# Motivations, Strategies, and Movement Patterns of Video Gamers Playing Nintendo Wii Boxing

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## Abstract

*Video game consoles that employ physical activity as an interaction mode can benefit from using the gamer's movement as feedback and adapt to it. But to be able to design such systems we need to know how gamers actually move and what we can infer from this. This paper reports preliminary, qualitative results of a study that aims at identifying playing styles and related movement patterns of gamers that play the Nintendo Wii Boxing game. Interviews of video gamers revealed that they approach the game with two different motivations (to achieve and to relax) that lead to different strategies (game and simulation). A movement analysis study using motion capture data, video recordings, and observer ratings identified three different movement patterns that relate to these strategies.*

## 1. Introduction

A new generation of video game consoles enables video gamers to employ active body movements as interaction mode. Initial studies show that usage of such movement-based consoles reaches exertion levels that increase physical health and appear promising for reducing obesity [10], [11], which is at least partly the result of a sedentary lifestyle [12].

Presently, there is a fair amount of research done to develop intelligent interfaces [16], i.e. interfaces that employ the user's behaviour as input and adapt to it. Such interfaces usually act on affective cues that are inferred from the users. But with the advent of movement-based interaction, intelligent interfaces also have to analyze the movement patterns of their users. For instance, what does the force when swinging a baseball bat or the number of punches when boxing say about the gamer's experience? How can we detect a gamer over pacing himself or move in an unhealthy way?

Apart from the challenge of developing technology that can detect movement patterns of the user, another important task - and one that should precede the development of technology - is to investigate and identify the movement patterns that users display. If we want to build systems that react on the user's behaviour we must know what we can observe and what it means in the first place. This is not a trivial task as the human body is complex with a large number of degrees of freedom, usually represented by joint rotations.

Some approaches circumvent joint rotations and just consider the amount of movement in an image or track the head or the hands. But also here the task of identifying patterns in the movement and what they mean remains.

It is the goal of this paper to contribute to the search for behavioural patterns and their meanings. In the study described here we attempt to identify movement patterns of video gamers that are playing on the Nintendo Wii. The Wii is a popular video game console that gamers steer by using one or two handheld controllers that are fitted with accelerometers and that allow the console to detect the location of the controllers in 3D space.

In a first step we conducted interviews with video gamers to investigate how they conceptualize and interpret their movements when playing movement-based games. In a second step we fit gamers with an inertial gyroscopic motion capture suit and observed their movements while playing the Wii Sports Boxing game. The Wii Boxing game was chosen because the Wii is presumably the most widely distributed movement-based video game console at present and Wii Boxing reaches the highest activity levels of the Wii Sports games [10].

The paper is organized as follows: We first discuss potential benefits of movement-based games as opposed to sedentary games and outline areas where adaptive interfaces could improve the interaction. We then present the outcome of the interviews with video gamers. The movement analysis study is described next. Finally, we discuss the results of both studies and give pointers to future research.

## 2. Potential Benefits of Intelligent, Movement-based Video Games

A video game that employs both active body movements as interaction mode and can adapt to the gamer's behaviour, offers several potential benefits.

Before moving on to our findings, we want to discuss two domains of potential benefits, arising from such games: (a.) a healthier interaction, and (b.) a richer, more enjoyable interaction.

## 2.1. Healthier Interaction

Video games are usually seen as contributors to the growing obesity epidemic [5]. Hillier [12] notes that "children today are engaging much less with the world outside their homes in terms of physical activity ... Technological innovations in media have contributed to these changes, keeping children inside and sedentary in their playtime..." (p. 56). But instead of simply blaming technology for this, she advocates making technology part of the solution to it. Physical activity promoting video games can be seen as an example of such a technology driven solution.

Initial studies show that physical activity during gameplay increases energy expenditure significantly compared to sedentary games. Lanningham-Foster and colleagues [14] measured the energy expenditure of children playing sedentary video games and playing active video games like Sony's EyeToy and Konami's Dance Dance Revolution. The energy expenditure more than doubles for Dance Dance Revolution and the authors conclude that such games could be useful for obesity prevention and treatment.

