Turning training into play: Embodied gaming, seniors, physical training and motivation

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R. Aarhus, E. Grönvall, S.B. Larsen, S. Wollsen, Turning training into play: Embodied gaming, seniors, physical training and motivation. Gerontechnology 2011; 10(2):110-120; doi:10.4017/gt.2011.10.2.005.00 Embodied gaming has been adopted and gained credibility in the field of physical rehabilitation. In this paper, we report on findings from a six-month-long study of three groups of senior citizens, and their use of Nintendo Wii Fit in a supervised physical training context. We argue that the study participants generally found physical training both fun and socially engaging, and experienced improved fitness. We also argue that embodied gaming motivates seniors to do more than they think themselves capable of, and allows seniors with different mental and physical capabilities to play together. However, there are also certain barriers, when seniors interact with the system. Speed and complexity of what is displayed on the screen are examples of barriers that affect the seniors' satisfactory use of the technology. Based on these findings, we discuss how physical rehabilitation may be facilitated by computer gaming technology.

Keywords: embodied gaming, Nintendo Wii, seniors, rehabilitation, motivation

The gaming industry and affiliated research have in the recent years explored new ways of controlling videogames in respect to the traditional keyboard and mouse/joystick paradigms. This includes full-body interaction games, or embodied gaming, where the player controls and manipulates the game and its elements via the body and its movements. This is exemplified by research projects such as PingPongPlus[1] and Kick Ass Kung-Fu[2] and commercial products such as Nintendo Wii[3] or Microsoft Kinect[4]. Relying on different technological solutions, they all explore how we can change the game-space and game experience by allowing the body to provide game instructions rather than only some fingers on the keyboard. Kick Ass Kung-fu for example uses a camera to 'capture' the players and animate them in the graphical game environment. Sticks, swords or other 'tools' or weapons can be used, as they are captured by the camera and inserted into the game environment. Furthermore, the voice becomes a control element as shouts activate features in the game.

Video games are traditionally (and usually) played for entertainment purposes. However, recent developments have led to special-purpose games designed to train and rehabilitate the player, rather than only entertain. Systems such as MITII[5], Silverfit[6], and CAREN[7] are examples of this. While MITII represents a 'low-tech' solution running within a browser of a web-cam-enabled computer, CAREN is an advanced 3D virtual reality system situated in its own room. Silverfit positions itself between these two products, requiring a setup of designated cameras and sensors, but can otherwise run on a standard computer system. These systems remain rather expensive, and in some instances are difficult to acquire.

Conversely, mass-produced consoles for embodied gaming have gained immense popularity during recent years, and investigators have begun reporting on the use of such standard products for physical rehabilitation purposes. A readily available system may be used by physiotherapists and other professionals without the need for technical assistance, and since they may know the system from private use, its adaptation does not present as many barriers as more immature systems might. Indeed, one of the first scientifically reported cases using embodied gaming as part of physical rehabilitation involved Nintendo Wii in the rehabilitation of an adolescent with cerebral palsy[8].

Other studies have focused on the use of Nintendo Wii by senior citizens. According to Theng et al.[9], senior citizens engage positively with the games, and Voida and Greenberg[10] claim that computer games may facilitate play in intergenerational groups. Yim and Graham[11] claim to be writing a "first attempt to tie the exercise motivation literature to the design of exercise games". Despite this growing body of knowledge, the understanding of seniors' reception of embodied gaming and its virtual, computer-simulated environment is still not comprehensive.

This paper presents how three groups of seniors with different physical and mental capabilities responded to gaming with an off-the-shelf system, and to discuss how gaming might motivate and contribute to physical rehabilitation.

METHODS
The study took place at the combined assisted living residence and senior centre Bjørnshøj, just outside of Aarhus, Denmark. The centre opened in 1989, and includes common spaces, such as a cafe, restaurant, social areas, and physical training and rehabilitation facilities. There are 20 apartments for seniors connected to the centre, and 24 nursing home apartments. Both people living at the centre and seniors from the neighbourhood use the centre and its facilities. The centre conducts physiotherapist-direct-ed exercise programmes with groups of seniors referred for rehabilitation by the public healthcare system. Due to our study, three new groups (see below) were established, and were offered twice-weekly physical rehabilitation sessions for six months.

