

# Acceptance of a targeted exergame program by elderly

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## Abstract

*In a project a targeted exergame for elderly was developed and tested. The goal was to find out how our old elderly users received a combined exergame program, whether they felt that this was real exercise for them, and what type of exercises they preferred. The three-year project applied user centred design, and the exergame consists of seven mini-games. First the elderly users played them all, one mini-game at a time. Five of the mini-games were sequenced into a 4.5 minutes long exercise program, and ten elderly users played through the program and then went through a semi-structured interview about how they perceived the program. All seven mini-games were then used in the final twelve minutes long exercise program, and seven elderly users played through the program and then participated in group discussions about how they perceived the program. The users reacted positively to the combined exergame program. This paper describes the games and trials.*

## Keywords:

exergame, game theory, experimental game, video games, health services for the aged, exercise movement techniques, frail elderly, pilot study, user centred design, Microsoft Kinect camera

## Introduction

While the population is getting older, the resources for care will be even more limited in the future than they are today. A continuous increase in the number of elderly aged 80 years old or more is expected [1]. The most common reason for loss of functional capabilities among elderly is inactivity. Physical activity can effectively delay this process [2, 3]. There is a need for solutions where elderly can manage themselves and stay fit as long as possible. Exergames are a promising solution that still faces a lot of open research questions before it can be applied properly in the target group of the oldest elderly (hereafter called elderly).

Exergames can be defined as “digital gaming systems with an interface that requires physical exertion to play” [4]. Exergames both record and instruct the users in how to exercise correctly and motivate the users by giving feedback on their achievements.

Exergames are already used for elderly by several institutions, but most commercial games are not suitable for elderly, and also they do not always give the exercises that are needed to help the players keep balance, strength and flexibility [5, 8].

Studies show that elderly enjoy playing commercial exergames [6], and that gameplay can be good for balance and rehabilita-

tion [6, 7]. The Bleakley review [6] concludes that there is “preliminary evidence that games is a safe and effective medium to promote physical activity in elderly, and may be associated with a range of physical and cognitive benefits”, and “there was no evidence of an optimal exercise dose in terms of exercise type, duration, or intensity”. The Larson review [4] concludes that all the included studies have low to medium low methodological quality. Six out of the seven studies had positive results. Furthermore, there are no indications that exergames are worse than other training programs.

## Trial goal

The main goal of the trials was to learn about the elderly’s reaction to a targeted exercise program, from start to end. The combined exergame program consists of a set of different mini-games that are sequenced or queued. This included learning whether they felt that this was real exercise for them, what type of exercises they preferred, and whether the quick shifting of mini-games was overwhelming.

The sub goals were to find out whether the elderly users noticed information between the mini-games and the final score page and to get tips and ideas for further developments.

## The exergame

The exergame has seven mini-games for balance, leg strength and flexibility and uses a Kinect camera as motion sensor. The mini-games have four difficulty levels, catering for different abilities. Speed, outreach and length can be changed. Many of the mini-games can also be played while seated. The physical movements required in order to play are all chosen by physio-therapists and are amongst those that are valuable in order to prevent falls in an elderly population.

In the three picking mini-games (ApplePicking, ChickenPicking, StarPicking), the player picks falling apples/chicken/stars with either the left or the right hand. In the easy level the items fall slowly and just right above the player’s head while the player sits or stands in one position holding on to a chair. In higher levels the items fall more quickly and the player must walk sideways in order to reach them, and both speed and distance vary between the three next levels. The items are of different colours, and they are supposed to be dropped into a bar-rel that corresponds to this colour, one barrel on the left side and the other on the right side. The players are supposed to pick the items as high up in the air as they can. When an item is picked, the player may have to move it to the other hand by clapping the hands together to be able to put in the correct

barrel. For instance the red apples must be put in the red barrel and the yellow in the yellow barrel. Figure 1 show the game when a star is picked in the star picking mini-game.



