The Design Space of Body Games: Technological, Physical, and Social Design

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ABSTRACT
The past decade has seen an increased focus on body movement in computer games. We take a step further to look at *body games*: games in which the main source of enjoyment comes from bodily engagement. We argue that for these games, the physical and social settings become just as important design resources as the technology. Although all body games benefit from an integrated design approach, the social and physical setting become particularly useful as design resources when the technology has limited sensing capabilities. We develop our understanding of body games through a literature study and a concrete design experiment with designing multiplayer games for the BodyBug, a mobile device with limited sensing capabilities. Although the device was designed for free and natural movements, previous games fell short in realizing this design ideal. By designing the technology function together with its physical and social context, we were able to overcome some of the device limitations. One of the games was subsequently incorporated in its commercial release.

Author Keywords
Body Game; Exertion Game; Gesture; Movement; Design; Sensing; Game; Dance; Children; Play; Interactive Toy; BodyBug; Oriboo; Social Play.

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Design, Human Factors, Measurement.

INTRODUCTION
There exists a long tradition of games that tap into the players' social and movement experience as their main source of enjoyment. Such games predate the computer game, including many traditional children's games and games from the New Games movement [10]. Common for such games is that they encourage their players to move in strange, fun, and often almost silly ways.

Although the traditional computer game bears little resemblance to such games, the introduction of movement-based interaction has led to a renewed interest in the social and corporeal experience of play. Many researchers have argued that movement brings about a positive emotional and social response [5, 27, 16]. Developers have striven for an interaction model that is more direct and 'natural', e.g. the Kinect platform is marketed with slogans such as: "*You are the controller*", or "*Technology evaporates, letting the natural magic in all of us shine*" [22]. Paradoxically, to make technology "evaporate", movement-based games need elaborate technology solutions. Commercial games in this genre rely on powerful sensing mechanisms and complex calculations embedded in the game platform.

We see two problems with this approach. First, the technology is in many cases not ready for this responsibility. This happens even with high-tech platforms. To continue using the Kinect as our example, the renowned game developer Peter Molyneux has reported on appreciating the sense of freedom the platform is able to create while at the same time struggling with its technical limitations [36]. This problem is even more severe for platforms that do not use the traditional videogame setup with a stationary device and a TV screen. For mobile devices, the opportunities for precise sensing and visual feedback are severely reduced, since the small size of these devices constrains both hardware and software.

Second, striving for precise sensing also leads to the technology controlling the users' body. Below, we will review literature to show that too precise control may hamper enjoyment, as the social environment and corporeal experience lie at the core of the experience in body games.

We argue that many movement-based games are better seen as *body games*: games in which the body is brought to focus and becomes the main source of enjoyment. This may very well include both digital games with movement-based interaction, like exertion games, and non digital games and activities, such as games like 'Twister', or sports. Taking inspiration from traditional games, we propose to look at the physical and social setting of the game as important design resources complementing the technology.

Our goal is to develop a design approach where all three factors are considered in the design of the game in a systematic manner.

Similar ideas have been proposed for exertion games, as in Mueller *et al.*'s [33]. However, we want to emphasize the importance of the body over the exertion experience, which typically focuses more on the physical effort and precise performance.

To us, three questions surface as critical. The first concerns the physical design of the game, including the role of technology as a physical artefact. The second concerns the distribution of control over the game, between players and technology so that some functions remain stable whereas others can be subject to social agreement among the players. Finally, it is important to understand how an integrated design approach can serve to alleviate sensing limitations of a device.

BACKGROUND

Movement-based interaction in games has received increased attention both commercially and in research. We have witnessed successful commercial examples such as the exertion games developed for the Nintendo Wii, the Sony Eye-toy games, the Konami Dance Dance Revolution [23], and the Dance Central for Kinect [7]. Many of these games seem to share a premise of "*the more the user moves, the better*" - as can be seen in commercial campaigns of some of these exertion games [47].

All these games rely on a powerful sensing platform that supports the whole game. The manufacturers compete to deliver the latest, most precise, and most sophisticated movement recognition system. The technology used in these exertion games has rapidly developed from the early pressure reactive mat in Dance Dance Revolution and the web camera used in the Eyetoy, to the sophisticated infrared camera based Kinect [22], the Sony Playstation Move [37] or the Wii nunchuk accessory [47].