Participants
Thirteen seniors were selected and divided into three groups by the staff, on the basis of physical and mental ability, and their relationship to the senior centre. In all three groups, most participants knew one another beforehand, from previous activities at the centre:
(i) Group 1 (four people: three women, one man, aged 62–76), 'the unreferred': Independent seniors, living off-site. They constituted the healthiest and most active group, with no or limited decrease in physical ability. One participant suffered from osteoarthritis, and another from neuritis. They lived in the neighbourhood, and mainly used non-therapeutic services at the centre, such as the restaurant and social areas.
(ii) Group 2 (four people: two women, two men, aged 61–84), 'the referred': Seniors with physical impairments for which they were prescribed rehabilitative training at the centre. Three of the participants suffered from poor balance, one had a knee replacement, one suffered from rheumatism, and one was severely overweight. These participants lived on the centre's premises, in individual senior apartments.
(iii) Group 3 (five people: all women, aged 69–89), 'the residents': Seniors living in the centre's nursing home, with various levels of physical or mental impairment. Two of the participants had had strokes: one was wheelchair-bound, the other used a walker. Another participant had poor balance, and used a walker. Two had no physical impairment, but psychological diagnoses and loss of memory. This group was split into two subgroups during the project, as it took a long time for each player to get into position, which did not allow each individual their planned 'Wii-time'. They could engage in game activity at similar levels, but all needed more and individualized support to begin playing in contrast to the other two groups.

Apart from the seniors, four staff members participated in the project. They included two physiotherapists, one occupational therapist, and one health care assistant.

Materials and study setting

The technical setup consisted of a Nintendo Wii Console, two 'Wiimotes', one Wii balance board, the DVDs for 'Wii Sports' and 'Wii Fit Plus', and a projector for displaying the screen. Before the project was initiated, the risk of accidental falls was considered. Although the risk was not found to be high, precautions were taken: A chair was placed in front of the balance board for the participants to grasp, if they felt they were losing their balance (*Figure 1*).

Every game session was directed by a staff member who assisted the participants in carrying out the exercises. The sessions were initiated with a group warm-up, consisting, for example, of one participant performing an exercise game with the other participants joining in. The fitness training assistant would then give each participant turns with different games, usually 'Table Tilt', 'Ski Jump', 'Ski Slalom' and 'Hula Hoop'. For some of the more disabled participants, the slower-paced and simpler 'Bowling' game was more appropriate. In some cases, the fitness-training assistant chose one game for everyone to play, depending on the physical capabilities of the group. In other cases, the participants individually chose the game each wanted to play. Each game session lasted 60 minutes.

Procedure and measurements

The study was constructed as a mixed methods study[12], and combined an ethnographic approach, which the researchers were in charge of, with physiotherapeutic tests, which staff at the local senior centre carried out. The ethnographic study was descriptive and qualitative[13]. Fifteen separate and complete game sessions were observed, using either background observation or a more participatory approach. The observations were accompanied by informal interviews. The observations were documented

Figure 1. A game session at Bjørnshøj

through field notes and photographs, with the consent of the participants involved. Semi-structured group interviews were conducted with each group of participants, as well as with the staff group, at the end of the project period. All interviews were recorded and transcribed. The data from observations and interviews were coded and categorized into themes, when searching for interrelationships as well as exceptions.

The fact that the ethnographic study took place over a period of six months allowed the researchers to challenge preliminary understandings, and thereby obtain a more profound and valid understanding of the participants experience using embodied gaming in a physical training context. The validity of the study was also improved by triangulation[14], as different methods were used simultaneously. Furthermore, the four participating researchers had different academic backgrounds and hence contributed with different perspectives. Finally, findings were discussed with the staff involved in the study, to clarify possible misinterpretations.

