**NTNU – Trondheim**
Norwegian University of
Science and Technology

# Step-based Exergames Used in Balance Training for Seniors

A Usability Study

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Submission date: June 2013
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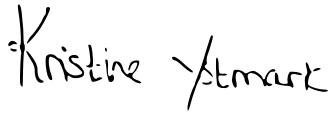
# Preface and Acknowledgements

This study is a master thesis conducted in the last semester of the masters degree program in Computer Science at the Norwegian University of Technology and Science(NTNU). The specialization of the thesis is Software. The research in this thesis is conducted for the Department of Computer and Information Science, in collaboration with the Faculty of Medicine at NTNU and the EU project FARSEEING.
This thesis is completed with help and support form several people.
Firstly, I would like to give a big thank you to my supervisor professor Dag Svanæs at NTNU, for much appreciated guidance and feedback during the whole semester of study, in the spring of 2013.
I would also like to give a special thank you to Nina Skjæret, Beatrix Vereijken and Ather Nawaz in the FARSEEING project for all their valuable help and support during the usability tests, as well as contributions and guidance in writing this thesis.
Appreciation is also given to Senior Engineer at the Department of Computer and Information Science, Terje Røsand, for the instructions on how to use the equipment at the NSEP usability laboratory.
Lastly, I would like to thank all participants who attended the usability tests, pilot tests and the experts at the focus group session for all their valuable input, as well as all the participants attending the FARSEEING meeting for their attention and interest in my presentation of this thesis.



Kristine Midjås Ystmark
Trondheim, Juni 2013

# Sammendrag

Dette er en masteroppgave utført i siste semester av studieprogrammet for Datateknikk på NTNU, med fordypning i program- og informasjonssystemer. Oppgaven ble utført i samarbeid med Det Medisinske Fakultet på NTNU og forskningsprosjektet FARSEEING.
Denne oppgaven har utforsket bruken av kroppsstyrte video spill i balanse-trening for seniorer. I løpet av vår semesteret 2013, ble to forskjellige faser med forskning utført.
I den første fasen ble det uført individuelle brukbarhetstester med 14 seniorer i alderen 65 og over. I disse brukbarehetstestene ble tre forskjellige treningsspill evlaulert. De utvalgte kroppsstyrte spillene var SilverFit systemet, Your Shape på Xbox 360 og en modifisert versjon av dansespillet Dance Dance Revolution for PC. Resultatene fra brukbarhetstestene er basert på SUS spørresjemaer, en kort-rangering, og et semi-strukturert intervju for hver av testene. Ut ifra resultatene fra testene, ble det ble slått fast at det best likte spillet blant seniorene var SilverFit. Det kan også konkluderes med at den eldre brukergruppen generelt er positive til treningsbaserte video spill, men at den potiensielle bruken kan hindres fordi mange eldre har små leiligheter med mye møbler, og kan ha mye annen trening på agendaen. En kvalitativ analyse ble utført på transkripsjonene av video opptakene fra brukertestene. Denne analysen viste at fem ulike spillelementer gjør spill mer attraktive for den eldre brukergruppen. Utfordring, mestring av spillets mål, topplister og progresjon, underholdene konsept og mulighet for at flere kan spille samtidig er spillelementer som er viktige i seniorers preferanse iforhold til kroppsstyrte dataspill.
I den andre fasen av forskning ble en fokusgruppe med domene eksperter holdt. Domene ekspertene hadde utdanning og bred erfaring innen bevegelsesvitenskap og ga en innsikt i hva som var viktige aspekter ved kroppsstyrte spill brukt i balansetrening, fra deres synsvinkel. Videoklipp fra deltakere under brukertestene som ble utført i første fase ble vist for at ekspertene kunne evaluere de tre spillene individuelt. Fra denne fokusgruppen ble det funnet at gøy, sikkert, vektskifte, individuelt bruk, full-kropps bevelgelse og utfordrende konsept var suksesskriterier som eksperter ville stillt til spill som skal brukes i balanse trening for eldre. I forhold til de nevete suksesskriteriene var det SilverFit spillet som ble funnet som mest egnet til ønsket bruk. Det ble også nevnt at dette spillet ikke var helt optimalt fordi de ikke ga spilleren noen muligheter for vidre progresjon i spillet.
Denne studien har funnet at nye kroppsstyrte dataspilll må utvikles med spesiell tanke på langvarig balanse-trening og den eldre brukergruppen.

