

Exploring Opponent Formats

Game Mechanics for Computer-Supported Physical Games

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Abstract. The recent growth in development and research in computer-supported physical games has sprouted a wide variety of games merging qualities from both computer games and sports. Despite the increasing interest in this type of games, exploration of their specific game mechanics and the understanding of how the opponent format and relationships impact a game are almost absent in current research. Thus, this paper aims to elucidate how the perception of a competition differs, depending on the opponent format, by presenting a game mechanic framework. The paper furthermore presents an interactive football-training platform, as well as games designed to explore the different opponent formats. The games are qualitatively evaluated to illuminate the qualities of and distinctions between different types of opponent formats, proposed by the framework terminology.

Keywords: Sports, framework, game mechanics, exergames, competition.

1 Introduction

Every year, hundreds of new traditional computer games are being developed by game developer companies and embraced by consumers. Many of these games rely on several similar features known from computer game theory, and a vast amount of conceptual frameworks have emerged, providing game developers with guidelines and advice on how to create new games (e.g. [1, 3]). Sports, on the other hand, evolve slowly and new types of sports seldom appear. However, recently there has been an evolution, where computer games and traditional sports seem to fuse, creating new opportunities for game development, producing commercial computer gaming products, such as Nintendo Wii and Microsoft Kinect. A parallel increase in interest, has emerged in research communities, resulting in development of new games, e.g. Air hockey over a distance [12] and TacTowers [9] among many others. In research, the idea of combining physical elements from sports with computer games, exists under various headings, from Mueller and colleagues' [10] definition of exertion interfaces, to exergames[16], kinaesthetic empathy interaction [5], interactive training equipment [9], everyday fitness applications [2] and Computer-Supported Collaborative Sport [22]. Despite the rise of computer-supported physical games, only few game mechanic frameworks have appeared, targeting the qualities added to

games by making them physical. As an example, Fogtmann [6] has explored and reflected upon the impact of the spatial setup of players competing through technology, as well as the players ability for kinaesthetic empathy within computer-supported physical games. Thus, when designing computer-supported physical games, it is important to be mindful about the way players physically compete and how it impacts a game. Often computer-supported games relies on sports as source of inspiration, however, when bringing elements of sports into a new context, it is important to rethink how players compete, relate and interact, and consider the impact it has on a game in order to utilise it in the creation of new games. This paper initiates the investigation of game mechanics for computer-supported physical games, by focusing on the aspect of opponent format and the impact it has on a game. We define opponent format as the rules, game elements and spatial setup that facilitates a competition between the participants of a game. Examining for example the opponent format of the 100-metre sprint, the high jump, football and curling, each of the games present different ways to be opponents, which ultimately affects the competition, e.g. whether competitors have the ability to encumber each other's actions, whether the competitors compete concurrently or subsequently and how competitors can physically and mentally pressure one another.

In this paper we explore the impact of the choice of opponent format, when designing computer-supported physical games, and in what manner it influences how players perceive the game and their opponents. We investigate existing classifications of sports and computer-supported physical games (Section 2), present and discuss an opponent format framework, based on two format distinctions: Encumbered versus unencumbered, and subsequent versus concurrent (Section 3). Furthermore, we present an interactive football-training platform and apply the framework in the development of three new computer-supported physical games with diverse opponent formats for the platform. We evaluate the games through a qualitative test and attempt to extract some general qualities within each of these three types of opponent formats (Section 4). We conclude by presenting initial findings on qualities inherent in different opponent formats and suggest how this can be utilised, when designing new exergames, interactive training equipment or even physical competitive games in general.

2 Analysing Existing Classifications of Sports and Computer-Supported Physical Games

Prior work, within sports science as well as HCI, has produced a number of frameworks and classifications, seeking to identify different types of games. The frameworks and classifications presented in this section do not build on an identical frame of reference, but form their distinctions on either the basis of competitions [4, 6, 13, 17], or a broader definition of games encompassing both competitive as well as non-competitive games [21]. Beyond the work presented here, classifications of games, dealing with sports, can be found within e.g. [14, 18].