At the beginning, middle, and end of the project period, the personnel at the senior centre conducted Senior Fitness tests[15] for the groups of unreferred and referred participants. The Senior Fitness Test, developed by Rikli and Jones[15], is designed to measure the physical capacity needed to perform everyday activities, and is targeted at those aged sixty and over. It consists of eight tests: 'Chair stand test', 'Arm curl test', 'six-minute walk

test', 'two-minute step test', 'Chair sit-and-reach test', 'Back scratch test', 'eight-foot up-and-go test', 'Height and weight'. The staff at the senior centre decided to include six of the eight tests. They decided to not include the six-minute walk test, but instead chose the two-minute step test, which may be used as alternative in the case of space or other limitations. The height and weight test was not included, as weight loss was not a defined goal for the participants. For the group of residents, Senior Fitness tests were only conducted at the beginning and end of the project period due to unforeseen events. Therefore the Senior Fitness Test results will be based on the before and after tests for all three groups.

RESULTS

The participants played several of the available games. The most popular game was 'Table Tilt'. The game involves using the weight of the body to tip a 'table' up and down and from side to side, to make balls roll into holes. 'Table Tilt' is a more simplistic game with less animation on the screen, and the fact that you control a board by using your weight was observed to be more relatable than 'Balance Bubble', for example, in which you control a bubble in a river. As the participants improved their skills and managed to get further, they enjoyed it more: "*We are more interested in the game with the balls on the table because we made it far in that game*" (Woman, 81, referred; all Danish to English translations courtesy of the authors). The participants also emphasized the fact that 'Table Tilt' reminded them of the wobble board they knew from doing callisthenics and traditional physiotherapeutic training, and therefore they found it easier to relate to than some of the other games.

All three groups considered exercising with the Nintendo Wii games fun. After the initial novelty wore off, turnout for the game sessions remained high. In total, turnout was above 90% for the entire period.

Socially engaging

Much of the enthusiasm for the physical training was not attributable to the Nintendo Wii itself, but rather to the social interaction taking place around the game. "*It isn't fun to do it alone. I'd rather have someone to talk to while doing it*" (Woman, 84 years, referred). In particular, the unreferred participants emphasized the importance of the social interaction, that is, cheering one another on, competing, and so forth. One participant explained: "*I wouldn't like a Wii at home, when I'm alone. Had I had my husband, I might, he was also very sporty. Wii is something to do together with others*" (Woman, 76 years, unreferred). In their study, Voida and Greenberg[10] found that mature adults and elderly persons would only play console games in groups, which is supported by our study. Gajadhar et al.[16] have investigated seniors' experience of different forms of co-play (mediated, virtual and co-located), and also stress the importance of enabling social interaction and cooperative play in digital gaming in order to maximize enjoyment for seniors.

In our study the group of residents was observed to be the least socially engaged while playing, but in interviews, they emphasized that the social aspects had some importance: "*It is fun watching the others*" (Woman, 82 years, resident).

While we did not experiment with intergenerational gaming[17], some of the participants in our study were motivated by the fact that their grandchildren also play Nintendo Wii: "*It is wonderful to have something like this in common with my grandchildren*" (Woman, 65 years, unreferred).

Playing alone together

When observing the participants playing Nintendo Wii, it became obvious that there were several ways to participate or engage. Ducheneaut et al.[18] use the phrase 'alone together' to describe a situation in which a player plays surrounded by others, rather than with them. To a large extent, this way of playing was what took place among the group of residents. One of the participants said: "*Alone is enough for me*" (Woman, 82 years, resident). On the other hand, she was

observed to pay considerable attention to the screen while others played, and commented on how the others were doing. During a game, the residents not playing primarily remained silent while paying attention to what happened on the screen. Thus, the one actively playing usually played alone, surrounded by others, or in Voida and Greenberg[10] terms, engaged centrally, while the spectators engaged peripherally.

Elements outside the game that affect the gaming experience, or 'metagaming'[19], played a larger role among the referred and, in particular, the unreferred, than among the residents. While onlookers still participated peripherally, they ensured metagaming, in terms of cheering, support, talking, laughing, comparison, and sharing of experiences. Both the employees and senior participants in the two groups found this metagaming motivating. One participant explained: "*they are exceptionally kind to comment 'wow that's good"* (Man, 62 years, unreferred).