Figure 1- Star picking mini-game detail.

In the PickVegetablesLeg mini-game the player stands and holds on to a chair, and slowly stretches the right leg sideways first to one side, as far as they can, and slowly back to the middle again. After a while the user is asked to switch leg. Each repetition grows a potato, a carrot or an onion. The higher the level, the further out the player must stretch the leg, and at higher levels a rabbit pops up at random intervals and disturbs the player. Figure 2 shows the game when the leg is in its outermost position in the PickVegetablesLeg mini-game. A help window in the bottom right corner shows the movements of the players to help them see how they are performing.



Figure 2- PickVegetablesLeg mini-game detail.

In the tip-toe (GrowFlowersHeel) mini-game the player stands and holds on to a chair, and slowly stretches up to stand on the tip-toes, as far as they can, and then slowly gets the heels on the floor again. This game can also be played seated in the easiest level, where the players lift themselves up of the chair with their arms, and then slowly get down into the seat again. Each repetition grows a different kind of flower. The higher the level, the further up the player must stretch, and also at higher levels a worm crawls across the field at random intervals disturbing the player.

In the knee-bend (FillWaterSquat) mini-game the player stands and holds on to a chair, and slowly bends the knees (squat), as far down as he/she can (or as the player in the right corner indicates), and then slowly rises up to a standing position again. It can also be played seated in the easy level, where the player sits in a chair and then stands up, and then sits again. Each repetition fills some more water into a glass. The higher

the level, the further down the player must bend, also at higher levels cows pop up at random and disturbs the player. Figure 3 shows a screen from the FillWaterSquat mini-game to the right.

In the CutCornArms mini-game the players stand and imagine that they hold a scythe in their arms, and make movements like they are cutting the corn with the scythe – moving the upper body while the hips are still. This is an exercise for flexibility. This mini-game can also be played seated in the easiest level, where the player sits in a chair and turns his/her upper body from left to right. Each repetition cuts a row of corn in the

corn field. The higher the level, the further the player must turn, also at higher levels rabbits pop up at random and the player can only cut when there are no rabbits in the screen.

Figure 3 shows a screen from the CutCornArms mini-game to the left.

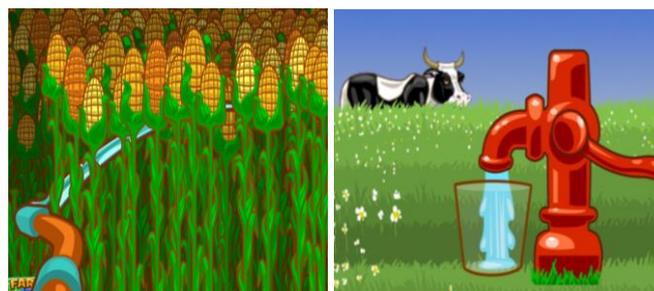


Figure 3- Details from the CutCornArms and the FillWaterSquat mini-games.

## Methods

User centred design was used throughout the project, with a mixed method approach, and the methods depend on the phase of the project. Since this was part of a user centred design approach with a small user group, the methods are qualitative. The tests described in this article were performed towards the end of the project, and was part of the evaluation phase.

The same test was done twice, the goal of the second test was to see if it gave the same results as the first time, now that the users had tried it once before and were more familiar with the concept.

The exercise program consists of seven mini-games all with exercises especially targeting those at risk of falling. The duration of each mini-game was initially set to two minutes by the project physiotherapist; this gives fifteen minutes playing time. We played with shorter playing time.

The first test with a 4.5 minutes program consisted of the following mini-games: PickVegetablesLeg, ApplePicking, GrowFlowersHeel, FillWaterSquat, and StarPicking. Each mini-game had duration of 50 seconds.

The second test with a twelve minutes program consisted of the following mini-games: PickVegetablesLeg, ApplePicking, GrowFlowersHeel, ChickenPicking, CutCornArms, FillWaterSquat, and StarPicking. All picking mini-games were 120 seconds, the others 50 seconds, except GrowFlowersHeel where the player use one leg at a time has 70 seconds which give 35 seconds per leg.