Commercial products have been subject to numerous studies, many of them leveraging the connection between movement and positive socio-emotional responses, such as increased arousal [16], energy level [17], social interaction [27, 16], and increased engagement [27, 5]. In parallel with the studies of commercial games, many researchers have also developed games for research purposes. A major research area has been health and exertion games [24, 13, 41, 32].

Isbister *et al*. [17] compared a range of Nintendo Wii games that require low, medium, or high intensity movements from the players, and showed that there is indeed a significant relationship between how much you move and the level of energy and engagement reported by the players. In terms of engagement, Bianchi-Berthouze *et al.* concluded that an increase in body movement resulted in an increase in the player's engagement level [5].

Bianchi-Berthouze *et al*. argued that the kind of engagement that increases with movement is related to Lazzaro's concept of 'easy fun', where intrigue and curiosity are at focus rather than winning, in contrast with 'hard fun' games (when challenge, strategy, and problem solving are at focus) [25]. They noticed that a strong focus on achievement was correlated with a decrease in body movements, and intervened with the emotional and social experience [5].

Many authors have also emphasized the co-located social aspects of motion-controlled games, highlighting how the physical performative aspects of these games help to create a playful social context [14, 46, 39].

Gestural excess

One concept that is particularly important for our approach is *gestural excess*. The term was coined by Bart Simon in his studies of exertion games with the Wii [42]. He observes that for many players, the fun lies in moving the body and performing funny or silly gestures in front of other players, quite independently of what can be sensed. The gestures performed by the users are excessive, compared to what can be recognized by the game software. For this to happen it is important that the sensing technology is not too precise and leaves some room for improvisation.

In the Wii games that Simon studied, the game design does not reward the gestural excess. In fact, challenge focused players may short cut and perform small movements by flicking a wrist, rather than large expressive movements. By contrast, the research prototype game 'Wriggle' [16] was designed to stimulate corporeal emotions and social play, rather than to achieve precise scoring. The designers found higher emotional arousal when the game allowed for free movement.

Co-Located Social Games

The other aspect of body games that we wish to highlight is that they are also predominantly *co-located social* games. As pinpointed by Voida and Greenberg [46], a major motivation for group console gaming is the social interaction that affords co-located play. De Kort [8] argues that multiplayer games are as much about social interaction as about interaction with the software. Everything, from spatial organization, to co-players, audience, and the game content, shape the player experience. Ravaja [38] argues that social play leads to similar effects as physical play, such as higher engagement, arousal, and positive emotions.

Jakobs *et al*. argue that co-location is not the only element that explains how the social context affects the gameplay experience and performance [19]. De Kort [8] has analyzed this further, highlighting the socially secluded character of traditional computer games, result of the social affordances of the game interface and the spatial characteristics of the player's physical environment. In essence, most co-located digital gaming takes place in playing, seating, and viewing arrangements that hinder mechanisms such as mutual eye contact, natural reciprocation of approach or avoidance cues and mirroring, or emotionally relevant communication signals.

Technology-Supported Body Games

As discussed in the introduction, body games have a long-standing tradition that predates computer technology. Many interactive body games retain something of this non-technological nature, and are for this reason *technology-supported* [48] rather than fully implemented computer games. In this section we will focus on games that either use physical space as a design resource, or games that have deliberately incomplete or open-ended implementations.

Designing space around technology

One category of games that use physical space as a design resource are those designed to be played in a physical space with certain properties. For example, the game 'Weather Gods and Fruit Kids' [20] was is played in a gym hall and uses multiple means of feedback, including both staged sound and light sources. The game was based on Wii technology, but abandoned screen based interaction in favor of social interaction. When it comes to dance games, 'Yamove' [15] is a particularly interesting design experiment. It is based on a critique of the interaction patterns [11] that most commercial dance games use, which are very different from the interaction patterns that happen when dancing in a club. A particular effort was spent on taking players away from screen-based interaction. The spatial design of 'Yamove' is complex and includes the dance space itself as well as a distribution of roles among a mesh-up of people and devices. The game is played with mobile phones and can include a 'master of ceremony', a DJ, a dance model, players.