Competition

For the participants in all three groups, competition took place at a personal and an inter-personal level (*Figure 2*). In the interview with the group of referred participants, one person exclaimed: "*When some are much better than others, we will have to try harder next time"* (Woman, 81 years, referred). Hence, the competitive element motivated participants to work harder, of which most participants seemed to be conscious.

However, the competition and possibility of comparison could also have a demotivating effect: "*How did the other players manage to get so far? I haven't even made it on the board yet. There is no doubt that I am the worst player. I can never be as good as the others"* (Man, 62 years, unreferred). Thus, some participants disliked social comparison in line with the findings of Gajadhar et al.[16] who observe that losers experience more frustration and less competence. According to them co-play games for seniors should therefore put little focus on social competition. We cannot make the same conclusion

Figure 2. The participants in the unreferred group competed in two-player mode

based on our findings. While some participants were demotivated by the competitive elements, most of them found it motivating. Some participants emphasized that they primarily competed with themselves: "*I think I only compete with myself. I try to do better every time"* (Woman, 84 years, referred), although observation indicated that they also competed with each other, either implicitly or overtly, for example, by comparing scores, or discussing the previous week's rankings. These observations also confirmed that playing while surrounded by others had a social meaning for the participants, although they might not play together.

Some technical troubles

First, it was not possible to select the participants' native language, and only a few of them (all from the unreferred group) spoke English. Most menus in the games used icons and simple words that were understood or easily learned by most participants. However, when the screen presented longer paragraphs of text, the majority of the participants relied on the employees' translations, which delayed the game. Nap et al.[20] also discuss digital game design for seniors and we agree with them when they stress that seniors will benefit from the option to select their native language as the interface and in-game language.

Second, the Nintendo Wii Fit board caused trouble, particularly for the resident group. On several occasions, we observed that the

amount of time that the system allowed for getting on the board was inadequate for this group. Often, they had to step off the board, and on again, which in itself is a challenging task if you are in a wheelchair and have limited strength in your legs.

Third, as Neufeldt[21] also states, the Wiimote is not designed for seniors, especially not for those among them who are mentally and/ or physically compromised. One of the difficulties was remembering to release the control at the right time, or choosing the Mii figure, when switching users or beginning a game. One of the referred participants said: "*We often forget to release the button underneath. It is not as easy as the remote for the TV*" (Woman, 84 years, referred). For the groups of referred and resident participants, it was also difficult to equate the Wiimote with for example a tennis racket delimiting the possibilities to connect physical movements with actions in the virtual environment.

Usability problems are not uncommon among seniors, as discussed in a study reported by IJsselsteijn et al.[17]. The usability problems in our study caused inconvenient time consumption (e.g. allocated time-slot for game play), leading to the employees taking control of the Wiimote.

Interaction with the game
According to Bianchi-Berthouze et al.[22], physical involvement increases a player's engagement, among other things. The participants in our study found it interesting to engage with embodied gaming, and they highlighted the possibility of being actively involved in the game: "*It is interesting because you are the one who makes the computer do something. You don't just stand and observe*" (Woman, 82 years, resident).

The participants easily understood the Wii interface, as long as there was only one figure on the screen. However, the two-player mode of some games was too complex for the groups of referred participants and the residents. Among other things, these groups

found that the speed of such games made them difficult to follow, and they sometimes lost track of who they were on the screen, and what they were supposed to do. One of the referred participants referred to playing tennis in two-player mode, when she explained that "*We are not as fast in our movements as we once were*" (Woman, 84 years, referred). The group of unreferred participants did not experience the same kinds of difficulties, and revelled in the social and competitive aspects of the boxing game, for example. However, they still needed practice to become acquainted with this kind of gaming.

Many of the participants in all the groups acknowledged the body language of the small, animated characters in the game as feedback on their performance, for example, when one woman noted: "*It shakes its head. This was not so good*" (Woman, 84 years, referred). In her case, the character expressed disappointment, despite the score being above her average. Observation revealed that in such cases, the characters could have either a motivating or a demotivating effect on the player, depending on factors such as the individual's results, when compared to those of other group members.

