would be considered the player.

Application

Breakout for Two [24] showed how a distributed game that requires participants to hit virtual targets can still support excessive exertion. Interviews with players showed that they were very exhausted after the game, and very sweaty. A water cooler needed to be placed close-by to avoid over-hydration. We believe if instructed over a telephone, the participant kicking the ball would be considered the player, not the person on the phone, satisfying Vossen's [34] definition in terms of physical involvement.

8.2 Provide a shared experience, in which players would feel like they are "doing something together"

Nardi [30] describes "sharing an experience in a common space" as a way for people to come to feel connected with one another, "readying them for further communication". According to this research, designers can facilitate social bonding to occur by supporting these shared activities in their designs. Previous work on social jogging has emphasized the importance of a shared experience for enjoyment, rapport and motivation [31]. Similarly, the idea of team-building is grounded in the belief of personal bonding through shared experiences, in particular challenging experiences that are often more easily achieved when tackled together rather than alone [11].

The "common space" Nardi describes can be physical or virtual we believe, in our networked approach we realize the "shared experience" through a "shared activity", most often a networked gaming task. It can provide players with behaviors to do and a ritual to follow together with the other person. Nardi documents user accounts in which participants were "actuating a field of connection via a simulated shared physical space", allowing them to meet each other "*somewhere*" [30] (italics in original). Networked games can function as facilitators for a shared experience, which in turn can serve as catalyst for social interactions, as suggested by traditional leisure games.

We would like to point out, however, that the notion of doing "something together" does not exclude a competitive aspect of the game: competition also requires collaboration in terms of agreed rules and assumed conventions, and the competitive gameplay has advantages players value in a game [18].

Application
An application in which the notion of a shared experience is emphasized comprehensively is Airhockey over a Distance [25]. Unlike most other networked exertion games, the physical element that is shared via the exertion interaction is unique amongst the locations (at least for the players): the puck appears to travel "through" the network, and can only exist at one end at a time. This design choice was aimed at facilitating a sense of a shared experience: if the other player would leave the table, the game could not continue. Feedback from players showed that they valued the feeling of a "shared space", and considered the setup as "sharing a table" despite the geographical distance between the players [25].

The networked Tug-of-War highlights the use of a physical artifact that is augmented with a digital layer in order to facilitate a shared experience between participants. The rope appeared, at least for the participants, as one long object that goes "through" the network, however, the players contributed physicality to the interaction by throwing their entire body in to pull the rope.

In Table Tennis for Three, players aim to hit virtual targets projected onto the vertical half of the table. The easiest implementation would have been to simply count the number of hits, make each hit score a point, and the winner is the player with the most points. However, we aimed for including a sense of a "shared experience" by sharing the blocks across the network: if player A hits a block, the same block is clearly marked as being hit, visible also to player B and C. All players aim for the same blocks: they exist for all players alike and are unique in the virtual world. This game element aims to support a shared experience, in which players could get a feeling of breaking the blocks together, to get through to the "other side".

8.3 Utilize familiar artifacts to facilitate immediate engagement and social facilitation

Benford et al. states in their framework for sensing-based interaction that preexisting functionality is important [2]. Utilizing familiar artifacts can decrease the time needed to learn how to interact with an artifact and also make engagement immediate by supporting existing skills.

If a physical task is familiar, such as a gross-motor skill already learned by playing a traditional non-augmented sport, it can lead to increased performance: Social facilitation and social support theory suggests that the presence of others can lead to improved performance, but only if the users are involved in familiar physical tasks. If the users have to learn new skills, a negative effect can be expected [7].

Ishii et al. have previously used existing sporting equipment for an augmented experience in their early work on "computer supported collaborative play" and an "athletic-tangible interface" [14]. We draw on these approaches by recommending designers to use and support common equipment and their associated physical actions, which we believe can be advantageous: Users might be already familiar with the artifacts, possibly making adoption easy and engagement immediate. Artifacts such as balls have been successfully used for social leisure for many years across the world. The sheer usage of these artifacts might contribute to a social experience, either through the familiar handling or through their physicality or both.