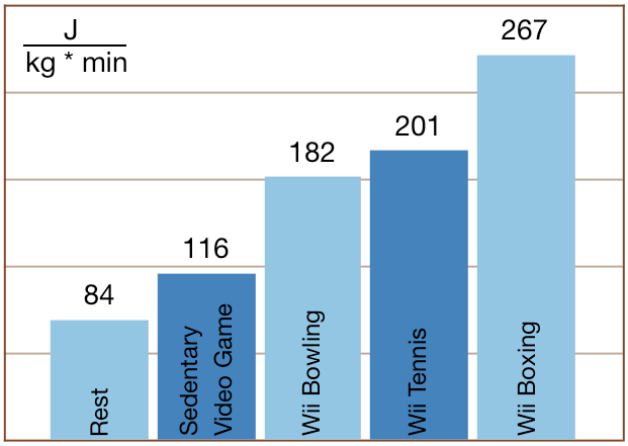

Fig. 1: Energy Expenditure of Adolescents whilst Playing Video Games, from Graves and colleagues [10]

Graves and colleagues [11] also measured the energy expenditure of children playing active video games as compared to sedentary games, but observed an older group of children. Interestingly, they compare the expenditure values of the Wii Sports Bowling and Tennis with values for real Bowling and Tennis. The Wii games require significantly more energy than sedentary activities, but less than the real sports that they simulate. Yet, the measure they employ does not take upper limb movements into account. In a more recent study Graves and colleagues [10] use a measure for estimating the energy that includes upper limb movements, which form a crucial part of interacting with the handheld controllers of the Wii and that were neglected in [11]. Including upper limb movements promises more accurate results and indeed, they report higher activity levels than in the previous study. Figure 1 shows the energy expenditure levels that Graves and colleagues [10] found for the Wii Sports games, in comparison to a rest value and a sedentary video game on the Microsoft XBOX 360 video game console.

Of all the Wii Sports games (i.e. baseball, bowling, boxing, golf, and tennis) boxing reaches the highest activity levels. The authors conclude that while the intensity of real boxing is much higher, the intensity of the Wii Boxing game exceeds the cut-off for moderate intensity physical activity. It is thus high enough to contribute to recommended amounts of exercise.

Besides in obesity prevention, active video games have also been envisioned for use in rehabilitation. The field of Virtual Rehabilitation has used virtual reality technology for some time now for the rehabilitation of patients [3][13], [17]. Recently, also physical activity promoting video game consoles have been deployed in rehabilitation measures. Morrow and colleagues [15] present a rehabilitation system, which is based on Microsoft's XBOX. They advocate the use of entertainment technology for physical rehabilitation, mainly to reduce system costs. Galego and Simone [7] combined a Wii remote control and Second Life into a Virtual Rehabilitation system. They also point out the potential of such low cost rehabilitation approaches. Though there are no results of scientific evaluations available yet, therapists have already coined the term "Wiihabilitation" and report of increased motivation of their patients, who are often unmotivated to carry out the very repetitive limb movements common in rehabilitation [19].

All this gives evidence for the benefits of video games that require the gamer to be physically active as compared to sedentary games. Still, they also expose gamers to new threats: Injuries from playing the Nintendo Wii have been reported in popular media and physicians have already introduced the diagnosis "Wiitis" [2] or "Wii shoulder" [4]. Bonis [2] describes the condition as follows: "If a player gets too engrossed, he may 'play tennis' on the video screen for many hours. Unlike in the real sport, physical strength and endurance are not limiting factors" (p. 2431). It is also an example for how much the interaction with the Wii is dependent on arm movement. One could also speculate that a further reason for such injuries is that gamers do not perceive their video game consoles as sport devices and consequently do not care about warming up before playing [17]. This is certainly an issue that should be addressed in future research as well as in future game design. Otherwise the health improving

effect of the physical activity can degrade.

By enabling game technology to monitor body movement and movement patterns, the game could be adapted at run time in order to foster a more positive and personal experience by encouraging healthier body movement. Once a threat is identified the game can then steer the gamer towards a healthier behaviour. Also, an adaptive game could monitor the exertion level of a gamer and steer the gamer towards recommended exertion levels.

### 2.2. Richer Interaction

The second domain we discuss is the promotion of a richer and more enjoyable interaction. Riskind and Gotay [18] found that the sheer posture of person has influence on the mental state. Subjects that were put in a hunched, threatened posture reported greater stress than subjects that were put in a relaxed posture. Fox [6] reviewed studies that investigate the influence of physical activity on mental well-being. He concludes that there is growing evidence that exercise increases mental well-being, largely through improved mood and self-perception. Returning to a video game context, Bianchi-Berthouze and colleagues [1] found evidence that body movements not only increase the gamers' level of engagement, but also have an influence on the way a gamer becomes engaged. Their results demonstrate that the controller itself plays a critical role in creating a more complete experience for the gamer.