The participants in our study did not identify themselves with the characters. Reed and Fitzpatrick[23] have studied seniors' creation of avatars in Second Life and found that seniors generally prefer to create avatars younger than themselves. In our study, we are not able to conclude on the reasons for our participants' lack of identification, nor whether the degree of identification would improve if the participants could create the characters themselves. Future research should investigate character identification among senior gamers, to clarify its potential.

BMI disclosure and motivation
When creating a personal profile in the Nintendo Wii Fitness game, the board calculates the player's BMI, as well as the centre of gravity, by conducting balance tests. The fact that the participants BMI and Wii

age were displayed for everyone to see was experienced by some as demotivating. In particular, the unreferred participants expressed dissatisfaction with this display of one's personal data. One of the unreferred participants commented on this: "*Well, I have always been tubby. I feel that it comes a bit too close. Then it tells me that I'm overweight, and I really don't like that*" (Woman, 65 years, unreferred). This woman's statement supports Yim and Graham's argument that the design of exercise games should enable the concealment of the player's fitness level, to increase motivation[11]. On the other hand, the unreferred participants also discussed how, for some, being reminded of one's weight could be a motivating factor for weight loss. One of the unreferred participants noted: "*I think it's okay, because you're told in a different way than usual. I promised the computer to lose weight*" (Woman, 65 years, unreferred). Among the group of referred participants, the BMI disclosure was observed to have a demotivating effect on one of the participants, while none of the residents was observed to be influenced by it.

When Hannah forgot she could not stand up
A primary motivation for some of the participants was that when playing with the Nintendo Wii, they experienced the ability to do things with their bodies of which they did not think themselves capable. On several occasions, it was observed that playing Wii caused participants to forget that they were doing something physically exhausting. This was the case with Hannah (Female, 84 years, resident), who used a wheelchair, and with whom the staff, in their daily interactions with her, had difficulty in getting her to stand up. Attracted by the Nintendo Wii, Hannah was motivated to stand up. She experienced a change in, or at least a challenging of, the boundaries of what she believed herself capable. The personnel generally found that the study participants had more endurance when playing Nintendo Wii than when engaged in traditional physiotherapeutic training, because they were distracted from the fact that they were doing something

physically exhausting. This was most evident within the group of residents, who also had the most severe functional impairments. "*They have had successful experiences, even though they were in a wheel chair or had to stand with a walker*", said one of the physiotherapists. Therefore, it would be relevant to further investigate the contributions of embodied gaming to physical training settings where it is difficult to engage and motivate the elderly with traditional physiotherapy.

Senior Fitness test results
The 'eight-foot up-and-go' test measures how many seconds it takes to rise from a seated position, walk 2.44 metres, turn, and return to the seated position. All participants except one showed progress in this exercise, when 'before' and 'after' scores were compared.

The 'chair stand' test measures the number of full stands from a seated position that can be completed in 30 seconds with the arms folded across the chest. Ten participants showed progress in this exercise, and three maintained their original levels.

The 'arm curl' test measures the number of biceps curls that can be completed in 30 seconds, while holding a hand weight. Ten participants showed progress; two maintained their levels, and one regressed.

The 'two-minute step' test measures the number of full steps completed in two minutes, raising the knee to the required height. The average score of the resident group was higher than the referred group, which is explained by the fact that they were allowed to hold onto a bar for balance support. Seven of eight participants in the unreferred and referred groups showed improved or maintained levels. Only one resident showed progress in this test.

The 'chair sit-and-reach test' measures the number of centimetres (plus or minus) between the extended fingers and the tips of the toes when seated at the front edge of a chair, with one leg extended, and the hands reach-

ing towards the toes. All participants showed progress except three – two of the referred participants and one of the residents. Two of the referred participants lowered the average for this group. Both had pain and reduced mobility, owing to the recent knee operation of one, and a recent broken shoulder of the other.

The 'back scratch' test measures the number of centimetres between the extended middle fingertips (plus or minus), with one hand bent back over the shoulder, and the other stretched up the middle of the back. Eight participants showed progress. Again, the average score of the referred group was affected by the participants with knee and shoulder troubles.