# Abstract

This study explores the potential of the use of step-based exergames in balance training for senior citizens. Three exergames were tested and evaluated by healthy senior citizens to provide a basis for further development and use of these types of exergames.

Three mini games were chosen for evaluation; SilverFit and "the Mole" mini game, Your Shape and the "Light Race" mini game, and a modified version of Dance Dance Revolution for PC. The reason for the choice of exergames to be evaluated, was that all of three games require the player to perform a step-based movement that can potentially improve the player's balance. To collect data to evaluate these exergames, there were two main phases of research conducted. Firstly, 14 individual sessions of usability tests were conducted with senior citizens. Secondly, a focus group session with domain experts in human movement science was held.

The aim of the first phase was to evaluate which of these three selected exergames, was most preferred by the senior user-group and what game elements that contributed positively and negatively to the seniors' motivational factors and preference of game. The aim of the second phase was to explore the aspect of success-factors and requirements that exists for the use of exergames in balance-training from domain experts' point of view.

In the usability tests that were conducted, 14 healthy senior citizens each played the three selected games in a balanced order, and was asked to give their opinions and preferences afterwards. A card-ranking session and System Usability Scale forms filled out after every game-play showed that it was the SilverFit game that was the most preferred game by seniors. The seniors were also asked what elements that they found important in a game like this for them to take it into use. Through a qualitative analysis of the data form the usability tests, it was found that a challenging of level of difficulty, mastery of game aims, high-scores and progression, entertaining concept, and multi-player functionality are game elements that are important factors if senior citizens are going to use exergames at a regular basis.

After conducting all usability tests, one focus group session was held with two domain experts in the field of human movement science. These experts established that the success criteria for use of exergames in balance training with seniors are fun, safety, shifting of bodyweight, independent use, full-body movement and challenging game-play. SilverFit: "the Mole", Your Shape: "Light Race", and a modified version of Dance Dance Revolution were all evaluated on the basis of recordings from the usability tests. In terms of the criteria established, experts found that SilverFit was the most suitable game, although not optimal, due to the lack of progression in

the game.
After conducting two phases of research and data collection, it can be concluded from this study that new exergames need to be developed specifically intended for regular balance-training for senior citizens.

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# List of Acronyms

**NSEP** Norwegian Center for Electronic Patientjournal

**DDR** Dance Dance Revolution

**Exergame** Exercise game

**COTS** Commercial Off the Shelf

**SUS** System Usability Scale

**NSD** Norwegian Protection Official for Research

**UTAUT** Unified Theory of Acceptance and Use of Technology

**GUI** Graphical User Interface

**TOF** Time-of-Flight

# Part I
# Introduction

# 1 Introduction

This section will introduce the motivation for doing the research, context of use and the research questions formulated to drive the research in this study. In addition, the research methods used as well as limitations and ethical issues in the the study, will also be presented briefly before providing a readers manual for the whole thesis.