## The user group

A regular elderly user group has been meeting every second Friday for almost three years to participate in user centred design in the project. They played commercial Kinect xbox360 exergames, with their activator present when there were no project tasks. When there have been tasks in the project to perform, they have done that instead. They are not very fit and many of them come to the gathering by taxi. Some of the users have been replaced for several reasons during the almost three years the project has been running. Figure 4 and figure 5 show the testing environment.



Figure 4 - One user is playing the exergame, notice the chair placed nearby.

In the first test there were ten elderly between 66 and 90 years old, with an average age of 81.7 years, three were men, and seven were women. In this user group six out of ten have participated from the start of the project.

In the second test the same users as in the first test participated, but with three persons less. The second test thus had seven elderly users between 73 and 90 years old, where two were men, and five were women. In this user group four out of seven have participated from the start of the project.



Figure 5 - Testing environment.

## Data gathering

For the data gathering observations by the authors, semi-structured interviews and group discussion were used. All players were in the same large room, and the interviews were performed in the back of the room by one author while the rest of the participants were playing with the other author organizing the gameplay.

## Design of the trial

One big room was available for the project. In the front of the room there was a big TV screen used for the exergaming, and the participants were seated in a semicircle in front of the screen. One and one participant would play while the rest were watching, as shown in figure 5. The TV, PC and the Kinect camera were set up. Also a white tape was used to mark where to stand on the floor when playing. A chair was placed beside the standing zone so the player had something to hold on to while playing.

When it was a player's turn to play he/she would stand in front of the tape on the floor, and the exergame started automatically without any menu navigation, or use of buttons.

The trial was run as two physical tests, with a preparation phase before the tests were performed.

Early in the project the users played commercial Kinect exergames, so they were already used to gameplay. The commercial exergames do not have a tailored exercise program; they play one type of game at a time. Then the participants were introduced to the project developed exergame by presenting one mini-game at a time. All users have tried each mini-game. One or two mini-games have been presented per gathering. The overall game concept, namely farming, was explained and the farming tasks and the scenes between the mini-games were presented and explained. The last pages with a summary of the game results were also explained.

The users learnt how to play and gave comments on the playability.

This initial training revealed that running the full exercise program of fifteen minutes would be too much for the user group, since the test was to be run with an audience, the players do not pause or rest at all when they have an audience, and it was also too long for those waiting for turn.

For the first test a modified exercise program on 4.5 minutes with five different mini-games was made, in addition the duration of each mini-game was set to 50 seconds. The difficulty or intensity was also modified for some of the mini-games. During the first test the two authors were present, one controlled the gameplay and instructed the players, the other interviewed one by one in the back of the room. After all had played, there was a short group discussion while all the participants were seated.

To prepare for the second test with the full exercise program, the test notes regarding mini-game duration and difficulty while playing was examined. It was decided that two minutes was a suitable playing time for three of the mini-games but that for the last four mini-games the playing time was set to from 50 to 70 seconds depending on how strenuous they are. The difficulty or intensity was again modified slightly for some of the mini-games.

In the second test, the full exercise program with all seven mini-games in sequence and a playing length of twelve minutes was used. The elderly were also told to try to play without getting any help from the researchers or the audience. In the second test two and two players played one exercise program, the first player played the first three mini-games, while the second played the four last mini-games. After a short rest the user who played the first part played the last part. After all the participants had played through the whole exercise

program, there was a group discussion, using the same questions as in the interview in the first test.

Both authors have gone through the observation notes of the tests and the questionnaires from the structured interviews, and checked that results are correctly presented in this article.

## Results

### The first test

The first test was performed with the 4.5 minutes game consisting of five mini-games.