Skultety's [17] classification of competitions builds upon four points, often used to outline a competitive event or 'format' within sports philosophy: "(1) *multiple participants engage in behaviours*, (2) *the quality of which is then assessed, compared and ranked* (3) *in accordance with rules* (4) *that do not determine the results ahead of time*" (p.440 [17]). Skultety adheres to these four competitive conditions, but criticises their neutrality as well as the absence of human agents. Considering the four points, Skultety adds additional distinctions, dividing competition into four competitive formats based on two distinctions: Vis-à-vis versus standardised, dealing with how the competition is judged; and encumbered versus unencumbered, concerning the manner in which the competitors interact.

Vossen's [21] classification of games is firmly grounded in Suits' [20] game definition, which considers play an attitude rather than an activity. Vossen's classification includes three distinctions: competitive versus non-competitive games, interactive versus non-interactive games, and physical versus non-physical games. According to Vossen the difference between competitive and non-competitive games is based on involvement of one or more opponents, pursuing the predefined goals of a game. Interactive and non-interactive games are distinguished by, "[...] *interactive games involve aspects of offence and defence, while non-interactive games do not*". Thus, all competitive games are also interactive and all non-interactive games are non-competitive in nature [21]. With regard to physical competitive games, Vossen, divides these into two: Physical non-interactive competitive games and physical interactive competitive games, or respectively parallel sports and interactive sports [21].

Focusing on computer-supported games that require physical activity of the user, also known as exertion games, Mueller and colleagues [13] present a taxonomy drawing extensively on Vossen's [21] classification. The taxonomy predominantly relies on the same categorisations and terminology as Vossen, but focuses solely on what in Vossen's terminology would be termed physically competitive games. Mueller and colleagues [13] add an additional distinction within interactive sports, dividing it into combat versus object games. Combat games are defined as games wherein the player tries to control the opponent, whereas in object games, the player attempts to control an object in direct competition with the opponent [13].

Fogtmann [4] further elaborates on the framework proposed by Mueller, through adding a third aspect to Mueller's combat and object categorisation, namely that of grappling. Grappling refers to techniques used in games, in order to gain a physical advantage over an opponent. In [6], Fogtmann further examines the competitive roles, through comparing different physical setups of interactive training equipment. Four different types of physical setup are described: Individual, side-by-side, 'in front remote' and 'in front collocated', distinguished by their different possibilities for kinaesthetic empathy interaction.

2.1 Opponent Format in the Classifications

The classifications proposed by Skultety [17], Vossen [21], Mueller [13] and Fogtmann [4, 6], all, to some degree, deal with the opponent format within physical

competitive games, however, the specific aim of these taxonomies and classifications is not to describe the opponent format. If we compare the 100-metre sprint and the high jump, then participants in the 100-metre sprint compete simultaneously along the track side-by-side. The physical setup enables the participants to read and decode their opponent's actions and push themselves harder, while they run, if their competitors are doing well. Contrary, in the high jump the competitors compete one after another, taking turn in getting over the highest bar, and if an opponent clears a height, it increases the pressure on the subsequent competitors. Despite their obvious differences in opponent format, both Skultety [17], Vossen [21] and Mueller [13] place these games within the same category. The importance of making a distinction between different opponent formats, is supported by Fogtman's [5, 6] notion of kinaesthetic empathy. Comparing the possibility for kinaesthetic empathy in the two games, then in the 100-metre sprint the participants compete simultaneously, enabling kinaesthetic relations, which allow them to decode and react directly and continuously upon their opponent actions, whereas the competitors in the high jump exclusively react upon the static result of the previous participants.

3 Towards an Opponent Format Framework

Building on the existing work by Skultety [17] and Vossen [21], we propose a framework classifying physical competitive games based upon the opponent format (a visual representation of the framework can be seen in figure 1). In order to capture and define the relationship of the opponents in a physical competitive game, we present two opposing distinctions; Encumbered versus unencumbered, dealing with the physicality of the competition; and subsequent versus concurrent, dealing with the temporality of the competition. In the following sections we, firstly, discuss the two distinctions and reflect upon them in relation to existing frameworks and classifications. Secondly, we present the opponent format framework, and describe each of the four opponent formats derived from the two-fold distinctions.

