

Designing Bodily Engaging Games

– Learning From Sports

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ABSTRACT

This paper presents a novel approach for designing bodily engaging games based on fundamental skills and gaming characteristics specific to interactive sports. The concept of kinesthetic empathy interaction is used to articulate the space of interaction where the motivation for action is developed in collaboration between the participants. General open skills of interactive sports are distilled into design parameters, and three gaming characteristics are derived. Together, these contribute to the theoretical foundation for the design of new games that encourage the use of both cognitive and physical abilities. The approach is based on two experimental design cases, and illustrates how the developed design parameters are a determining factor in the physical design or digital qualities embedded in the product.

Author Keywords

Kinesthetic empathy interaction, game, sports, design, theory, kinesthetic interaction.

ACM Classification Keywords

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

General Terms

Design, theory.

INTRODUCTION

Within the interaction design community, there has been a growing interest in designing interactions where the body is a contributing factor not only in the interaction, but also in framing the user experience [e.g. 6, 10, 11]. In kinesthetic empathy interaction (KEI) [5, 12], emphasis is on the human-to-human interaction and co-creation of a shared kinesthetic experience. It describes the interaction of multiple co-located users negotiating a shared goal for the interaction. In interaction based on KEI, the actions of the individual are not solely based on his or her own decisions

but are instead dependent on which actions the other participants choose to engage in. Through the process of recognizing kinesthetically what is sensed visually, auditory or tactilely and by including the kinesthetic empathic aspect in the interaction, the collective interaction space is emphasized as a forum where decisions made by one participant continually depend on the actions of others. It affords a shared kinesthetic consciousness that is associated with, but not necessarily present within, social and Collective Interaction [9].

When studying movement, sport is an obvious choice of domain since movement and kinesthetic development are paramount here. As shown in the next section, others have drawn inspiration from sport when designing interactive games, and the benefits include, among others, engagement through the game design, physical exercise, competition, entertainment and socialization. However, most of the examples are either a direct translation of the sport or very close to this. In this article, it is suggested that there is an unexplored potential not only from being inspired by sport, but more importantly from drawing on the underlying gaming characteristics and skills specific to interactive sports.

In Vossen's (2004) classification of games [16], a distinction is made between physical and non-physical, competitive and non-competitive and interactive and non-interactive games. Both within sports and gaming theory, the term "interactive" is used to refer to games or sports involving participants who serve as obstacles to be overcome by the opponents while trying to reach a defined goal. The concept involves aspects of offence and defence. When the term "interactive" is used in the context of sports, it should not be mistaken for games/sports involving computational technologies. Based on Vossen's work, the focus of this article is the design of physical, competitive and interactive games that are computationally enhanced. In interactive sports, e.g. basketball, the performance of the individual athlete is no longer solely dependent on his or her own skills but, more importantly, on how the opponent performs. In these types of sports, athletes make use of open skills. Open skills are motor skills performed in an unpredictable and ever-changing environment that dictates how and when the skills are performed. Closed skills, on

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the other hand, are performed in a predictable environment and tend to be self-paced, e.g. free throws in basketball. In interactive sports, knowing the right time to attack is crucial, and the ability to read and decode the opponent's possible movements is necessary for success. It is this combination of cognitive, perceptual and physical skills that is exploited in the pursuit of designing new bodily engaging games.

This paper begins with an outline of related work within interaction design that has drawn inspiration from sports including two or more participants. This is followed by a description of two design cases in which the design parameters and gaming characteristics are both employed and derived. This is followed by a review of the open skills anticipation, tactics and deception, and it is described how these skills can act as design parameters for new types of kinesthetic games that engage the participants mentally as well as physically. The gaming characteristics are then described, and it is illustrated how they can be transferred to the design of physically interactive games. Finally, it is demonstrated how they can be embedded into the physical structure of the equipment as well as the software operating it.

GAMES INSPIRED BY SPORTS

Sports are used in a wide variety of ways as an inspiration for new types of games. In these games, the motivation for movement and thus the potential for promoting a "fun" experience come from the game design and, in some cases, the physical design. What characterizes all these multi-player games is that they exploit main aspects of sports, competition and physical exercise in combination with varying emphasis on entertainment, socialization and exercise.