### Exercise program

In the interview all ten of the elderly users said they liked to have an exercise game program made up of different mini-games, three very much and seven much. See figure 6. Those who commented on this said it was good to have some variation as opposed to play one and one game.

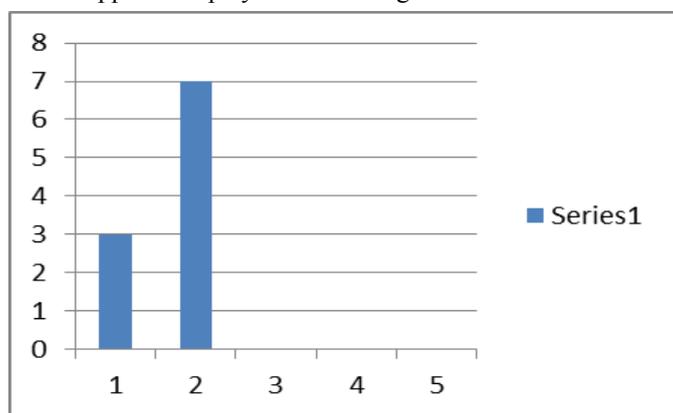


Figure 6 - How did you like an exergame with many exercises? 1-very good, 5-very bad.

It was a short discussion, about the game and whether it was fun, where all replied yes. One theme was whether the tip-toe mini-game should have a shorter duration, here also all were positive. When asked if they wanted to continue with the combined exergame program at the next gathering, all replied yes.

Also the observations confirm that they enjoyed to play and nobody stopped before the exercise program was over (it was repeated several times that they could stop if they wanted).

### Impression of exercise

In the semi-structured interview we asked whether they feel that the exergames were good exercise, with the alternatives very good, a bit good, and no. See figure 7. One said no, three said a bit good and six very good. When asked why we had replies like "it was good for the calves", "good for balance", "good for movement", "moved the joints", "bend, and balance". One said it could have been longer. Most important: all are very positive, and four said that the combination was good.

We also wanted to know whether they found some physical movements in the game especially important for their health. Five replied that the combination was good, one answered the tip-toe, two the knee-bend, one said leg movements, one said balance, one to move the shoulders and one to bend down.

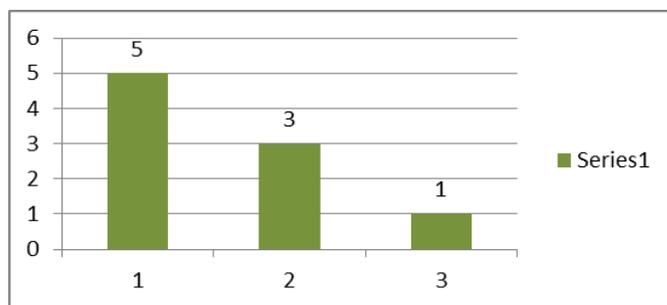


Figure 7 - Do you think this is good training for you? 1-very good, 2-a bit good, 3-no.

The users were also asked if they felt exhausted after gameplay. Here eight replied that they became a little bit exhausted and two that they were not exhausted, they commented that it was tip-toe and or knee-bend that was the most difficult. In the observations we could see that most of the participants got exhausted; they breathed quickly and became quite red. All except one got exhausted and all had to drink water after gameplay.

When asked if they found the mini-games too long, one said yes, and commented that it was the knee bend. Seven found the length of the mini-games suitable and two found them too short. One of those who found it suitable said, "it has to be this much".

It was clearly observed that the length of several of the mini-game were not suitable, especially the picking games where some did not get time to pick any items at all.

### Preferred games

When asked which mini-game they liked the best four said that they like the picking games the best, one the knee-bend and one the tip-toe game. None preferred the leg abduction. See figure 8.