There also exist technology-sustained approaches to games and play spaces. A very elaborate example is presented in [40]. In this project, a wiimote device is connected to a multiwall virtual theatre and connected to multiple (rather than the normal singular) sensor bars, creating a landscape where the player can interact with the room in any direction and not just towards a single screen. The difference is that while 'Yamove' and 'Weather Gods and Fruit Kids' leave the control of the game setup to the players, the interactive theatre captures and reacts on how the players move in space, and can implement rules concerning spatial movement. Following Bianchi-Berthouze *et al.* [5], this is likely to be more appropriate for skill-based games than for social games, and may thus lead to less engagement in the social and corporeal experience of play.

Incomplete and open-ended rules

There have also been several direct attempts to create games or gaming platforms inspired by traditional body games. A common feature of these games is that the games are not fully implemented, leaving some of the instructions and rules for players to decide.

The explorations by Bekker *et al.* [2] are illuminating. The goal for them was to design games that had no overarching goals, in order to stimulate children to be creative in constructing their own goals, and stimulate social interaction in the form of rule negotiation. One example is the game device 'LEDtube' and its successor 'ColorFlare'[2]. Both of them are cylinders that emit light at each end and that react to movement by changing the color and behavior of the light. Bekker *et al*. tested the former in two different settings: with given rules, and in an open-ended play exploration, and saw that the children tended to prefer open-ended sessions. She also saw several examples of social negotiations concerning the creation of rules and goals, as well as whether the goals had been fulfilled.

Bekker's approach is related to Gaver's concept of self-effacing play [12]:

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

Bekker's work shows that children can – and do - create their own rules and goals. Bekker *et al*. also highlighted that it is not only the functionalities and interactional behavior of the device but also its *shape* that influences the play activity and the invented games.

It is also possible to provide complete rules for a game, but leave some of them out of the implementation. The art game 'B.U.T.T.O.N' (Brutally Unfair Tactics Totally O.K. Now) [49] is a particularly interesting example of this. This game has one single game goal: players compete for being the first player to press a button on a controller according to some rules shown on a screen. 'B.U.T.T.O.N' does not in any way sense if people actually follow those rules - that is entirely left to social control between the players. Drawing upon DeKoven [9], Wilson points out that rules are "*made for the convenience of those who are playing. What is fair at one time or in one game may be inhibiting later on*" [49]. In leaving some of the rules over to social negotiation, games like 'B.U.T.T.O.N.' are focused on being fun to play, rather than important to win.

While 'ColorFlare' is an open play device leaving the game to be defined by its players, 'B.U.T.T.O.N' is a fully defined but *broken* game. By constraining the players to rules that cannot be controlled, it deliberately encourages them to cheat to one another and the game platform. The name itself illustrates this, and this together with the playful artwork of the game design creates a festive context for the play activity in which, essentially, anything goes.

TAKING PHYSICAL AND SOCIAL DESIGN INTO ACCOUNT

From the discussion above, we can see that many design projects have relied not only on the technology, but also on a spatial layout or other physical properties of the setting, or have varied the level of social control that players exert over the game. We take one step further to explicitly include these as *design resources* for body games. Our goal is to develop a design approach in which all three factors, the technology, the physical properties, and the social setting, are systematically included in the design of body games.

We illustrate our approach with a concrete design exploration of the BodyBug, a device with limited sensing capabilities. Our goal was to design multiplayer games for the device; a challenging goal given its limitations. The setting serves to illustrate the design possibilities of placing greater focus on physical and social factors in body game design.

UNDERSTANDING THE TECHNOLOGY

In any project dealing with a limited device, it is important to first understand the technology, its capabilities and limitations. The BodyBug, now commercially launched as Oriboo [34], is intended to be a tool for exploring movement and dance, devised by Jin Moen. She described it as "*an artefact that initiates and maintains bodily movements through its need to be fed with movement input*", and that would give "*the user the possibility to create and explore 3D movements within a personal interaction space, both individually and in groups*" [30]. The design focus was therefore put on the use of natural movements and the personal space.

Physically, the BodyBug is a sphere slightly larger than a tennis ball, made of hard plastic. The sphere is assembled on a plastic leash, along which the sphere can move by means of a built-in motor (see Figure 1). It takes input from a small touch screen on its 'back' side and built-in sensors (like a 3-axis accelerometer), and it presents the output in the form of sound, light (two 'eyes' composed of 6 LED each), and the touch screen. Finally, it can move along the leash (see more technical information in [29]).