Platform games

In platform games such as Nintendo Wii [20], Xbox 360 Kinect [23] and PlayStation Move [21], the whole body is involved as an interaction tool which acts as a means for entertainment. In Nintendo Wii and PlayStation Move, controllers are needed whereas Xbox 360 Kinect detects bodily movement by infrared light. In these types of games, the players stand side by side while interacting with each other through a screen. Some games, for example Wii boxing, mimic the actual sport that they are inspired by, though in most cases there is very little resemblance to playing the actual game. For example, when playing virtual boxing, the players have no bodily feeling of being hit, and the kinesthetic relation to the opponent is minimal. The kinesthetic empathic element that is inherent in any interactive sports where two or more people are directly interacting with one another is missing because the players, instead of facing each other as in the real sport, are competing against one another by means of representative figures shown on a screen. When movements are translated in this fashion, the players are no longer able to feint the opponent or anticipate what the next move might be

because movements are abstracted into limited on-screen actions.

Physical fitness games and exergames

Both fitness games and exergames rely on technology that tracks body movements or reactions and uses them as input into a gaming environment that encourages exercise. An example of an exergame is Konami's DanceDance Revolution [18]. The game involves the players moving their feet to a set pattern while stepping in time to the general rhythm or beat of a song. The higher the level, the more challenging and physically exhausting the game is. In this type of game, the computer is directing the player's motions. The only influence the players have on how the game evolves is whether or not they hit the dance mat at the right time. The primary interaction is with the computer, and the challenges of deciding when and what to do are largely absent.

Makoto [19] is an example of interactive training equipment inspired by martial arts and is used to train reaction time. It consists of three pillars that constitute an interactive arena. Each pillar can light up at different heights, and players use a stick to hit the light which is activated by contact with a stick, a foot, a fist or whichever body part or tool is relevant to the athlete's particular sport. Though two or three players are able to play alongside each other, they have only little influence on each other's actions, and the objective of the game is mostly related to training speed and reaction. The game doesn't rely on tactical and anticipation skills as is the case in real martial arts.

Sportpong [22] is an interactive physical computer game that is a combination of soccer and the videogame Pong. The playing field is a projected floor surface where two or more players can fight in teams against each other. The players use their feet to kick the digital ball towards the goal at the opposite end of the field or to defend their own goal. The purpose of the game is to create playful enjoyment and to promote social interaction. Though capturing and retaining the interactive element from the real game, it is more or less a direct translation of an existing game.

Exertion interfaces – sports over a distance

Exertion interfaces [14] are physical games that are enhanced by computing technology and deliberately demand intense physical effort. They use video gaming technology to allow players located at different locations to compete against each other. According to the authors, these types of games are used to promote social interaction. In the exertion game 'Breakout for Two', which is inspired by soccer, the players hit a ball against a wall with a projected image of the opponent and a shared display overlaid. The objective is to hit virtual blocks projected on the screen. Whoever hits a block and causes it to break scores a point. Even though the players have visual contact with one another, it is not clear whether or not they are able to

anticipate movements made by the opponent. This is partly due to the construction of the game. In ‘Breakout for Two’, each player is provided with an input device whereas in the real game of soccer, the ball is shared and is what motivates the players in their interaction with each other.

Common to the platform games, fitness games, exergames and exertion interfaces reviewed is that they are all inspired by sports, but they fail to reproduce the kinesthetic emphatic relationship that exists between the players in interactive sports. What is proposed is to involve the mind and not just the body and to let the players negotiate their actions. This enables a different form of interaction where the participants are encouraged to relate kinesthetically to one another and not just to the computer when competing or collaborating toward defined goals.