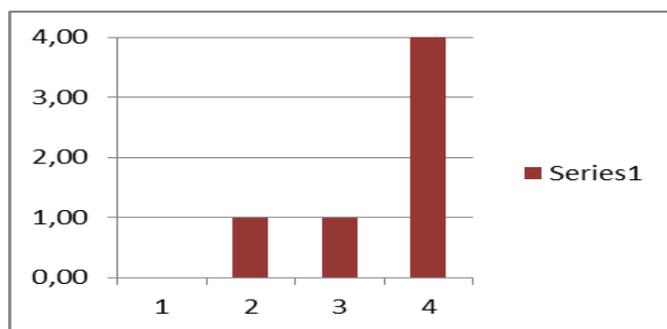


Figure 8 - Any exercise you like better than the other? 1-leg abduction, 2-knee bend, 3-tip toe, 4-picking games.

All commented on this question and five had positive comments on the combined exergame program; combination gave more movements, variation, and they found it "good with variation", "nice with variation". One said that it was nice that they also got to use their arms. One said all mini-games were good. One said; "got a lot out of it".

When asked whether they would prefer to play the apple picking mini-game a longer period instead of the combined exergame program, three replied yes and six no. See figure 9. The ones that replied yes are the ones that have apple picking as their favourite. The ones that replied no commented with; "then I would not get to play the other mini-games", "it would be too monotonous", two want more variation, "want combina-

tion”. One said “the combination makes it more challenging for the brain too” (which they find positive).

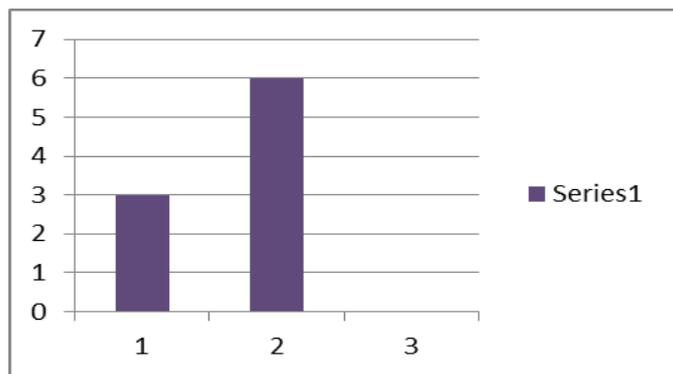


Figure 9 - Would you rather only play the picking games?  
1=yes, 2=no, 3=uncertain.

### How they managed changes

We had no direct questions about this, but we could clearly observe that the players did not have any problems with the changes.

### Information between and after games

The players were asked about how they like the scenes between each mini-game, where a farmer non-playing character asks for help to gather potatoes, give water to the cows and so on. The text was in Norwegian but the voice was in English. Here two were positive, four were neutral and three were negative. Some said it would be ok if also the voices were in Norwegian, two said it was childish, two had not noticed it, one had not given it a thought, and one could not see it due to bad eyesight.

We observed that they do not pay any attention to the scenes between each mini-game, where the farmer asks for help, they just use that time to rest and get their breath back.

When asked if they were able to see and understand the overall summary at the end, three replied yes and seven no. The ones that said yes also comments on their actual score, so maybe they believed the authors expect them to remember the score, and said no if they had forgotten it?

In the group discussions the two summary pages where the current game score was compared to the average of the last five games that day, and to the average of the last ten days, were discussed. Many said it was too complicated to understand, and said they rather would see the sum of each mini-game on the last page.

From the observations we could see that many but not all look for the overall score at the summary in the end to check how well they did it. When they have the role of a cheering audience they study it in more detail. Several just ask “are we finished?” and go for the chair before the last screen is shown.

They all listen more to the sounds and dialogues in English, than they read the Norwegian dialog text or see things on the screens.

Since the mini-games were part of a garden game story, we also asked whether they felt they were doing garden work or that they were playing a game, all except two responded playing a game. One said as a comment that it was perhaps garden work too, but in a way that he might have wanted to please the authors. Here two did not respond, and one of those said she

thinks most about holding on to the chair so she does not fall. One replied she plays it for the game points.