The physical design of the BodyBug was already the result of a user-centered design process [30, 31]. The goals were to support mobility, ease of use, and openness for appropriation. For example, the leash can be held in different ways, each introducing different constraints to body movement. The output methods of sound, light, and the BodyBug's own movement on the leash were intended to support 'head up' interaction [43]: while playing with the BodyBug, players should be free to look at and interact with each other.

However, the technical limitations of the BodyBug were quite relevant, as we will discuss below. At the time when this project was carried out, the only movement sensor in

Figure 1. The BodyBug; front and back.

the device was a 3-axis accelerometer[1], and although its hardware included an antenna for wireless communication, it was not functional at the time. All implemented functionalities therefore targeted single users. The purpose of our project was to develop multiplayer games, since wireless communication was potentially going to be included in the next version of the platform.

First step: Analysis of the situation at hand

Our first goal was to understand how the already existing BodyBug games worked in practice. At the time, there was only one dance game implemented for the device, the game 'Dance It'. This is a single-player game in which the BodyBug instructs the player to perform movements from a repertoire of eight different movements[2]. The dancer/player is given a limited time for performing each of them, indicated by beep sounds. If the movement is done correctly, the player scores and the game continues; if the movement is done incorrectly (or the BodyBug fails to recognize it), the game ends and a result score is displayed on the BodyBug's screen.

The game 'Dance It' has been studied by Tholander and Johansson [44, 45]. They reported two major issues with its interaction model: Firstly, participants were found to keep their visual focus mostly directed at the BodyBug.

The use of visual cues for instructions and feedback made the players keep their eyes on the display, losing contact with the physical and social environment of the play activity. This 'artefact-focused' mode of interaction [44, 45] goes against the design ideals of the BodyBug (free and natural movements, space around the player, etc. [30]). Another issue with the game laid in the way the movement recognition interfered with the players' dance activity. In order for a movement to be registered as correct, it needed to be performed in a 'clean' way. Hence, the players felt forced to stay still and just move in a constraint way.

[1] The commercial BodyBug, the Oriboo, also includes a gyroscope.

[2] Tug up/down, sideways, forwards, spin, twist, jump [29].

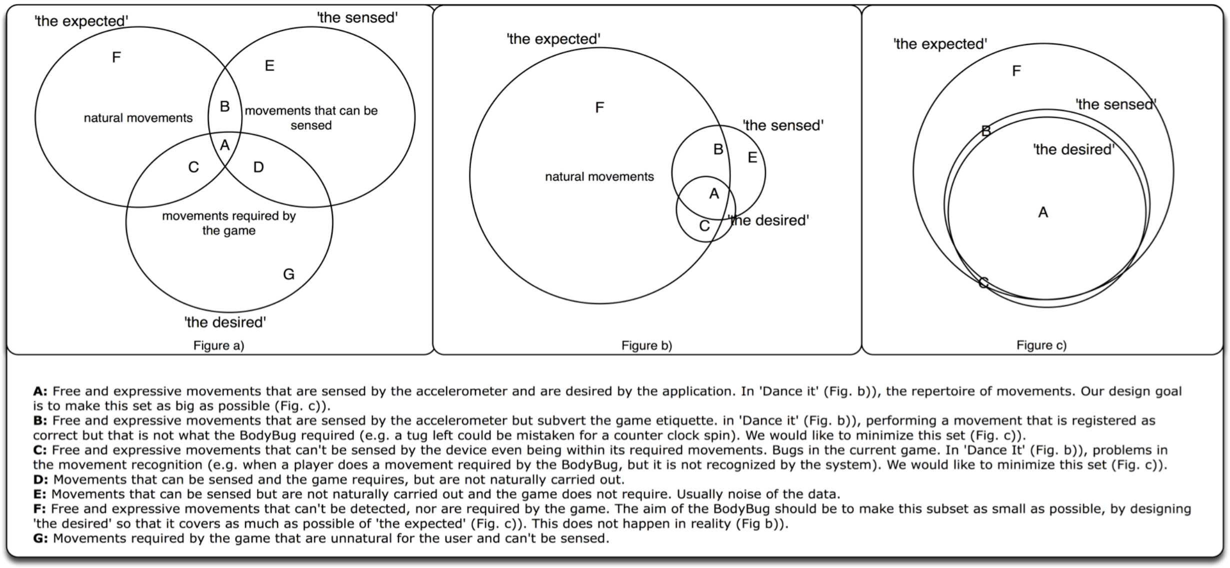

Figure 2: a) The expected, sensed and desired by Benford, b) applied to the game 'Dance It', and c) our design goal

Analyzing 'Dance It' from a movement perspective

Benford *et al*. [3] have developed an analytic model of user movement in relation to a moveable, physical or mobile system (Figure 2a). They distinguished between what is

i) '*expected'* (movements independent of any specific application, naturally performed by the users), ii) '*sensed'* (movements that can be measured by the system, due to the available sensing technologies), and iii) '*desired'* (movements required by a given application). These three categories do not necessarily overlap [28], leading to potential problems in the interaction.