Whether the increase in engagement in physically active environments is due to the actual physical activity or to a higher perceived level of control remains open for research. Yet, more knowledge is needed about the link between physical activity and engagement in order to develop adaptive games that steer the gamer's movements towards a more enjoyable interaction.

Movement patterns can for examples shed light on the affective states and motivations of the gamer. A game technology able to capture such information and exploit it to adapt the game would provide a more natural and richer experience that could facilitate a sense of presence. By becoming aware that the game is reacting to the gamer's body movement, this may motivate the gamer to further exploit this channel of communication. This would offer a much richer set of strategies for challenging the opponent or communicate with possible teammates.

## 3. Interviewing Video Gamers

Interviews with video gamers were held to investigate how they experience, conceptualize, and interpret their movements when playing movement-based games.

### 3.1. Setup

Four experienced video gamers were recruited for this study. It did not appear useful to recruit novices, as some level of exposure is required for interviewees to reflect on their experiences with movement-based games. Interview sessions were held in a semi-structured style and initial outcomes were used to update the interview guide for the following interviews. Before the interview, subjects were primed by a 20 minutes session of playing the Nintendo Wii Sports games, during which they were videotaped. Subjects were instructed to play a game with a slow pace (i.e. bowling, golf, baseball) and a game with a fast pace (i.e. boxing, tennis) with the idea of asking about differences between the games, i.e., how the amount of physical activity and the type of movement may affect their gaming experience.

The interviews were transcribed and analyzed using a Grounded Theory approach, a qualitative methodology developed by Glaser and Strauss [8]. Aside from the statements of the interviewees, also observational data in form of memos was used in the analysis, as recommended by Goulding [9].

Open coding was applied to the data, i.e. labels were assigned to the statements of the interviewees and the observations. Then, relations between the labels were identified and finally put into concepts.

### 3.2. Results

A concept that emerged early in the data was that gamers have several distinct motivations to engage with movement-based games. In fact, some experienced gamers seem to be aware of their changing motivation and adapt their gaming strategy accordingly:

*"As you play and play you start to realize that you don't really need to swing and it's just a small movement that you need to make - so I tend to play more technically rather than emotionally. […] When I am playing to relax and I play baseball, I swing like I would with a real baseball bat. But if I am playing to beat somebody else then I do what I need to do to do the movements."* (i3)

The statement of interviewee 3 shows he has realized that he does not need to swing his arm with force. For the Nintendo Wii it is sufficient to make a small movement from the wrist. The challenge is thus the timing of the movement. In fact, to achieve a higher score it is beneficial to only make small movements from the wrist, as this allows more precise control. Nevertheless, the interviewee states that sometimes he deliberately makes big, forceful movements, when his motivation is not to achieve a high score, but just to relax and immerse into the virtual environment.

Gamers seem to appreciate the reduced complexity of the Wii compared to a real sport: "*Playing tennis in real life is harder"* (i4). Yet, there were also statements that gamers felt exhausted after playing on the Wii. Further, physical fitness was hardly mentioned by the interviewees and only as nice byproduct, but not as a motivation to

engage with the game.

### 3.3. Discussion

We can conclude that there are two different strategies that gamers employ when playing a movement-based game and that they derive from different motivations to play in the first place. In the first case, the gamer is playing a game with the motivation to challenge his/her ability to find the best way to make points and have fun. The aim is to win and to achieve something. The related strategy is thus to maximize all efforts towards achieving a high score.

In the second case, the motivation for playing is to relax by experiencing and/or challenging their movement skills like they would do in a sport situation. Relaxation here does not refer to physical relaxation, but rather a mental relaxation that derives from immersing into the game and imagining oneself as playing the actual sport, not just a video game. Gamers that want to relax in such a game employ a different strategy. Instead of optimizing their gameplay towards achieving a high score they rather simulate the actual sport, i.e. they do the same movements as they would in the actual sport or how they think a good player would execute the movement in the real sport.

## 4. Movement Analysis Study

We conducted a motion capture study to investigate whether different motivations for playing and therefore deviating strategies identified from the interviews can be found back in movement patterns.