3.1 Encumbered versus Unencumbered

Both Skultety [17] and Vossen [21], touch upon the notion of opponent format, through classifying games based upon whether or not the opponents can hinder each others actions. Albeit, dealing with the same aspect of competitive games, they do not base the distinction upon the same criterions. Skultety makes a distinction between whether or not competitors can affect one another's behaviour, defining games as being either encumbered or unencumbered. Vossen on the other hand, draws the line between whether or not the game is interactive, defining interactive games as games with aspects of offence and defence, where game participants serve as obstacles to be overcome by opponents [21]. Examining the two classifications, then Vossen's distinction provides a clearer definition, however the distinction, in our opinion, holds two difficulties in relation to defining opponent format, as well as applying it within HCI. Firstly, the term 'interactive', as Mueller and colleagues [13] have pointed out,

hold a different connotation, in the realm of HCI, as opposed to sports science, thereby convoluting its meaning. Secondly, and more importantly, Vossen limits offensive and defensive moves to interactive games. Surveying for example running races, then although direct physical interaction is not allowed, the game is not devoid of tactics, strategy as well as offensive and defensive moves. The runners do not run individual races, but run simultaneously enabling them to hide behind a frontrunner, who is breaking the wind, or take the lead to push up the pace early in the race. The example shows that although the opponents do not go head to head in combat for the same objective and interact directly, it is not devoid of offensive and defensive strategies.

Based on the deliberations above, we have chosen to base our framework on Skultety's terms, dividing competitions with regard to whether or not the actions of a competitor are encumbered or unencumbered by their opponents. However, in choosing Skultety's terms we are aware of the vagueness of his definition and of the critique posed by Royce [15]. Skultety defines the distinction between encumbered or unencumbered, as "*...differences between not directly interfering with one another (unencumbered) and affecting one another's behaviour (encumbered)*" [15]. To which Royce [15] poses the question, "*when in sport is one's behaviour not affecting others?*"[15]. We agree with Royce, in his critique of Skultety's unclear definition, however, we still find the terms useful, as a way to classify different types of opponent formats within physical competitive games. We seek to clarify the distinction from Skultety, defining encumbered games as games, where players can directly interfere with each other's objective, by engaging in physical interaction or interacting with one or more shared objects, e.g. football, tennis or curling. On the other hand, unencumbered games are games, where physical contact is not allowed between the player and no objects are shared between them e.g. high jump, 100-meter sprint and synchronised swimming, where the only affect the participants have on each other is the pressure derived as a result of their performances.

3.2 Subsequent versus Concurrent

The temporal aspect of competitions is absent in the frameworks and classifications presented by both Vossen [21], Skultety [17] and Mueller and colleagues [13]. However, we believe that the temporality in a competition has a significant impact on the opponent format and how the competition is perceived, i.e. the participants' actions and their perception of a competition differs if participants compete concurrently in contrast to competing subsequently. Thus, we introduce a new distinction between concurrent and subsequent games. We define concurrent games as games, where participants compete at the same time, e.g. football, tennis and 100-meter sprint. It is our claim that a concurrent games intensifies participants' relations to one another, creating a more direct competitive atmosphere between them. In relation to Fogtmann's [6], concurrent games enable participants to utilise their innate kinaesthetic empathy to read and react upon their opponents actions. We define

subsequent games, as games, where participants take turns competing, e.g. curling, the high jump and synchronised swimming. In subsequent games, the competitors compete against a static pre-determined goal, generally decided by previous opponents' performances, whereas the goal in concurrent games changes continuously during the game, allowing the competitors to adjust their performance accordingly. For example, in curling the field is static when a player is about to make a play, whereas in tennis a player is aware of the opponent's concurrent actions and position, which affects how the ball is played.

3.3 Four Types of Opponent Formats

In the following section each of the four opponent formats is in turn described, and exemplified through familiar sport disciplines as well as computer-supported physical games. The illustration below visualises the interactions of the opponents in each of the four types of opponent format categories.