As an interaction concept, the BodyBug aims to encourage the user's natural and free movements, i.e. 'the expected' [29] (see Figure 2). Hence, 'the desired' or the movements allowed by the game 'Dance It' should have been intended to circumscribe 'the expected'. However, the technical limitations of the device constrained the game design and in 'Dance It' only a set of several simple movements are allowed, i.e. within 'the desired'. Moreover, even those movements are not properly identified and classified by the BodyBug. This happens in cases in which those movements are not performed 'clean'. The 'Dance It' game also presents an ample opportunity for cheating (subset B in Figure 2) through performing a simpler movement than required that is registered as correct (e.g. a counter-clockwise spin, for instance, is easily mistaken for a 'tug up' movement [29]).

To summarise, it is both the interaction design of the 'Dance It' game and the computational capabilities of the BodyBug that makes 'Dance It' appear as a rather stale and private game, compared to other body games such as 'Twister' or 'B.U.T.T.O.N.'.

With our game designs, we aim to extend the movements that the BodyBug allows, i.e. 'the desired' so that to embrace as much as 'the expected' or the user's natural movements as possible (see Figure 2c). We also aim to avoid artefact-focused interaction as much as possible.

CORE DESIGN PRINCIPLES

Social Control

Our first decision was to design technology-supported rather than technology-sustained games [48]: Instead of implementing a game maintained and supported by the BodyBug in all its facets, from control over the outcome to feedback and monitoring of the rules, we aimed to design games in which the BodyBug was responsible for just a few of these tasks. By doing so, we expected both to expand 'the desired' beyond the limitations of the BodyBug capabilities ('the sensed'), and address the artefact-focused interaction issue.

It should be noted that the game 'Dance It' to some extent already affords this. When we let children try that game during our project, they would frequently take turns in using the device to see who could score the highest. In this usage of the game, children expanded the game from a single player to a multiplayer competitive game through the social agreement of maintaining a high-score list.

A question we deliberately left open was to what extent the games would be goal-oriented or self-effacing. As illustrated by the comparison between 'ColorFlare' and 'B.U.T.T.O.N', both approaches are possible and can lead to games that are open for appropriation and social control. In both cases, we wanted to design 'head up' games, and we would do so by designing roles maintained outside the technology. A related issue was if win conditions could be judged by players rather than the BodyBug, as this would help in extending 'the desired'.

Physical design

It became a goal of its own for us to not use any visual display. The goal was driven by a desire to move players' focus away from the tiny screen, avoiding the artefact-focused interaction from 'Dance It' [44, 45].

We hypothesized that this issue could be mitigated by a technology-supported approach to game design. If players were made responsible for maintaining parts of the game, the attention of players would at least need to shift between the players and the device. Also, our designs emphasized *social mirroring* [21] –when your actions are mirrored in what other players do. In this sense, our example games were still heavily dependent on visual information, but from what surrounds the player rather than from screens. For device output, we focused on the use of sound.

BODYSTORMING BODY GAMES

The first step in our process was to explore the design space provided by the physical features of the game setup and the affordances of the BodyBug. For this purpose, we selected to use bodystorming [35]. However, rather than just bodystorm ways of playing with the BodyBug, we designed a set of games (both goal-oriented and self-effacing) that utilized the social and physical setting as well as the device, and played them out with children in a workshop. The participants were instructed to play as if the device was functioning in a specific way, or to play a game with and without the BodyBug. Throughout the bodystorming workshop, the device itself was turned off.

The games we designed for this purpose were inspired by traditional body games for children (mainly outdoor games), as well as by 'Heads Up Games'[43] in our desire to keep the players' focus away from the device. In taking inspiration from children's games, the games became similar to games from the New Games movement [10], in that the rules were open for interpretation and negotiation within the group.