### 4.1. Setup

10 participants (7 male; mean age: 26 yrs, SD: 2.6) were fitted with an inertial gyroscopic motion capture suit (Gypsy 6, Animazoo, Brighton, UK) and their movements were recorded while they played the Wii Sports Boxing game for 15 minutes. To avoid biasing the participants, the experimenter left the room during this period.

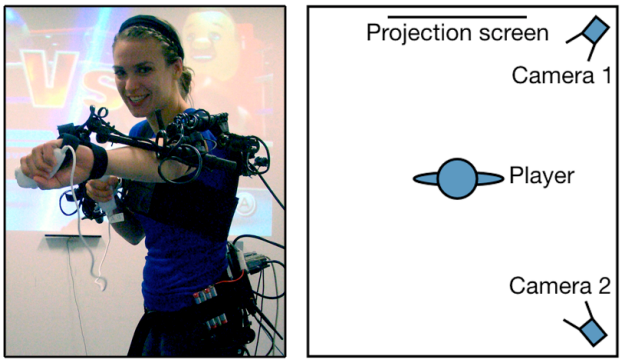


Fig. 2: Setup of the Motion Capture Study; Left: Participant in Gypsy 6 Motion Capture Suit; Right: Camera Positioning

In addition to the motion capture data, video recordings were made from a frontal-lateral angle and from over the shoulder of the gamer, to be able to correlate movements to game events. Figure 2 shows the setup of the experiment. A third measure comes from five observers that rated video clips of the participants. Three 10-second video clips of each participant were shown in a random order to the observers. The results from all three measures are given in Table 1.

### 4.2. Analysis

A first analysis step was a visual inspection of the video footage. This revealed great differences in playing styles, i.e. differences in punch frequency, punch amplitude, and overall body movement. Roughly, three types of playing style were observed: One group of gamers only made very little extensions of the arms, while punching at a high frequency. Another group of gamers showed big extensions of the arms and also punched at a high frequency, to the extent that it appeared they were over pacing themselves. In both groups it appeared that the gamers' behaviour was almost independent of game events, i.e. they showed only little defensive behaviour, even when their avatar was hit repeatedly.

The third group appeared to box realistically, i.e. with big arm extensions, a low to medium frequency of punches and reacting to game events.

In a next step we quantified the features that were deemed important during the visual inspection. The punch frequency was measured for each participant by annotating a short segment of the video recordings.

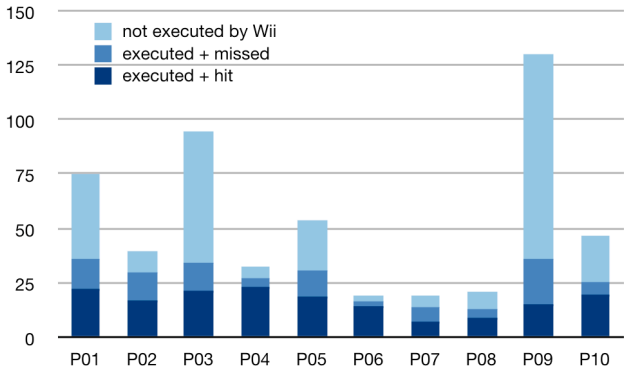


Fig. 3: Number of Punches over a period of 20 seconds.

Figure 3 shows a representation of the punch frequency distinguishing between when a gamer punches but the Wii does not execute the punch in the game, when a gamer punches but misses the opponent ("executed + missed"), and when a gamer punches and hits the opponent ("executed + hit"). The Wii does not execute a punch e.g. when a punch is too soft or when a gamer punches while the avatar is still in the process of executing a previous