## 1.1 Motivation

Predictions of the development of our population expects that in the next 40 years the largest growth in the world population will be in people in the age group of 65 years and older. This is the phenomenon of what we refer to as "the Wave of Elderly" in Norway. It is even depicted that the senior population will become twice as large as the younger population(Secretariat, 2007). This growth in the senior population will lead to major healthcare expenses for the society, as the need for professional healthcare, institutionalizations and hospitalizations increases. With the potential of contributing to lower the healthcare costs, there is therefore a need for a cost-efficient way of treating the most common health problems among seniors such as improving balance and reducing their risk of falling.
Physical exercise is a factor in everyday life that has important benefits and has been known to have the potential of improving the health and general wellbeing of all individuals . In the senior age group, physical exercise is also associated with reducing the chance of cognitive decline (Yaffe et al., 2001), and lowering the risk of contracting chronic diseases (Taylor et al., 2007). Rehabilitation in hospitals due to common injuries and health problems among seniors, are expensive and require a lot of time from both the patient as well as the health care system itself. Many patients are given an exercise program to follow closely in their own homes. For many individuals, compliance with big life-style changes such as physical activity or a customized rehabilitation program is often hard to achieve (Wisløff et al., 2006; OUERAD et al., 2008). Compliance with rehabilitation programs has shown to be closely related to the individual's follow up by their physical therapist (Boyle et al., 2012; Metzger et al., 2007). These mentioned challenges opens up for an alternative treatment option that can be long-term, economically feasible and lets the physical therapists follow up their patients' exercise routines from the clinic.
Playing video- and computer games has for the most part been considered as a lazy leisure activity for children only. However, the popular commercial motion-sensing technologies such as Nintendo Wii, PlayStation Move and XBox Kinect, has triggered the concept of full-body games. Full-body games allow the player to be physically

active while controlling the activities in the game. When these games are used in the purpose of exercise, these games are called *exergames*. Such games can for example include mimicking activities such as bowling, zumba, volleyball and various other sports and activities.
To motivate seniors to become more active, the incorporation of exergames in physical therapy is a growing trend(Lange et al., 2010b). Researches have found that there can be a range of benefits in using motion-sensing technologies and interactive games in physical therapy. Lange et al (2010a) found that while traditional physical therapy programs may be difficult to comply with, therapy related to interactive games are designed to be entertaining and motivational and therefore may increase the amount of time the user spends in physical activity. In addition, playing interactive games can promote social interaction with others, and can be very useful in for example nursing homes or at social occasions in a patients home.
Lange et al(2010a) also highlights that using interactive games provide the benefit of being portable as well as being affordable, and therefore, these technologies can be used both in a clinic as well as in a home setting by a range of patient user-groups. If used in a patients home, motion-sensing technology can provide unrestricted frequency of treatment without a specialist present. Although the commercial off-the-self(COTS) technologies available today lacks specificity in rehabilitation, they have the advantage that they are available in many stores at a relatively low cost, compared to traditional physical therapy. The advantages of low cost, as well as portable equipment makes technologies have great potential for use in i a patient's home.
This study explores the use of motion-sensing technologies and step-based exergames to motivate senior citizens to increase their physical activity and prevent future falls by combining entertainment, balance-training and exercise. Three different game concepts are evaluated. The games selected are all exergames that require the user to take steps with their feet to control the game. The reason for the selection of games is the potential clinical effect of reducing the player's risk of falling by training their stepping skills and thereby improving the player's balance. The concept of the games as well as the technology used is described in section 11. The focus of the evaluation is on the elements of the specified exergames, and not the particular technology equipment required for home use.
The primary goals of this study is to evaluate which of the three games that senior citizens prefer to use in their everyday life as well as what game elements that can provide motivation for use, and what makes an exergame successful in fall prevention training.

## 1.2 Research Questions

With the goal of exploring the potential of using step-based exergames in fall-prevention for senior citizens, four research questions have been formulated to drive the research in this study. The three first research questions are formulated with respect to the seniors user-group's point of view, and the fourth research question is formulated with respect to domain experts' point of view.

1. *Which of three selected exergames are preferred by senior citizens?*

   To answer this research question a number of usability tests are conducted. These tests will be hands-on usability assessments where all test subjects will try out all of the three selected games. The exergames will be presented in section 11. Participating in the usability tests will be people in the senior user-group of 65 and up.
   The answer to this specific research question will be based on the participants answers to a System Usability Scale questionnaire filled out for each individual game, a card ranking of the selected games and observations during game-play. In addition to providing the answer to this research question, the usability tests will provide an empirical basis that will answer the second and third research question as well.