One example of the games we used was 'The Mirror'. The children were paired up facing each other. One was told to play as 'the leader' coming up with movements; the other one played as the 'follower', mimicking the former. This game was very open in that there was no real 'winning' condition and we did not tell the children what the BodyBug would measure. We played this game in multiple versions: with and without the BodyBug, music, and beeps for timing. Our aim was to understand how these elements helped in shaping the activity.

Another example game was 'The Bomb'. In this game, the players were placed in a big circle and were told to pass an imaginary bomb to each other. To pace the game, we used contextual beep sound; a beep that increased in frequency over time, ending in an explosion. In this game, each child was holding a BodyBug and was told that the device would eventually keep track of who was holding the bomb. The aim was to explore whether a sound cue would be enough to trigger the children's imagination and create, as suggested by [26], an immersive game experience. Part of the enjoyment of this game came from the use of contextual sound cues simulating a bomb about to explode.

The bodystorming workshop took place in a dance school and was carried out with 20 children aged 8 – 14. The age range reflects the target audience for the BodyBug. We included both games that focused on fun and playful activities reported to be enjoyed by children aged 8-12 [1], as well as games that opened up for personal performance and expression that the older were expected to enjoy [4].

Capturing data for analysis of physical aspects is a challenge. We used two cameras, and placed them in roughly 90 degrees angle from each other. Furthermore, we made good use of the fact that one wall had a big mirror: altogether, we created a recording where the events in the room could be seen from four directions. The videos were analyzed exhaustively to the level of physical description of the movements of singular players in relation to the physical planes in which they were performed, as well as in relation to the unfolding activity in the group.

Observations

We saw that some movements transcended the local space where they were performed. For example, in 'The Mirror' the children looked every now and then at other pairs and acknowledged their performance, sometimes mimicking particularly cool movements. Movements are contagious in much the same way as emotions are in social play [18].

Another important observation was the difference in proprioceptive skills between children in different age groups. We realized that the youngest children were unable to fully mirror each other's movements. For example, a movement of the shoulders up and down could be mimicked as a forwards/backwards movement by 'the follower'. This information became important in designing 'the desired' set of movement for our games. The observation made us discard game designs in which there was a fixed set of 'desired' movement to be measured by the BodyBug. (At the very least, we would not go beyond what was already present in 'Dance It'.)

Players would both collaborate and compete. There was a lot of cooperation in 'The Mirror' to cope with the fast-paced beats of the game. For example, 'the leader' would repeat sequences of movements, or the players would take turns in controlling the game. In 'The Bomb' we saw a child enjoying taking control over the game, playing strategically and holding 'the bomb' until the very end to make it explode on a girl. She revenged passing the bomb back to him, whom eventually tried passing it to someone else in the group. However, the whole group seemed to agree on 'punishing' him and passed the bomb back until eventually it exploded. This all brought excitement and enjoyment.

Regarding the use of the BodyBug, we could confirm that a core strength of the device is the way its physical design interacts with the users' body movements, in that it both constrains movement and encourages the user to explore movements that are slightly out of the ordinary. For instance, 'the leaders' in 'The Mirror' were seen to include new movements to their repertoire, and also extend their use of the surrounding space around them (their kinaesthetic sphere) when using the BodyBug, compared to when performing without the device. This in turn influenced 'the followers', who also incorporated those movements into their 'repertoire'. When taking over as 'leaders', they would often continue using them.

The BodyBug was also useful for the players in that it provided them with an excuse to perform 'embarrassing' movements, allowing them to not dance 'well' (this was a dance school after all), and to explore new movements. Finally, the device would trigger the players' imagination (they used it as if it was a bomb, and it also became a jumping rope or a lasso in 'The Mirror').

EXPLORING THE ROLE OF TECHNOLOGY

Next, we turned to the question of how to distribute the tasks/responsibilities within the games among players and technology. To get adequate feedback on this issue from participants, we needed to give them a good understanding of the function of the technology. Hence, in these tests we placed an increased focus on simulating what the technology would actually do.

Fullerton [11] highlights the usefulness of playtesting to test whether the player experience goals are achieved and to refine a model of the game before "*a single programmer, producer, or graphic artist is ever brought to the project*" [11]. In keeping with this, the games used in this test were designed to be *implementable* on the next version of the BodyBug (which would feature wireless communication). One of the games (that did not require wireless communication) was fully implemented. For the rest of the games we used a combination of implemented functions in the BodyBug, and Wizard of Oz techniques [6] to simulate the functionalities that relied on wireless communication.