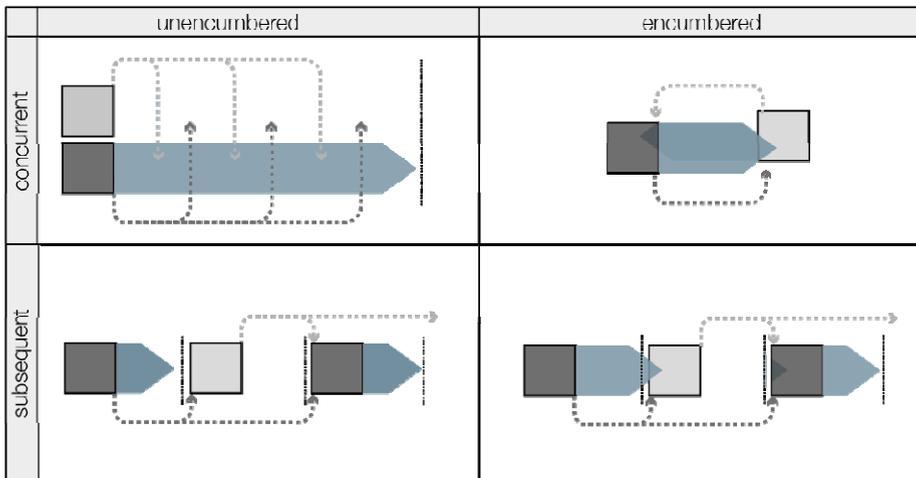


Fig. 1. Opponent format framework, showing how opponents, either individually or as a team (squares), can physically interfere (broad arrows), directly or through objects, as well as how mental pressure (dotted arrows) affects the performance of the opponent.

Concurrent unencumbered (top left): We define concurrent unencumbered games as games wherein the participants compete simultaneously, while not directly physically interfering with the objective of their opponents. This category includes sports such as 100-metre sprint, rowing and cycling races, as well as computer-supported physical games such as Dance Dance Revolution [23], Kinect Adventures Reflex Ridge 2 player game [24] and Jaw [7] developed by Kiili and Merilampi.

Subsequent unencumbered (bottom left): Subsequent unencumbered games, hold that participants take turns competing, thereby having no contact with their opponent and the only affect the participants' actions have on each other is the pressure derived as a result of their performances. Sports such as the high jump, bowling, golf and dressage are examples of this category, alongside examples of computer-supported physical games, such as Hanging of a bar [11] and Sports wall [26].

Concurrent encumbered (top right): We define concurrent encumbered games, as games where the participants compete simultaneously, in a manner where they can directly interfere with each other's objective, allowing them to engage in physical interaction or to interact with one or more shared objects. Examples of concurrent encumbered games can be found within sports such as: tennis, handball, basketball or karate, as well as computer-supported physical games such as Shootball [19], TacTowers [6], BodyQuake [4] or Airhockey over a distance [12].

Subsequent encumbered (bottom right): In subsequent encumbered games participants compete through turn taking, however opposed to subsequent unencumbered games, the competitors can interfere with their opponent's objective through one or more shared objects. This includes sports like curling and boules, and computer-supported physical games like 'Follow My Leader' on the Digiwall platform [8].

4 Opponent Format Experiments Based on a Computer-Based Football Training Platform

The opponent format framework presents a way to analyse and classify different types of game mechanics. However, in order to make the framework a constructive design tool, rather than solely an analytical one, it is important begin to uncover the inherent qualities of the different opponent formats. As a basis for beginning to uncover the inherent qualities of different opponent formats and their influence on user experience, we have designed and tested three games for an interactive football installation, called Football Lab. In the following subsections, we describe the Football Lab installation, the three games used in the user experiment, describe the user experiment setup and reflect upon the result from it.

4.1 Football Lab Installation

The computer-based game platform, we used for the experiment, is called Football-lab. It is a 12*12 m square artificial grass football field with 4 rebound surfaces (M-stations [25]) (see fig 2.). The rebound surfaces are wired with piezo sensors enabling measurement of where balls hit the surface.

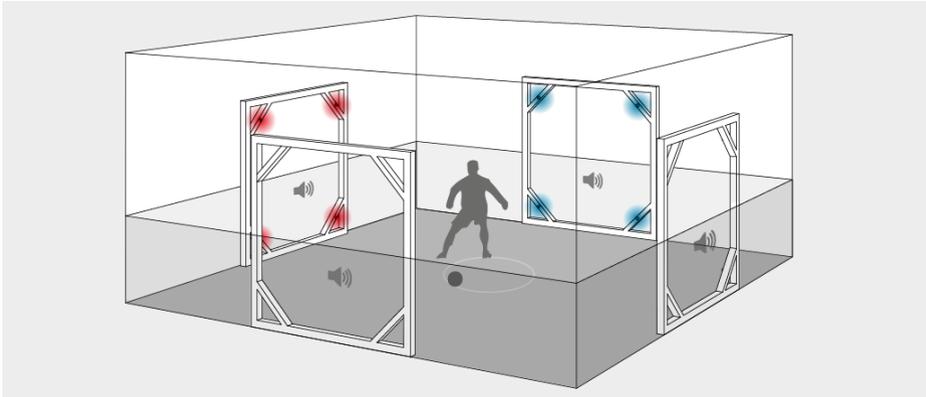


Fig. 2. Football Lab game space

Light and sound signals controlled by the games, guide the players to which rebound surface they are supposed to hit. The sounds played are recorded voices saying, “Play me!”, “I’m free!”, “Here!”, similar to football lingo for co-players calling for the ball.