BODILY ENGAGING GAMES

TacTower and BodyQuake are two examples of games that are designed based on the open skills, gaming characteristics and kinesthetic empathy [5] specific to interactive sports. These traits are all embedded into the games in terms of their physical structure and the digital qualities of the equipment. In the following sections, a description of both games is given. In the section Learning from Sports, it is illustrated how sports have impacted on the two designs. TacTower is an interactive training device aimed at kinesthetic development [6] within handball. The equipment has been tested with national level handball teams. The BodyQuake concept, on the other hand, is developed as a kinesthetic means [6] to engage users in an experience that is both bodily and mentally challenging. Currently, BodyQuake exists as a refined concept, and the prototype is under development.

TacTower

TacTower [12] consists of four towers, each made up of eight plastic balls stacked on top of each other. Each ball functions both as an interaction surface and as an RGB display. Twelve touch sensors are placed in four bands running down the sides of the towers. When a touch sensor placed at the top or bottom of a ball is hit, the light signal is



Figure 1. Two top handball players training with the interactive training equipment, TacTower.

sent up or down the tower. When a sensor on the middle part of a ball is hit, the light signal is sent horizontally in the direction of the hit onto another tower, depending on how hard the ball is hit. When the towers are placed on a line, a distributed display and interaction surface is formed, thus separating the two players and minimizing the amount of physical contact. The relative distance between the towers can be varied to ensure that the athletes are pushed physically and are able to train their capacity for endurance. This set-up calls for traditional sideways movement as seen in handball. Peripheral vision is trained due to the fact that the players not only have to focus on what the opponent is doing, but also on the digital movements displayed in the equipment. Different training games have been developed for TacTower, one being “Blocker”.

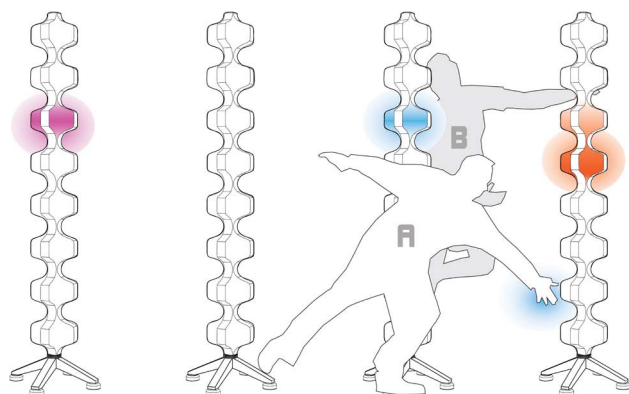


Figure 2. Illustrates the game “Blocker”. Player A is trying to prevent player B from getting the red light into the goal by placing blockers around the playing field.

In Blocker, one person has an offensive role while the opposing player acts as defence as in the real game of handball. The offensive player (B, see figure 2) controls the “ball” represented by the red light signal, and his objective is to get the ball into the purple goal zone. The opposing player (A, see figure 2) has two “blockers” (blue lights) that are used to defend the goal zone and corner his opponent. To place a blocker, the defensive player hits one of the sensors placed in the bands facing him. If the red light hits one of the blockers, the game is over, and the athletes change roles. Another example of a game is “Extinguish”, which is explained later in the article. Since the players are placed on opposite sides with the equipment between them, they are able to pay attention to the actions of the opponent, thus promoting bodily empathy through interaction. A space is created where the primary interaction is developed by the players and interaction with TacTower becomes secondary.

BodyQuake

BodyQuake is an interactive playground device designed to encourage movement through kinesthetic empathy interaction as in running, jumping and skipping. BodyQuake trains and develops gross motor skills and requires both balance and coordination.



Figure 3. BodyQuake.



Figure 4. Concept drawings of BodyQuake – illustrates where the hit and attack-zones are located.