The results of the tests showed a general positive trend in the physical improvement of all participants. However, the number of participants was too small for the results to be statistically significant. Furthermore, the validity of the conclusions is curtailed by the lack of a control group, and by the fact that the referred participants were receiving traditional physiotherapy in parallel with playing Wii. Rather than providing quantitative evidence, the qualitative study suggests a positive effect of using Nintendo Wii in a rehabilitative context.

Physiotherapy and Nintendo Wii

While the results of the Senior Fitness tests indicated that the seniors benefitted physically from playing Nintendo Wii, the staff concluded that playing Nintendo Wii should be considered a supplement rather than a replacement to the physiotherapy exercise. Nintendo Wii added an evaluative instrument to the training session, primarily because it gives the staff an overview of the seniors' physical states. A staff member said: "*The game gives a good picture of the seniors' weaknesses and strengths and specific areas where further physical training is necessary*".

That playing Nintendo Wii could not replace formal physical training was also supported by an unreferred participant, who remarked: "*Wii cannot replace my callisthenics, but it can be a supplement*" (Woman, 76 years, unreferred). This view of Nintendo Wii as a supplement to physical training was also expressed by one of the physiotherapists, who said that Nintendo Wii could be an integrated training instrument in the physiotherapeutic setting, on equal terms with the wall bar, for instance.

Nintendo Wii Fitness could also supplement the physical therapy by increasing the motivation to train and exercise. According to Yim and Graham[11], one of the reasons for this is that it combines fun and exercise, and therefore creates a playing environment where exercising becomes a game. This view was supported by a staff member, who said: "*They follow the game because it is so vivid. It kind of turns [physical] training into play*". This game setting may be regarded as a more appealing environment than the traditional physiotherapeutic training setting. One of the physiotherapists mentioned being unable to generate the same levels of motivation and enthusiasm in a traditional physiotherapeutic training session as were generated by the Nintendo Wii. A distinct indication of the participants' enthusiasm was that they often showed up 10 to 15 minutes before the session began, although they were aware that they had to wait for the staff to arrive. According to the physiotherapist, this was uncommon for the traditional physiotherapeutic sessions.

Discussion

Our study demonstrated that Nintendo Wii and Nintendo Wii Fitness may be used in supervised physical training sessions for various groups of seniors. It has social and entertainment elements that motivate seniors, but it also acts as a form of evaluative instrument for the physiotherapists. The results of the Senior Fitness tests suggest a positive effect of playing Nintendo Wii in a rehabilitative context. Similar findings are seen in a study by Theng et al.[9] who argue that playing Nintendo Wii may help seniors to improve motor skills and hand-eye coordination, and thus may be considered suitable exercise for this specific cohort. However,

the staff in our study doubted that Nintendo Wii Fit could stand alone as an instrument for rehabilitative activity, and suggested it to be considered a supplement to physiotherapy exercises instead.

The fact that we worked with three different groups of participants, to avoid categorizing all seniors under one heading, created a broader and more complex picture. The three groups were originally chosen to enable the observation of the reception of the Nintendo Wii system at three different levels of physical and cognitive capability, but all three groups demonstrated the ability to play. There was a distinct difference between the residents, and the referred and the unreferred participants, in terms of the extent to which they embraced the social aspects of the games, but playing Nintendo Wii was considered fun by all groups. In none of three groups did we encounter the reluctance to engage with the technology that we had anticipated. While everybody was able to use the technology and play, the residents generally required more assistance from staff, whereas the unreferred group was able to play almost unassisted. Our study indicated that motivation among most of the participating seniors increased, when exercises were framed as play.

Can computer games turn physical training into play? From a strictly physiotherapeutic point of view, there is often more to physical training than exercise alone. The computer game may diminish dedication to rehabilitation or physical training, since the physical movements of the individual are selected for game performance, rather than following a physical training programme: for instance, if a person has one weak shoulder, he or she could use the other shoulder to complete the game. Also, in terms of individual adjustment of the system to personal goals, and progress during physical training, the current system represents too much of a 'one size fits all' approach, which is an advantage in a global entertainment market, but not in a physical training or rehabilitative context. In our setup, the presence of a staff member ensured that the exercises performed during

the game were integrated into a physiotherapeutic framework, and the system could not have accomplished this on its own. Both the seniors and the staff were unambiguous in their statements that playing Nintendo Wii could not replace traditional physical training, although all participants displayed physical progress on the Senior Fitness tests. This suggests a distinction between perception and clinical outcome.