Three game designs were put to test: 'Make My Sound', 'The Blind Mirror', and 'Join My Move'. From the bodystorming session, the mirroring element transcended and was reflected in different degrees in all three games. From 'The Bomb', we maintained the configuration of placing the players in a circle for most of the new games. The distribution of responsibilities between players and technology was however varied over the games.

The game 'Join My Move' is an extension of the game 'Dance It' into multiplayer mode. In this game, there is a 'leader' placed in front of the rest of the players who performs the movement that they should mimic. To conform to the capabilities of the device, we restricted the game to the movements that were already implemented in 'Dance It'. The main difference between this game and 'Dance It' is that it is the leader, rather than the device, who instruct the participants on which move to perform. Just as in 'Dance It', we gave the role of judging the movements to the BodyBug. This game was tested in a Wizard of Oz setup. The children were told that the BogyBugs were sensing their movements and would communicate who had done a mistake to a computer. The result was shown on the wall using a projector connected to the computer. In reality, the researcher controlled this functionality by controlling what was projected on the wall.

This was the only game that was not meant to extend 'the sensed': we deliberately kept the mistakes in the movement recognition, since we wished to understand how the multiplayer nature of the game would affect the players' reaction towards errors. We intentionally introduced mistakes in the simulated judgements, roughly corresponding to the BodyBug's accuracy in 'Dance It'.

In the game 'The Blind Mirror' we placed the participants in a circle. The BodyBug would mark slots of time during which each player would perform one movement. At the end of the round, the BodyBugs selects a 'leader' from the group, whose movement had to be remembered and mimicked by the rest of the players as fast and accurately as possible. The 'leader' decides who wins. This game requires very limited functionality in the BodyBug, in that it only paces the game and selects the leader. Still, selecting the leader would require wireless communication and was therefore simulated in our experiment. Since the BodyBug does not evaluate the movements, the game manages to expand 'the desired' to overlap entirely with 'the expected'. The only restriction the children have in terms of performance lies in the duration of their movements. The goal for playtesting this game was to see how accepting the children would be towards having another player, rather than the device, judging the outcome of a game.

Finally, we tested one fully implemented game 'Make My Sound'. This was the most playful and self-effacing design. The BodyBug would play one of a repertoire of three music loops, depending on the movement quality of the player. To create a game challenge, the players were placed in a circle and told to try to generate the same music as a randomly selected 'leader'. The BodyBug distinguished between slow, fast, and jerky movements, and adapted its music feedback to reflect these qualities (e.g. slow music for slow movements). In contrast to 'Dance It', this game does not restrict the players' movements to a limited repertoire, but is able to provide feedback on anything within 'the expected'. The role of the BodyBug is that of giving feedback on the movement qualities. This feedback is not a judgement of success or failure, but open for interpretation.

The three game designs were playtested in a workshop at the same dance school. In total we had 13 participants, all of them had previously participated in our bodystorming session. In order to compare 'Join My Move' to 'Dance It', we also playtested the latter. Just as in the bodystorming session, we used a two-angle videotaping setup. However, as this playtest was less focused on the physical aspects of the games we only did a coarse analysis of the videos. To evaluate our games, we asked the participants to fill in a questionnaire with prepared questions concerning their preferences and their focus of attention during play. We also conducted a post-game interview.

Evaluation

From the evaluation it was clear that the new games were able to overcome two limitations of the previous game 'Dance It'. First, our games did not cause artefact-focussed interaction. As the new game designs placed part of the responsibility of the game outside the device, the children's attention was directed towards what surrounded them. The difference was clearly visible in the video recordings, as well as reflected in the questionnaire. We explicitly asked the participants to describe where they placed their focus. For 'Join My Move', the two most frequent top choices were 'My own movements' and 'Things and people around me'. By contrast, the two top responses for 'Dance It' were 'The Bodybug's display' and 'the Bodybug'. In a similar manner, we asked the children what resources they used to attune themselves to the leader in 'Make My Sound'. We received answers like: "*I listened to the music", "I looked at the others", "I just shacked it!*", all of them indicating that the focus of attention was on sound and on movements of others rather than on the device.