Table 1: Results from Video Annotation, Motion Capture, and Observer Ratings

| | P01 | P02 | P03 | P04 | P05 | P06 | P07 | P08 | P09 | P10 |
|---|---|---|---|---|---|---|---|---|---|---|
| ***Video Annotation Data*** | | | | | | | | | | |
| Number of Punches* | 74 | 39 | 93 | 31 | 53 | 19 | 18 | 20 | 129 | 46 |
| Ratio Hit to Total Punches* | 0.28 | 0.41 | 0.22 | 0.71 | 0.34 | 0.68 | 0.33 | 0.4 | 0.11 | 0.41 |
| Ratio Executed to Total Punches* | 0.47 | 0.74 | 0.35 | 0.84 | 0.57 | 0.84 | 0.72 | 0.6 | 0.27 | 0.54 |
| ***Motion Capture Data*** | | | | | | | | | | |
| Displacement Body Root (Hip)* | 357 | 22 | 76 | 232 | 316 | 261 | 572 | 301 | 139 | 386 |
| Angular Displacement of Elbows* | 55637 | 6539 | 47717 | 37274 | 35786 | 9264 | 14516 | 8190 | 13296 | 15699 |
| Punch Amplitude (X-Rot., in Deg.) | 95 | 8 | 118 | 160 | 90 | 63 | 90 | 105 | 18 | 75 |
| ***Observer Ratings*** | | | | | | | | | | |
| Boxing Realism** | 2.3 | 1.2 | 2.2 | 2.4 | 2.5 | 3.6 | 3.1 | 3.8 | 1.7 | 3.7 |

* accumulated over 20 seconds, sample taken from middle of gaming session
** scale: 1 (low) – 5 (high)

punch or is recovering from being hit.

Aside from total punches, Table 1 also shows the ratio of punches that actually hit the opponent and the ratio of punches that are executed.

From the numerical data of the motion capture suit we obtained the total movement of the gamers, as the displacement of the body core over a period of 20 seconds. Another measure is the angular displacement of the elbows. This is an accumulation of the angular displacement (in arc degrees) of both elbows combined over a period of 20 seconds. Also, we obtained the average punch amplitude for each participant. Table 1 shows the punch amplitude for the X-Rotation, i.e. the extension of the arm in a forward direction. Figure 4 gives an example for a rotation around the X-Axis.

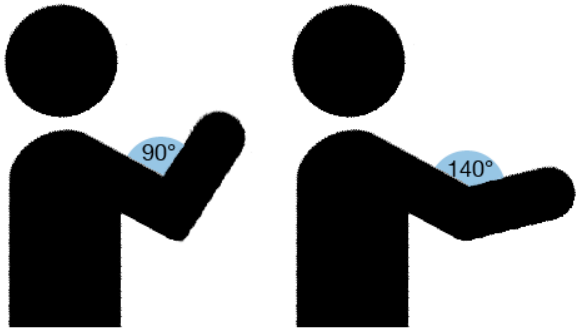


Fig. 4: Example of the punch amplitude for X-Rotation of the arms: A resting angle of 90° (left) and an extension angle of 140° (right) result in a punch amplitude of 50°

When plotting the observers' ratings of how much they thought the gamers are really boxing against the angular displacement of the elbows, we can easily identify three clusters that correspond to the styles that were mentioned above. Figure 5 shows that plot and in addition the average punch amplitude as bubble size.

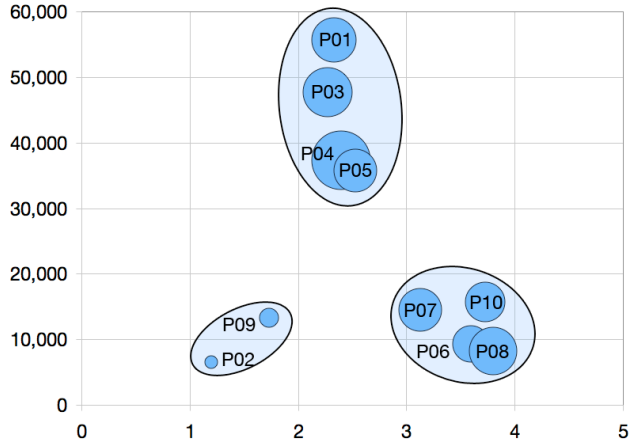


Fig. 5: Observer Ratings of Boxing Realism (X-Axis; Scale 1-5) vs. Angular Displacement of the Elbows (Y-Axis; accumulated over 20 seconds) vs. Average Punch Amplitude (Bubble Size; Size of X-Rotation, i.e. rotation in forward direction)

The group with the highest realism ratings (P06, P07, P08, P10) only shows low amount of angular displacements. Yet, if we look at the size of the bubbles, we see that they show medium to large punch amplitudes. When looking at the video footage one can indeed observe that these gamers react to events that happen in the game, i.e. they wait for a good moment to punch the opponent and they also take a defensive stance while waiting.

### 4.3. Discussion

In the interview study, we identified two motivations with which gamers approach the Wii Sports games: "Achieving" and "Relaxing". Also, corresponding strategies were identified: "Game" and "Simulation". In the movement analysis study we found three patterns: One pattern corresponds to "Simulation", while we have to differentiate for "Game". Here, there appear to be two different patterns.