IMPLICATIONS FOR DESIGN

First of all, technology designed for a physical training setting must acknowledge the significance of the social mechanisms at stake both during the actual physical training, and over the long term. This is in accordance with a study of multiple sclerosis (MS) patients undergoing computer-assisted collaborative fitness training[24]. For example, we recommend that the setup be organized with groups of people who can motivate one another from time to time. However, in contrast to the MS study[24], our study does not describe an active, collaborative game activity. Instead, this article has explored the social mechanisms existing within a group consisting of one active (at the time) player, the other players being spectators awaiting their turns. Points and scores may serve as means for creating competition, with both oneself and others. It is important, however, that each participant be allowed to determine his/her own level of engagement in the competition.

In games where only one person is active at a given time, the setup should allow for the rest of the group to watch the active gamer. This roots subsequent discussion and competition in common ground. At the beginning of our study, the physiotherapists' ambition was to engage those not currently playing with the Nintendo Wii (i.e. the spectators). However, this idea soon had to be discarded, since everybody was captivated by the games on the screen, and inevitably formed an audience.

Also implicit is the necessity for a flexible system capable of supporting individual physical training needs. Compared to games played in e.g. a schoolyard where it is com-

mon for rules to be negotiated before and/or during play, this is more difficult in digital games. In a digital game, the rules, structure, and remedies are often not easily negotiated and changed: It may require a programmer who can change the system through complex actions of which the average person is incapable, and may even be illegal.

The 'Age Invaders'[25] game incorporates adjustments that support both a child and one of its grandparents in playing a digital game. However, these adjustments (as understood by the authors) are static. They represent two concurrently active difficulty levels or profiles, which support the differences in the reaction-times and movement-speed between a child and an elderly person playing together. In our study, we identified areas where individual adjustments are needed, including speed, degree of screen detail, language, and how quickly a game becomes more complex and difficult. This control should go beyond profiles or static, predefined levels of difficulty. This would make it easier for the individual to play the game but, more importantly, if different but concurrent settings were supported, it would also improve the possibility of individuals with different capabilities to playing together.

We observed that as the gaming situation became more cognitively challenging (for example, more players, increased speed, more colours, or more things happening simultaneously on the screen), the participants generally found it harder to both play and appreciate the games. Thus, they were not able to perform the level of exercise that these games could have provided, had individual adjustments had been possible.

Finally, a digital game should be easy to install, use, and trouble-shoot, even if it is used in supervised sessions. Staff members are not by definition expert users, and the allotted time is often restricted, so technical problems lead to frustration, and possibly non-use. The Wiimote, for example, is not an ideal interface object for many older users.

The Nintendo Wii platform fulfils some of the requirements identified in this study, but there is room for improvement, particularly with regard to user-friendliness for the senior population. Nevertheless, we have seen the concepts of physical training and play approach each other with the use of Nintendo Wii in supervised trainings sessions, and the potential of computer games in such settings unquestionably exists.

References
1. Ishii H, Wisneski C, Orbanes J, Chun B, Paradiso J. PingPongPlus: Design of an athletic-tangible interface for computer-supported cooperative play. Proceedings of the SIGCHI conference on Human factors in computing systems: The CHI is the limit. Pittsburgh; 1999; pp 394-401; doi:10.1145/302979.303115
2. Höysniemi J, Hämäläinen P. Children's and parents' perception of full-body interaction and violence in a martial arts game. Proceedings of the 2005 conference on Designing for User eXperience. San Francisco; 2005; pp 2-16
3. Wii at Nintendo; www.nintendo.com/wii; retrieved: May 30, 2011
4. Microsoft, Kinect - Xbox.com; www.xbox. com/en-US/kinect; retrieved: May 30, 2011
5. MITII; www.headfitted.dk/da/projekter/mitii.aspx; retrieved: May 30, 2011
6. Silverfit; www.silverfit.nl/en/index.htm; retrieved: May 30, 2011
7. Eerden W van der, Otten E, May G, Even-Zohar O. CAREN-Computer Assisted Rehabilitation Environment. Studies in Health Technology and Informatics 1999;62:373-378
8. Deutsch J, Borbely M, Filler J, Huhn K, Guarrera-Bowlby P. Use of a low-cost, commercially available gaming console (Wii) for rehabilitation of an adolescent with cerebral palsy. Physical Therapy 2008;88(10):1196-1207; doi:10.2522/ptj.20080062
9 Theng Y-L, Dahlan AB, Akmal ML, Myint TZ. An exploratory study on senior citizens' perceptions of the Nintendo Wii: The case of Singapore. Proceedings of the 3rd International Convention on Rehabilitation Engineering & Assistive Technology. Singapore; 2009; doi:10.1145/1592700.1592712