### Tips for improvements

The players also gave valuable comments on how to improve the mini-games to get it more fun and make it more challenging. Many mentioned that several levels are important, some wanted to be able to play two and two.

### The second test

In the second test we had a twelve minutes long program with all the mini-games. This time we had no semi-structured interviews, just observations and a group discussion, but in the group discussion we posed the same questions as in the interview in the first test. We also played the game without helping them unless they asked for help.

### Exercise program

All seven of the players agreed that they liked to have an exercise game program made up of different mini-games, they replied good, very good, or good with variation on this question.

It looked like they enjoyed playing the combined exergame program. Comments like “I want to play one more mini-game” were common.

At the end our users discussed what they would like to do at the next gathering, play the exercise program or one mini-game at a time? All agreed that they would like to play this combined exergame program at each gathering but they were worried that it would be much waiting time in the semicircle then.

### Impression of exercise

When asked how they found the length of each exercise; all said that now it was good. Then the users started to discuss the difference between playing at home and here in a group. All agreed that now the length of the whole exercise program with twelve minutes was suitable for home use. But here in the group, it became too boring for those that watched if one player was to play that long before the next player gets their chance.

The users were asked if they felt exhausted, some said they got very exhausted, and some said they became a little exhausted. They said that the knee-bend and then the tip-toe were the most exhausting mini-games. When asked if they feel that the exergames are good exercise, some said yes and one replied that for him it was not good exercise. The others agreed that for him it was easy, he should have played on a higher difficulty level.

From observation the length and difficulty of each mini-game was more suitable, they had the time to get into it and at the same time it was not so long that they got too exhausted.

### Preferred games

When asked if they liked any of the mini-games better than the others, five said that they like the apple picking mini-game the best, one the chicken picking and one the cut-corn game.

### How they managed changes

It seemed that they did their very best on each mini-game now that they had learnt that they were not too long.

There were also very few playing errors, and the help needed was often because they did not get the chance to figure it out by themselves before the audience came with helping hints.

### **Information between and after games**

The players paid more attention to the instruction scenes than before, now that they knew they would not get so much help. The scenes between the mini-games are as in the first test more used to rest than to look at. But they do look at the mini-game result at the end of each mini-game and often comment on it too, since it was a new version with summary of the exercise program as they had asked for.

The overall new summary has a lot of information, the summary of each of the seven mini-game was interesting for some, but not for all. All were interested in the overall summary of the seven mini-games played, and commented on it; some of the teams of two players got a diamond and some a gold goblet.

### **Discussion**

The exercise program in the first test only lasted for 4.5 minutes, and in the second test each player played for six minutes twice with a break between the sessions – since the full program was twelve minutes. Many said they were a little exhausted, versus the observation that they were quite exhausted. It could be that they do not want to admit that they are in a bad shape, so they tend to underreport.

Two users got very exhausted by observation in the first test; they did not participate in the second test. On the other hand one user did not get exhausted neither by observation nor in own reporting, he is 81 years old and is still in a very good physical shape. The tests were run on difficulty level 1 (easiest) for all, and the authors have earlier observed that this participant masters the most difficult level (level 4), but even this level does not make him exhausted. The importance of the correct game levels were also pointed out in the group discussion at the second test. To have a choice between levels is considered to be extremely important by the participants, and we will add that this also applies if exergames shall be used with success at home by a large user group.

It seems that the participants like the combined exergame program, especially the chance to do a variety of movements and exercises. They are frail and many have problems with one or two of the mini-games, but when they do several, at least they did one that they could well. This was important due to the audience. This was also supported in the interviews; one said the combined exergame program was easier than playing only one of the mini-games.