Application
Physical game controllers such as used in Dogfight draw on pedaling as known from bike-riding to control a computer game. The user does not need to learn any new motor skills, hence the learning curve is very low. Previous experiments with exercise bikes have shown that the presence of others can lead to increased pedaling performance [17].

In Table Tennis for Three, we opted for using conventional table tennis paddles, so users can utilize their existing table tennis skills and also apply their newly acquired skills and transfer them to collocated matches. Table tennis paddles have also undergone so many technological advances over the years that it can be assumed that it addresses many ergonomic, durability and feasibility issues. Choosing existing artifacts with such characteristics frees designers to concentrate on other aspects.

8.4 Support the concept of "offense and defense" to encourage shared experience and interaction

In order to provide a taxonomy for games, Vossen [34] borrows the concept of "offense and defense" during gameplay to differentiate games in which players interact with one another's activity, and activities that are performed independently and assessed by comparing the results at the end: a game includes the idea of "offense and defense" if a player can actively prevent the other player from achieving his/her goal. This concept is one out of three core elements that Vossen uses to categorize games, and it can play a significant role in competitive, physical games. For example, a 100m track and field event, although clearly physically demanding, does not provide an opportunity for the concept of "offense and defense" due to it prohibiting participants to physically interfere with one another through marked lines that cannot be crossed, according to initially agreed rules. In contrast, football has an element of "offense and defense" because players physically interfere with one another in the fight for the ball. Many traditional physical leisure activities can be described in terms of "offence and defense" and we believe it contributes to their success in particular in terms of social support; hence we recommend designers should consider leveraging this aspect in their distributed environments.

Application
In Table Tennis for Three, the concept of a "shared experience" and "offense and defense" goes hand-in-hand. The blocks are shared across the stations to support a "shared experience". These targets, or blocks, "break" when hit by the players. They have three stages of breaking - one hit breaks them a little, two hits

break them more, but only the third hit breaks them completely and scores one point.

The blocks are synchronized across the three tables, so the other players see the same block layout and the same block states. If a block is hit once, it cracks a little. If it is hit again (regardless by which player), it cracks more. If hit three times, it breaks and disappears, revealing the underlying videoconferencing completely: the player has broken through to the remote players. However, only the player who hits the block the third and final time makes it disappear and receives the point. This adds an element of strategy to the game: a player can try to snatch away points by hitting blocks that have already been hit twice by the other player.

This was implemented to allow for the notion of tactics and strategy to support the concept of "offense and defense". Players can either act defensively by waiting for a block to be hit twice and then targeting that one, or play more offensively by quickly hitting the same block three times. It should be noted that controlling the ball simultaneously does not make either approach an easy task, so the player has to balance his/her skills within the selected offense or defense approach. This can also entail adjusting the strategy based on the other players' skills and the score.

8.5 Consider supporting a Flow state carefully

It is believed that allowing players to enter a "Flow" [5] state in games is beneficial [3]. The state of being "in the zone", in which the participants are focused on the activity at hand, is often associated with a joyful experience [3]. This flow state is defined as the optimal zone between the player's abilities and challenges she/he faces during the activity [5]. Sport activities in particular are considered to be supportive for flow experiences [15], hence a networked physical game that offers a sport-like activity, it appears, should leverage this potential.

However, flow is also described as total focus, blending out everything else around, which includes the other players, and is hence possibly counterproductive to our goal of facilitating social interactions [7]. Flow should therefore be treated at this stage with caution. More research is needed to inform our understanding of flow in this context.

Application

Our approach towards supporting a Flow experience is as follows: we believe by offering a shared multiplayer experience in Table Tennis for Three, in contrast to a single-user game, the players themselves have a high chance of putting each other into their respective optimal ability/challenge zone. Furthermore, their game partners are also involved in adjusting any parameters to keep the required ability/challenge balance. Traditional sports competitions might illustrate this approach: championships often produce results that outsiders (and sometimes even the players) would not have considered achievable based on the individual's skills; however, the other player(s) might have pushed her/him to achieve what was not possible alone. In Table Tennis for Three, players can push one another by being able to communicate at any time. This is facilitated by the fact that the participants can assess their partners' actions through the videoconference and consider their current relative gaming status by examining the score to re-determine the effort required to win the game. The addition of the third player can increase the opportunity of finding a challenging situation in the game, because each player can decide at any time to "at least beat player A", or "at least beat one player" or "beat both".