10. Voida A, Greenberg S. Wii all play: The console game as a computational meeting place. Proceedings of the 27th international conference on Human factors in computing systems. Boston; 2009; doi:10.1145/1518701.1518940

11. Yim J, Graham TCN. Using games to increase exercise motivation. Proceedings of the 2007 conference on Future Play. Toronto; 2007; doi:10.1145/1328202.1328232

12. Creswell J, ClarkV. Designing and conducting mixed methods research. Thousand Oaks: Sage; 2007

13. Pope C, Mays N. Qualitative Research in Health Care. 3rd edition. Oxford: Blackwell; 2006

14. Kvale S. Interviews: An introduction to qualitative research interviewing. Thousand Oaks: Sage; 1996

15. Rikli R, Jones C. Senior fitness test manual. Champaign: Human Kinetics Publishers; 2001

16. Gajadhar BJ, Nap HH, Kort YAW de, IJsselsteijn W.A. Out of sight, out of mind: Co-player effects on seniors' player experience. Proceedings of the 3rd International Conference on Fun and Games. Leuven; 2010; pp 74-83; doi:10.1145/1823818.1823826

17. IJsselsteijn WA, Nap HH, Kort YAW de, Poels K. Digital game design for elderly users. Proceedings of the 2007 conference on Future Play. Toronto; 2007; doi:10.1145/1328202.1328206

18. Ducheneaut N, Yee N, Nickell E, Moore RJ. "Alone together?": Exploring the social dynamics of massively multi-player online games. Proceedings of the SIGCHI conference on Human Factors in computing systems. Montreal; 2006; doi:10.1145/1124772.1124834

19. Mueller FF, Gibbs MR, Vetere F. Design influence on social play in distributed exertion games. Proceedings of the 27th international conference on Human factors in computing systems. Boston; 2009; pp 1539-1548; doi:10.1145/1518701.1518938

20. Nap HH, Kort YAW de, IJsselsteijn WA. Senior gamers: Preferences, motivations and needs. Gerontechnology 2009;8(4):247-262; doi:10.4017/gt.2009.08.04.003.00

21. Neufeldt C. Wii play with elderly people. Enhancing Interaction Spaces by Social Media for the Elderly 2009;6(3):50-59

22. Bianchi-Berthouze N, Kim W, Patel D. Does Body Movement Engage You More in Digital Game Play? and Why? Lecture Notes in Computer Science 2007;4738:102-113; doi:10.1007/978-3-540-74889-2_10

23. Reed D, Fitzpatrick G. Acting Your Age in Second Life. Lecture Notes in Computer Science 2008;5294:158-169; doi:10.1007/978-3-540-88322-7_16

24. Vanacken L, Notelaers S, Raymaekers C, Coninx K, Hoogen W van den, IJsselsteijn W, Feys P. Game-based collaborative training for arm rehabilitation of MS patients: A proof-of-concept game. GameDays 2010. Darmstadt; 2010; pp 65-75;

25. Khoo ET, Lee SP, Cheok AD, Kodagoda S, Zhou Y, Toh GS. Age invaders: Social and physical inter-generational family entertainment. CHI '06 extended abstracts on Human factors in computing systems. Montréal; 2006; pp 243-246; doi:10.1145/1125451.1125503