One big difference between playing the exercise program and playing one game at a time was the menu/button interaction required to be performed by the user. Typically a commercial exergame starts by pushing a start button, and after some calibration scenes, the users go to the menu and choose a mini-game to play. After the game is finished the user again has to go to the menu and start a new game. Our user group finds all this navigation annoying. The exercise program starts automatically, with no calibration or menu interaction. The first mini-game starts when the camera detects a user in the playing area, and the next one in the sequence automatically starts after the previous is finished. (The calibration was done in the initial

setup, and marked with a tape on the floor.) The user was in the control and did not need the activator to start the next game. Although not asked for in the questionnaires nor in the discussions, the authors think the automatic aspect added to the satisfaction score and that it also made the players say that the exergame program was suitable for home usage.

To the best of our knowledge there are not many research projects that have done long-term tests on elderly users in their own setting, and those we found that do [8, 10] or plan to do this [11] have given the elderly users the task of choosing the mini-games that they think will make up a good exercise program for them. They report [10] that the users play their favourite mini-games more often than those they like less... Our trials show that given a mixed program, the players will play through all and thus get more varied exercises. They also do not mind to play those games they are not so fond of as long as they are mixed with the most preferred games.

It is warned about giving the elderly users the chance to play commercial games before they try out the game to be tested [9]. This pre-experience indeed gives the users a knowledge that may give other comments to the game to be tested, but in the authors' opinion this is good. The user group knows that the project developed exergame is different than the commercial ones, it has one focus point at a time, not too high speed and it has tailored movements that are made to enhance the balance and give more strength. Also our participants knew that they were taking part in user centred design and development, and that their input was important for the final result. In the user group all except one prefer to play the project developed exergame and not the commercial ones. This is also maybe because the project game is new to them and they have played so long now, that they want to try out new games [8]. They were also aware of the fact that physiotherapists had recommended the game's movements. Last but not least they also think that these games are a bit "their" games.

The last summary page with total results from all the mini-games was seen and understood by a few in the first test, and by some more in the second test. After gaming they often need to get their breath back, and also prepare to change player, so they are not in a mood to get a lot of information. When they have the role of being part of the audience they notice a lot more information on the summary pages. For the experience of playing a combined exergame program compared to playing one mini-game repeatedly, the summary was not so important. The authors assume the summary will become more important when played for a long period, but this has to be checked further.

The initial training of users before testing is very important, and our users spent about six gatherings on this training, and this was in a user group already familiar with exergames. The authors have earlier introduced commercial exergames both on elderly colleges and other groups of old retirees that were not used to playing computer games. This test showed that the concept of exergames is not so easy; your body has to move correctly while you at the same time have to pay attention to the game on the screen. Talking to the participants afterwards revealed that a lot of information was not noticed by them, their minds were occupied with mastering the movements.

We see that also old people like variation, and if the users should play for a long period it should be possible to get to higher levels or even open new mini-games. Since the user

group may not get better physically, higher levels could also mean new game challenges. If the gameplay leads to more physical activity for the elderly, it could also have a positive effect on their physical and mental health.

## Conclusions

The elderly users were very positive to the tailored exercise program both the first and the second time they tried it. The trial has demonstrated that a varied game is more fun than just one game and one movement. In fact they wanted to play the combined exergame program on the next gatherings.

Due to the small user group it is not possible to generalize, but it is natural that variation is perceived as more fun.

These tests were also performed to prepare the ground for the real home tests, now that the project has an exergame with an exercise program with a suitable length and intensity. The users have proven to manage to play it by their own, given that they have learned how to use it beforehand by getting costumed to play exergames using Kinect as input device. Also the interface has been tailored to the user group.

Future work will be refinements on the exercise program and to test it in real home usage for a period. The project exergame was made with game elements that suits elderly users in their first interaction, such as one focus point at the time, simple graphics, and slow speed. The goal is that the exergame shall be fun to play at home for a long time; for this to be fulfilled more long term motivational elements such as more levels, more mini-games, scoreboards, and social elements must be added. Further research is needed on how elderly users can be motivated to play for a long period.

Also the exergame program should be tested with other user groups that have not participated in the design and development.

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