Secondly, the sensing limitations of the BodyBug that had previously constrained the game design were addressed in two ways: through reinventing the sensor mapping of player movements to movement qualities ('Make My Sound') rather on accuracy of performance, and also through designing games which did not rely on sensor data at all ('The blind mirror'). The video analysis showed that both games afforded a big and varied palette of movements.

The evaluation also brought important insights into the desired distribution of roles between technology and the social setting. Two of our games were goal-oriented: 'Join My Move' and 'The Blind Mirror'. By contrast, 'Make My Sound' was more playful. All three games brought fun and enjoyment; however, the game 'The Blind Mirror' was rated as the least fun of the three. The difference lied in the role attributed to the BodyBug, which ranged from just pacing the game in 'The Blind Mirror', to providing feedback in 'Make My Sound', and to 'judging' the movements in 'Join My Move'. The children (specially the youngest) preferred to be judged by the BodyBug (as in 'Join My Move') rather than by another participant (as in 'The Blind Mirror'). This happened even though they understood that the BodyBug made more mistakes than the 'leader' in the judgment. By contrast, the open feedback in 'Make My Sound' allowed the players to negotiate socially if the game was to be seen as a competition at all.

LESSONS LEARNED

In this section, we would like to highlight three main lessons learned from our design experiment.

The role of technology

The distribution of responsibilities between players and technology is not completely arbitrary. In particular, the requirements are different if we design for goal-oriented or self-effacing play. As discussed above, our participants (in particular the youngest children) preferred that the BodyBug would judge the success of the game, even if it made more mistakes in this judgment than a human referee would make. The most likely explanation is that when a win condition was at stake, the children opted for a judge outside the social and affective bounds of the group. For the more self-effacing game 'Make My Sound', the stakes were lower and the children were happy with social control over any 'win' conditions.

The problem with implementing win conditions in technology is that players may focus their play activity towards a more goal-oriented behavior, which in turn has been shown to limit the social and body engagement [5]. However, the experience from B.U.T.T.O.N. and our playtests show that by making the technology *less* precise, or 'broken' in Wilson's terminology, the game can still leave plenty of space for gestural excess and social negotiation.

Sensed, Expected and Desired

In our analysis of the designed games, we made extensive use of Benford's framework for analyzing our sensor-based application. The approach proved useful in framing the limitations of our technology, our design goals, and the possibilities for design.

In particular, we set our goal to extend 'the desired' to cover as much as possible of 'the expected' (See Fig 2, c)). We did so by extending 'the sensed' *socially* instead of technologically. For example the game 'The Blind Mirror', allowed 'the leader' to assess the movements in a way that would be impossible for the technology to do. The framework was also useful in order to evaluate our game designs in comparison with former games, by comparing to what extent 'the desired' overlapped with 'the expected'.

Bodystorming versus Playtesting

It is worth commenting on the convenience of combining bodystorming with more realistic playtesting. Bodystorming proved useful for exploring the design space of physical affordances, space, and movements, and is also very easy to set up. However, to thoroughly understand the results of the bodystorming session we needed a careful setup of video recording tools and a fine-grained analysis of the recordings. By contrast, playtesting proved to be a very useful method to explore how players would organize themselves socially around an implemented functionality. Playtesting required more implementation (or simulation) than bodystorming, but it was easier to analyze. While we employed the same configuration of video cameras in the playtest session, the analysis of social negotiation required less detailed video analysis and relied to a larger extent on post-game interviews and a questionnaire.

CONCLUSIONS

By introducing the concept of body games, we have shifted the focus from movement as an interaction method with a computer game, to the social and corporeal experience of the players in a game. When designing such games, the social and physical setting of the game become as important design resources, as the technology that supports the game.

Since the technology is responsible only for some of the tasks related to the gameplay in these games, designing the role of technology becomes a central design issue. The path towards making body games fun and engaging is not necessarily that of making sensors and feedback systems more and more advanced. In our work, we identified two design approaches that both allow players to appropriate the technology and the games. The first (well illustrated by the game 'Make My Sound') is to use the technology for qualitative feedback, leaving it open for players to decide if the function is used as a win condition or in a self-effacing, playful exploration. The second (well illustrated by the game B.U.T.T.O.N.) is to include win conditions in the technology but deliberately limit the technology's ability to recognize whether the rules were followed or not. From a technology perspective, such games may appear as 'broken', but from a social and corporeal perspective they leave room for playful exploration and social negotiation in quite the same way as self-effacing designs do.

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