The facility has been running 24/7/365 since June 2011 as part of a large football training ground in Herning, Denmark.

Users have played more than 20.000 games (an average of 1000 per month) on the facility according to the log files, thus the existing games are considered a success.

4.2 Games Illuminating a Variety of Opponent Formats

In order to compare the qualities of different types of opponent formats, we designed three games, covering three of the four quadrants presented in the framework. The games are intended to be as similar as possible, only distinguished in terms of interaction between and presence of opponents. Below we describe each of the three games in turn. The fourth category, subsequent encumbered games, is not included in the study, as the platform does not hold natural options for creating such a game.

Pass-and-Turn: One player, one ball. One minute in the Football Lab trying to hit as many targets as possible. To keep a high level of transparency, one target hit results in one point. Players competing in this game will try subsequently to get the highest score. Thus, opponents are not able to interfere or intervene directly in the performance of opposing players. The only influence opponents have on the game is the pressure put upon a player from the current highest score. Thus, Pass-and-Turn is defined as a subsequent, unencumbered game.

Dual Mode: Two players, two balls. Same game as Pass-and-Turn but two players are playing concurrently on the same field. LED-lights flash in different colours indicating which M-station should be hit by which player. In other words, each player

has her own ball and target and is as such independent from the opponent. However, the concurrent situation allows for some interference between the players. The pressure from the opponent is more obvious in this game than it is the case in Pass-and-Turn. The sound of the opponent hitting targets in a quick pace or seeing the scoreboard showing her supremacy will possibly stress the player. Thus, Dual Mode is defined as a concurrent, unencumbered game.

One vs. One: Two players, one ball. Same game as Dual Mode with one ball removed. As a result, players will not only stress each other but will also have to interfere with each other in order to control the ball, and thereby gain the ability to score. Thus, One vs. One is defined as a concurrent, encumbered game.

4.3 Experimental Setting and Game Test Process

The experiment was conducted at the football club, where the Football Lab is installed. The study was conducted with 12 participants, aged 11-15, which were recruited from two different youth teams, and more than half of them had prior experience with Football Lab, as the Pass-and-Turn game has been part of the installation since 2011. The 12 participants were divided into three groups, where each group was introduced to one game at a time, whereupon each participant played the game three times. After all participants had had their three attempts, an overall winner of the specific game was announced. The order in which the three games were played was altered for the three groups. In Pass-and-Turn the participants took turns competing, whereas they in both Dual Mode and One vs. One played one game against each participant in the group. After a group had played the three different games, a 15-minute semi-structured interview was conducted, focusing on the qualities of the different types of competition. It is relevant to note that group members not competing were spectators, and the entire experiment was videotaped.



Fig. 3. The three games, left: Pass-and-Turn, middle: Dual Mode, right: One vs. One

4.4 Results from Test of the Experimental Games

Findings from the experiment were centred on three different topics: Perception of competition, pressure during a game and spectator excitement. The three topics point to different qualities of the opponent formats exhibited in the games.

The majority of the participants perceived One vs. One as more competitive, as well as giving a stronger impression of winning, than the other two games. The participants stated that, *“it’s like there is more competition in it”*, and, *“you were against someone, where you can show that ‘okay, I won’”*. As a group of players went from playing One vs. One to Dual Mode a player said, *“Come on, Jens. Now we are not against each other anymore”*, indicating that perception of the competition changed. Considering the perception of the opponent, in Dual Mode the participants generally stated the objective as conquering the opponent, whereas in Pass-and-Turn, the objective was conquering the high score. This difference was emphasised in comments, remarking that in Dual Mode: *“It’s like you have someone you can beat”*, and, *“there you also compete against someone”*, whereas in Pass-and-Turn one participant even remarked that *“there was no opponent”*, indicating a focus on beating the score rather than the opponents.