8.6 Support a communication channel to allow for social interaction

Nardi [30] has pointed out the role of informal conversation for people to create the feeling of connection. We believe an exertion interaction can support this approach by initiating, supporting and facilitating rapport-building communication, especially in combination with a shared activity that the participants can talk about, providing a common topic all players can relate to. In order to enable such bonding interactions, participants need to be able to communicate with one another across the distance. We would recommend the inclusion of a video stream to allow for the display of visual signals such as body language, particularly in combination with exertion interactions. A combination with an audio channel could support conversation and reflection on the shared experience.

In order to capture the other persons' movements and display it accordingly, adequate vision capture technology is required that can span a large area, and displays should be nearing real-size for physical immediacy. The videoconference functionality should always be "on" to offer communication opportunities independent from a particular game. As demonstrated in the distributed airhockey game, designers can expect the display of nonverbal behaviors during and outside actual gameplay, similar to collocated activities, such as the rising of hands as a triumph gesture or the drooping of the head in case of defeat as a form of expressivity, which should be perceivable on the remote end.

Application

An example where the communication channel received particular attention is Push'N'Pull [36]. Push'N'Pull is a networked exercise machine, which the players use as interface for a cooperative game. Different to most other systems in this area, it featured a very high quality videoconference, in contrast to the traditional pixilated webcam-style video streams. Some of the salient findings when observing users were the uses of facial expression between the participants that were not only expressive, but also often synchronized and appeared to visualize the participants' exertion behavior, underlining the importance a thoroughly designed communication feature can bring to the interaction.

In Table Tennis for Three, the use of informal conversation is supported by the addition of two videoconference streams to the remote ends, capturing some of the participants' actions by use of a wide-angle lens. This video feed can also support awareness of general activities on the remote end, for example the exchange of advice between games and for discussions around rules. The videoconference is always on to support serendipitous games. The position of the camera and the position of the table in the room allows for bystanders to watch the game as well as be seen on the remote end, facilitating an audience involvement.

9. FUTURE WORK

We have presented reflections on networked exertion interactions based on experiments with existing systems. These heuristics have their origin in concepts that are most likely interconnected, but it is the role of future research to investigate these links and identify dependencies.

As described previously, the prevalence of existing systems that are situated in a game context can mean that the applicability of these reflections is limited to gaming systems. Future research is

needed to address the feasibility of the reflections in non-gaming contexts.

The presented reflections are aimed to support designers who are new to the field to provide initial guidance. Upcoming work will investigate if designers find these reflections useful and if they are concrete enough to guide them, while at the same time abstract enough to inform a wide range of designs.

10. CONCLUSION

We have outlined our approach of considering physicality by focusing on the interaction of the body, in contrast to other approaches that emphasize the digital augmentation of physical objects to support a physical/virtual hybrid interaction. We have proposed to consider the physicality in the interaction, and used a subset of bodily actions, exertion interactions, as an example to demonstrate our point. Designs have emerged that utilize this approach, and their aim to support well-being suggest that there are benefits in supporting and facilitating such interactions, in particular if they are computationally augmented with networking advances to offer similar benefits known from collocated sports to geographically distant participants. However, designers have only limited guidance in designing such systems so far. We have reflected on several prototypes from our own work as well as others in this area in order to guide designers who are new to the field and are interested in developing future systems. Our work is limited by the current focus of existing systems on gaming applications, and future work is needed to investigate other application domains.

We believe our work is the first step in introducing designers to the topic of supporting exertion aspects of physicality in their designs and guiding them towards better designs, however, we are aware that only future designs developed with our reflections in mind will be able to demonstrate the quality of our work.

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