BodyQuake consists of three so-called Quakers that the players stand on and use as tools in their interaction with the other players. Each Quaker consists of five green hit-zones and one orange attack-zone. In the handle, diodes are integrated to indicate scores, and a small motor is used to create force feedback. A game is chosen by touching one of the hit-zones with a foot. When a game is chosen, there is a ten-second delay before it starts. In this time period, the force feedback in the handle is used to indicate to the players that the game is about to start. During the game, a player scores points by striking the hit-zone of another player with his own attack-zone. A player can rotate the outer ring and tilt the Quaker to try to create a favourable situation where a strike is possible either from below or on top (see figure 4). When a strike is made, the hit-zone will light up for three seconds, and for that period of time, it can't be used for scoring. The person who is hit will feel a short vibration in the handle. In the game 'Hit', the objective is very simple: to strike the other players while avoiding being struck. To score a point, you have to strike another player's hit-zones with the attack-zone of your own

Quaker. For each point scored, one diode lights up, and the first to reach 10 wins the game. In this type of game, the players have to look for openings where they can strike an opponent while avoiding exposure of their own Quakers's "hit-zones". In the game 'Bomb', the objective is to pass a bomb, represented by lit hit-zones, to one of the other players before the bomb explodes. Whoever is left with the bomb when the time runs out has lost the game. The bomb is passed to another player by striking a hit-zone with the attack-zone. After a minute, the bomb will explode, and the player who is carrying it at this time loses. The computer randomly selects which player is to start out with the bomb. All hit-zones on the player Quaker that holds the bomb will light up, and after the 10-second delay, the game starts. In BodyQuake, the actions generated through the system are affected and determined by the other players. This promotes a mutual awareness between participants and encourages them to use their innate kinesthetic empathy to read and react to the bodily engagements of others.

LEARNING FROM SPORTS

As shown in the related work section, a lot of games, installations and fitness devices use sports as an inspiration for the creation of new games that are computationally enhanced. They use the positive aspects of sports such as socialization, physical exhaustion and competitiveness as well as the game construction itself. What this paper proposes is not only to use sports as a source of inspiration, but also to draw on the fundamentals of the game in terms of open skills and gaming characteristics, which are specific to interactive sports.

In this section, the three general open skills of interactive sports, anticipation, tactics and deception, are described and distilled into design parameters. These are all inherent and essential to interactive sports and were chosen because they are not sports specific, thus making them generalizable beyond any particular sport or game. Their nature as design parameters is exemplified by TacTower. An unravelling of three main gaming characteristics of interactive sports follows this example. They are exemplified by two design cases and one design example.

Open skills

Anticipation

Within the perceptual phase of motor learning, the athlete gathers information regarding the situation (the location of the ball, the opponent, etc.) and interprets this information. Knowing where and when to look is crucial to the athlete's chances of success, but the visual field is often filled with both relevant and irrelevant information. The athlete must be able to filter out useless information, direct his attention appropriately and extract meaning [13]. In the perceptual phase, anticipation is used to read the opponent and, to a certain degree, try to foresee what the next move might be. Based on this information, a decision is made about what to do next. This ability to 'read the play' is essential in interactive sports where the speed of the game means that

decisions must typically be made in advance of an opponent's action. This gives the athletes additional time to formulate and execute an appropriate response in order to counter the intentions of opponents [17]. Specific anticipation skills differ from sport to sport and range from very simple ones such as predicting the bounce of a ball to the more complex ability of reading the play sufficiently well to counteract, for example, a fast-paced ball hit by an opponent disguising his actions [4].

Tactics and deception

In interactive sports, decision-making is key. It is the ability to extract essential information from the playing environment, interpret it correctly and select the appropriate response under pressure of game play and time constraints [1]. Two fundamental and inherently linked skills of the decision-making process are tactics and deception. Tactics involve all voluntary operations executed by the players during the game in order to adapt to the immediate requirements of the ever-changing environment including the opponent, his spontaneous actions or those organized through the predetermined strategy. Tactics develop in the course of the game, thus altering the players' perception of information and affecting their considered moves according to the lessons they learn from the events of the game. The efficiency is determined by the player's capacity to decide and the speed of this decision-making. It is dependent upon the player's ability to conceive solutions [7]. According to Gréhaigne (1999), team sports embody different tactical notions: opposition to opponents, cooperation with partners, attack on the opposing camp, and defence of one's own camp. In team sports, all of these elements are present, but their complexity varies depending on the sport. For instance, in baseball the two teams take turns attacking and defending. In soccer, on the other hand, all four elements are present at all times. Tactics operate under strong time constraints. One difference between tactics in team sports and in combat sports is that in team sports, it is possible for a player to withdraw temporarily from the action, which means that the players have more time to attend to both strategic and tactical aspects of their game [7]. In combat sports, the players are competing one-on-one and are therefore constantly involved in the action. In this type of situation, the tactical element of surprise is of the utmost importance. Timing is an essential part of combat sports or of any situation in a team sport where a one-on-one combat situation emerges. Timing involves selecting the right moment to execute the movement when the opponent is least prepared or might not expect it [3]. The performance in interactive sports is determined by the most appropriate choice among the various solutions available to the players and by how fast these decisions are made [7].