Surveying the pressure, the participants felt from their opponent, it is noteworthy that One vs. One displayed the highest degree of physical intensity, shown by the players frequently yelled at themselves and their opponents, threw themselves on the ground in attempt to score a final goal as well as from fatigue after a match. However, despite the more intense and direct competition, the majority of the participants did not consider it the game, where the pressure from the opponent was greatest. Instead they pointed to Dual Mode, due to the uncertainty of the opponent’s score as well as the continuous peripheral auditory feedback from the opponent’s game progress. One of the participants described it as: *“in the duels (One vs. One) you knew where you had the opponent most of the time and you noticed when he scored and you knew reasonably well what the score was, but in Dual Mode, you could just hear when your opponent kept scoring, which forced you to make harder passes”*. In Pass-and-Turn participants remarked that time was the main source of pressure, however, the high score also provided a source of pressure, especially if one of the opponents made a significantly higher score, appearing impossible to beat. As one of the participants remarked, *“if one gets a high score, then you think that he has probably won”*, despite there being games left to play. The participants also exhibited different degrees of dedication to the three games. Some indicated that they tended to give up early in Pass-and-Turn games if they made a significant mistake. They stated both the lack of impact on the opponent’s actions, as well as a bad start to a game, as reasons for giving up, *“it was important to get a good start, otherwise it could all fail, and then you lose faith in it”*. Others argued that they quickly gave up in One vs. One, if the opponent had a significant lead, because the tactical element made it possible for the opponent to protect the ball and make a comeback an immense mission. However, in Dual Mode the players kept competing because, as the players said, *“they (the others) could still make mistakes”* and *“you feel that you can still come back”*.

In addition to the perception of competition and pressure between opponents, the reactions of the spectators revealed differences between the opponent formats. In the Pass- and-Turn games, the spectators typically were quiet throughout the game, until the last ten seconds, where they started yelling the score and counting down the clock, increasing the intensity of the game. However, the yelling only appeared when a player was close to the high score, which indicates the difficulty in evaluating, how a

player is performing during a game. A player recognised this issue and stated that the game would be ‘better’ if intermediate milestones were announced during a game, which potentially could create intensity peaks, increasing excitement for players and spectators. Furthermore, in Pass-and-Turn player and spectators knew the score to beat in advance, whereas in Dual Mode and One vs. One the score to beat depended entirely on the concurrent opponent’s performance. This dynamic objective seems to influence the perception of the level of direct competition for players as well as spectators, indicated by observations where spectators of Pass-and-Turn shouted the number of targets hit, whereas in the other games they shouted the relative score.

5 Conclusion

We have argued that there is a need for systematic development of game mechanics for computer supported physical games. In this paper we have taken steps towards the development of guidelines and theories for such game mechanics by exploring the variety of opponent formats and illustrated how the variations in opponent formats can impact game development. The main contribution of this paper is the proposal of a framework for design of computer-supported physical games, which seeks to unfold different opponent formats, derived from the two distinctions: Encumbered versus unencumbered, and concurrent versus subsequent, which in combination forms four types of opponent formats. Furthermore, based on an interactive football-training platform, we have utilised the framework to design three new computer-supported physical games with different opponent formats, which constitute the paper’s secondary contribution. We have attempted to begin initial investigations into the inherent qualities of the opponent formats through a user experiment. The experiment conducted, was a small-scale qualitative study, thus, there is a need to further explore the four opponent formats, with regards to both a larger volume of opinions, as well as within different contexts. However, based on the experiment, we begin to identify qualities related to the different opponent formats. We point to each format possessing different qualities with regard to; Perception of competition, pressure during a game and spectator excitement. For example, concurrent encumbered games are perceived as exceedingly competitive, however, they lack the constant pressure, which is present in unencumbered concurrent games. Additionally, concurrent games in general seems to excite spectators constantly throughout a game, whereas the spectators’ excitement is concentrated towards the end of unencumbered subsequent games. The work contributes to a better understanding of how the opponent format influences the game and the participant’s perception of it, and that it can form the basis for reflection when designing new computer-supported physical games, exergames, interactive training equipment or even physical competitive games in general. However, in order to get clearer knowledge about the qualities within different formats presented in the framework, more widespread quantitative evaluations are necessary. Furthermore, future work should include examination of qualities within subsequent encumbered games, since this format has not been covered by our work.

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