The first pattern can be described as "game with a low

intensity", i.e. gamers show only little physical engagement. The body core remains stationary and there are only very small arm extensions. Yet, they show a high punch frequency. Apparently these gamers have learned that for the Nintendo Wii the punch amplitude is irrelevant and that a short impulse is enough to perform a punch. The high punch frequency leads to a good performance in terms of total hits, even if many punches do not hit or are not executed at all. Still, the level of physical activity remains low and on the video recordings they do not appear to be emotionally engaged and almost look bored.

The second pattern can be described as "game with high intensity". These gamers are quite active, i.e. they move around and show high arm extensions and punch amplitudes. The punch frequency varies from medium to high.

The pattern "simulation" is characterized by gamers that observe the action on the screen and react to it. They thus have a lower number of punches as they wait their turn and do not punch blindly. On the other hand they show big arm extensions, as is done in real boxing, which they simulate.

Figure 6 gives an overview of the motivations, strategies, and movement patterns that were identified for video gamers playing Wii Boxing.

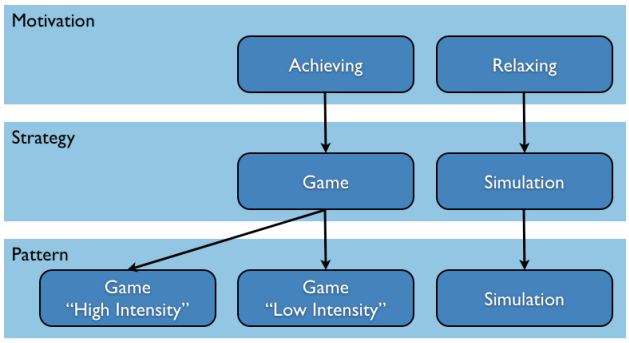


Fig. 6: Motivations, Strategies, and Movement Patterns of Video Gamers Playing Nintendo Wii Boxing

The following features appear thus important for identifying the gamer's movement behaviour. The average punch amplitude gives a good indicator to distinguish between the low intensity pattern of "Game" and the pattern "Simulation". Yet, it seems not sufficient to distinguish the high intensity pattern of "Game" from "Simulation". For this, the angular displacement of the elbows appears suited (see Figure 5).

## 5. Conclusions

The aim of this paper was to identify playing styles and corresponding movement patterns for gamers of physically active games, in this case the boxing game of the Nintendo Wii Sports games.

We identified two motivations with which gamers approach the Wii Boxing game ("Achieving" and "Relaxing") and two related strategies they employ ("Game" and "Simulation"). In the first one ("Game") gamers are aiming for a high score and to achieve this reduce their movements to what is necessary. This can result in two different movement patterns, one with low punch amplitude and corresponding low physical intensity and one with a high punch amplitude and high physical intensity. In common for both patterns is that gamers punch at a high frequency and neglect events in the gameplay like their avatar being hit.

Gamers that want to relax and to immerse into the game use a different strategy, which we call "Simulation". In the corresponding movement pattern they appear to imitate real-life boxing, i.e. they observe the opponent, try to block its punches and wait for good opportunities to attack.

The significance of the findings reported in this paper must be qualified by the rather small size of the pool of subjects. Still, our results identify trends and can help reduce the complexity of information that we obtain from movement data.

In a next step, the features that we identified here should be validated in a quantitative study. Also, other game scenarios should be investigated.

Reports from the interview study lead us to speculate of changes of the gamers' behaviour as they gain expertise in a game. We also found that a gamer can approach a game with changing moods and motivations. A longitudinal study could investigate how motivations and movement patterns change over time and exposure.

Another aspect of this new type of physically active games is a social one. From our interviews we learned that for this type of game, gamers appear to meet with friends to play, as a sort of social event. Interviewees reported of a preference to play in a social setting. We did not consider social aspects in this study, but they should be addressed in future research.

As in all game research, a further critical issue is the artificial setting of laboratory studies. This makes it hard to get a good and reliable measure for the gamers' experience. The use of a motion capture suit in this study was also quite intrusive and potentially influences the gamers' experience. The identification of relevant features should limit the amount of necessary technology to record movement of the gamer and help towards designing future studies into a more natural setting.

All this should enable us to inform the design of user-adaptive active games that steer the gamer towards a healthier and richer interaction.

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