Deceptive actions – such as feints – are cues that signal one action when another is actually intended. The aim of deception is to provide misleading information that ultimately will encourage opponents to make a wrong judgment [8]. Deception is especially prominent in any

sport where you have athletes competing in a one-on-one situation as in handball, soccer or wrestling. According to Jackson (2006), it is reasonable to assume that there is a clear conceptual link between anticipation and deception and that if expert athletes are good at anticipating the actions of others, the opponents will either try to disguise their actions by presenting deceptive actions or by minimising the availability or delaying the onset of movement information.

Design parameters exemplified

The open skills have been thoroughly explained, and in the next sections, it is exemplified how anticipation, tactics and deception impact on the design of games that aim at engaging the participant in a kinesthetic experience. Both TacTower and BodyQuake are examples of this. In the following section, TacTower is used to illustrate how the design parameters have not only affected the design, but also become essential skills needed to excel at the game.

In TacTower, the impact of anticipation, tactics and deception varies according to the game that is played on the towers. In the game 'Extinguish', the objective is to turn off the lit ball by hitting one of the sensors before the opponent does. The light will remain activated for ten seconds or until one of the players extinguishes it, and then it changes position. In this game, the players' peripheral vision is trained, and deceptive actions can help increase the players' chances of success. The players must continually scan the playing field for where the next light is going to appear. By feinting to one side, a player can trick the opponent into thinking that the light is in that direction when really it is at the other end of the playing field. Before the opponent realizes the mistake, the player utilizing the deceptive action will have a head start and most likely be the first to reach the light and score a point. However, in the game of 'Blocker' (described above), deceptive actions are secondary to tactics and anticipation. This is a tactical game where the players have to continually change their tactics according to the actions of the opponent. The players are also assigned roles where one is defending while the other is attacking. Though it is possible for both players to use anticipation and deception, it is natural for the player assigned the attacking role to make use of deceptive actions while the other player makes use of anticipatory skills to try to foresee the actions of the opponent. In this type of game, not only speed is required. It is also necessary to be able to anticipate the opponent's next move and then try to obstruct his actions while increasing one's own chances of success.

The TacTower design shows the benefits of designing games that are based on the fundamentals of sports. In these types of games, the players' actions are not formulated in advance or dictated by the computer, but are instead determined by the actions of opponents and possible teammates. The open skills are used as design parameters to encourage the design of games that engage the users both physically and mentally, thus creating a space where the

human-to-human interaction is primary and the interaction with the artefact, installation or space is secondary. From observations made during the testing of TacTower with handball players, it was evident that the game engaged the players. Within minutes, they were excited, sweating, shouting and cheering for each other. Victories were celebrated, and losses were followed by visible disappointment.

Gaming characteristics

Besides kinesthetic empathy interaction and the general open skills of interactive sports, the development of TacTower and BodyQuake are based on the gaming characteristics of interactive sports (non-computationally enhanced). In the design of new body games, the classification can help pinpoint the type of kinesthetic relationship attained in an existing design or the direction which a design could take. It is used to articulate the role of the participants and their kinesthetic relationship to the interactive artefact (computationally enhanced) through which they interact.

The gaming characteristics are inspired by Mueller *et al.* (2008) who propose a taxonomy of exertion games [15] inspired by non-computationally augmented sports and games where focus is on the user's perspective in regard to the social aspect of interaction. The taxonomy draws on Vossen's game classification [16] of non-interactive and interactive games, which Mueller *et al.* extend by distinguishing between object and combat sports within interactive sports. In object sports, the players try to control an object in direct competition with the opponent. Football (soccer) is an example of this whereas in combat sports, the players try to control each other. The taxonomy was developed to give a theoretical understanding of exertion games with focus on the social aspects of the interaction. Therefore, it does not differentiate between the kinesthetic empathic relations arising between the participants. As the kinesthetic empathic relationship is essential to these types of interaction games, a further distinction of combat sports is encouraged.

Regarding the bodily interaction in combat sports, there is a difference in the bodily relationship between participants in sports where grappling is allowed (e.g. *wrestling*) and sports where it is not (e.g. *taekwondo*). Grappling refers to techniques, manoeuvres, and counters used on an opponent in order to gain a physical advantage. The kinesthetic relations of the participants and their movability [6] differ from object sports to combat sports and again to combat sports where grappling is allowed. In object sports, the participants have freer roles, and although the teammates and opponents influence their actions, some players can always pull away from the fight and take on a more observational role. In a combat sport like *taekwondo*, this is not an option, as the intensity of the one-on-one interaction requires the participants to stay in the game. In this type of combat sport, deceptive actions are a key element to a

participant's success. Though it seems that there is little difference between combat with and without grappling, there is, however, a difference in the freedom of bodily movement that the participants experience. In combat sports where grappling is allowed, the participants can grip one another, causing their bodies to get locked together. Movements, subtle or rough, will be felt through the physical link that emerges between the two participants. Since the participants will not have visual contact at all times, they are forced to rely on body sensations.

Gaming characteristics exemplified

All three characteristics promote a mutual kinesthetic awareness between participants and encourage them to use their innate kinesthetic empathy to read and react to the bodily engagements of others, a core aspect of kinesthetic empathy interaction.



Figure 5. The gaming characteristics: object, combat and combat where grappling is allowed with corresponding design examples: TacTower, BodyQuake and Labyrinth.

The diagram in figure 5 illustrates three gaming characteristics: object, combat and grappling. Each category has a corresponding design example. The first two are designed based on KEI and are described in detail in the previous section. They are design examples in which I have both employed and developed the approach whereas the latter is an existing analogue example of a body game used to illustrate the gaming characteristics of combat sports where grappling is allowed. They highlight three different directions which a design can take. In the classification, the participants' level of bodily freedom changes. The participants go from manipulating an object (object sports) to manipulating each other without physical force (combat) and with physical force (grappling) through the interactive artefact. The gaming characteristics inspire three different ways in which kinesthetic empathy interaction can be achieved.

The TacTower prototype was developed based on the gaming principle of object sports in the sense that the participants are manipulating an object around a playing field defined by the physicality of the equipment. In this game, the object is a virtual ball instead of a physical one,

and the prototype encourages kinesthetic empathy interaction similar to that seen in traditional object sports. In this installation, the players are encouraged to rely on the bodily action of the opponent. The tactics change continually according to how the game evolves. In the game, it is possible for the players to gain advantage by trying to mislead the opponent or by anticipating the next move.

The BodyQuake game is a combat sports game. Even though the number of participants is three, their roles still resemble the roles in regular combat sports. Although the users manipulate an object (the Quaker they each stand on) in their interaction with one another, the equipment is experienced as an extension of the body in the same way as a foil in fencing. In this prototype, the players have to attack and defend at the same time. Much in the same way as in combat sports, the roles of the participants are defined by the restrictions of the playing field and, in this case, determined by the physical nature of the equipment. This strictly defined interaction space of Body Quake forces the users to be alert to what the others are doing at all times. They have to always seek openings and, at the right time, attack while simultaneously protecting themselves.

In Labyrinth [24], the participants have to collaborate and use shared force to tilt the equipment to make the marble move around the labyrinth. In this type of construction, the users manipulate each other through the equipment as is the case in any sport where grappling is allowed. In games where the participants compete against each other to obtain a shared goal, the participants will try to gain a physical advantage over the opponent. Any movement made is directly felt by the other person and has a direct bodily impact on him or her. The physical traits of the participants will either help or work against them, depending on who they are up against. This, of course, will only be a determining factor in situations where the participants compete against one another while in situations where the participants collaborate, physical traits such as weight, height and strength won't be as important to whether they succeed or not.

The gaming characteristics derived and employed impact on the kinesthetic relations of the users as well as on the physical construction of the game. They can be used to uncover otherwise unexplored design potential when starting a new design process or when working on an existing concept. The three gaming characteristics can help encourage the design of bodily games to go beyond using sports merely as an inspiration and instead use the kinesthetic attributes associated with interactive sports. They bring awareness to the kinesthetic roles of the users and how they are determined by the restrictions of the playing field and, in some cases, defined by the physical nature of the equipment. They are used to articulate the roles of the participants and their kinesthetic relationship to

the interactive artefact (computationally enhanced) through which they interact.

PHYSICAL AND DIGITAL CONSTRUCTION

When designing new games that are based on the gaming characteristics of interactive sports and make use of anticipation, deception and tactics, there are two ways in which these characteristics can be implemented. They can be incorporated into the physicality of the equipment and be woven into the digital qualities. When working with kinesthetic interaction where the whole body is used as input into the system, the physical character of the equipment is essential to whether or not the interaction will 'feel' right. For example, in BodyQuake, the Quaker that the users stand on becomes an extension of the body. It is crucial that users have the possibility to develop the necessary skills to gain complete control over the Quaker over time. An example of this is the way that roller-skates can become a natural extension of the user's body with practice [10]. If users are not able to gain control over the equipment, it will seem a hopeless task to act out preconceived tactics, to perform desired deceptive actions and to anticipate actions in the game. The equipment, installation or artefact must be constructed so that the interaction with the computer becomes secondary to the bodily experience developed in collaboration by the participants and mediated by the equipment. The choice of gaming characteristics will be a determining factor in the physical design of the object. In TacTower, the gaming characteristics of object sports have determined the physical design of the large interaction surface, the movability and free role of the participants. They also determine the way in which the installation is placed between the participants to ensure that they are visually linked which makes them "readable" and means they can react to each other's movement input. In Labyrinth, the participants are physically bound to each other through the physical construction of the game. Movements made by one participant are physically felt by the other participants. The nature of the physical design locks the users together as in sports where grappling is allowed.

In both the TacTower and BodyQuake prototypes, the digital construction constrains the structure of the games. Each game is constructed so that the players must apply different tactics and make use of some or all of the open skills to reach the objective. The digital games engage the players and motivate them by facilitating their competition with one another in a body game. Finally, the physical and digital constructions are merged in forming a game that engages the participants in an engaging bodily experience.

CONCLUDING REMARKS

The body plays a significant role when designing interaction. It is used as a tool, but can also be a contributing factor in framing user experiences that take into account both mind and body. This is done by creating a space of interaction where the primary interaction is

developed by the users and interaction with the equipment, installation or artefact becomes secondary. In this article, it is shown how to exploit sports when designing new games by drawing on the gaming characteristics along with the underlying perceptual and decision-making skills of interactive sports. BodyQuake and TacTower are used to illustrate the benefits of learning from sports when designing bodily engaging games. Through the interaction, the participants are encouraged to relate kinesthetically to one another and not just the computer when competing or collaborating with shared objective. In these types of games, the players' actions are not formulated in advance or dictated by the computer, but are instead determined by the actions of opponents and teammates. This promotes a mutual awareness between participants and encourages them to utilize their innate kinesthetic empathy to read and react to the bodily engagements of others. It is shown how the gaming characteristics and open skills can be incorporated into the physical and digital design. According to which game is played, the emphasis on anticipation, tactics and deception varies. Furthermore, it is demonstrated how the gaming characteristics can be a determining factor in the physicality of the design and crucial to whether or not the right 'feeling' is achieved in the interaction.

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