2. *What motivational factors exists for senior citizens in the use of exergames?*

   Concerned with motivational factors, this research questions explores what influences senior citizens in the use of exergames as a tool in balance training. The question also addresses how the motivational factors contribute negatively or positively to the future use of exergames.
   The answer will be based on a semi-structured interview(see section 7.5) based on the unified theory of acceptance and use of technology(see section 8.4) conducted during the previously mentioned usability tests.

3. *What game-elements are important contributors to the senior user group's preferences and potential use of exergames?*

   The third research question explores the "why-question" of the first research question. The focus is on finding out what game elements that make the users prefer one game over another and vice versa, as well as exploring what factors are important for the senior age group to use the games in their everyday

life. This will create a basis of what game elements that should be included when developing new exergames for seniors. The usability tests mentioned under the first research question will also be used to answer this question. A qualitative analysis will be conducted on the data collected through semi-structured interviews of the seniors after playing all three of the step-based exergames.

4. *What success criteria exists for exergames for seniors from domain experts point of view and how do the three selected exergames score in terms of these criteria?*

   The focus of this research question is to establish what factors are required for the success of exergames for balance-training, from a domain expert's point of view. To address this question a focus group session will be held in the weeks following the above mentioned usability tests. Attending the focus group is an expert panel consisting of physical therapists and experts in human movement science. Results from the previously conducted usability tests will be presented in this focus group so that each of the three games can be explored in terms of quality and utility.

## 1.3 State of Knowlegde

With the availability of new motion-sensing technology and game consoles, new audiences have been targeted. Since the introduction of the Nintendo Wii, the age range of the user-group has become wider. The amount of players in their forties and fifties has increased, due to the social aspect of the games for the Nintendo Wii. Research also shows that the use of full-body games have been widely accepted by senior citizens(Theng et al., 2009). It has also been shown that exergames has had positive effects on the general well-being of seniors in institutions(Jung et al., 2009) as well as contributing to reducing the risk of subsyndromal depression among senior citizens(Rosenberg et al., 2010). Ijsselsteijn et al. (2007) states that

*"Digital games hold a significant promise for enhancing the lives of seniors, potentially improving their mental and physical well being, enhancing their social connectedness, and generally offering an enjoyable way of spending time".*

Sugarman et al (2009) published a study where he used the Nintendo Wii Fit

as an additional tool for balance training which gave increases in balance and self-confidence. Several other researchers (Young et al., 2011; Bainbridge et al., 2011; Pigford and Andrews, 2010; Nitz et al., 2010; Gerling et al., 2010) also explores how physical therapy programs including the Wii may be an effective tool for rehabilitation among older adults with balance deficits. Goldstein et al. (1997) found improved reaction times, higher self-esteem and a general feeling of well-being among seniors playing video-games for five hours a week in the timeframe of five weeks. Wollersheim et al. (2010) also report of increased psychological benefits and positive changes in self perception after a study conducted with senior women playing the game Wii Sports twice a week.

Although much research have been done on the game consoles in rehabilitation, other motion-sensing technology has been researched as well. de Morais et al. (2008) presents a game interaction method where the user wears wireless wearable platform to detect movements, which can be used in a variety of applications that can promote physical activity among seniors.

Several studies with the theme of exergames for seniors have been conducted by students at NTNU, such as the research conducted by Young(2010) and Kolbjørnsen (2012). Both of these studies have focused on wether it is feasible to use motion-sensing technologies in physical therapy based on focus groups with experienced physical therapists. Young (2010) conducted a workshop where five physical therapists played the Nintendo Wii consoles and a selection of games. Young(2010) found that although commercial games are only to a small extent applicable as treatment methods in physical therapy due to their lack of customization, therapists are very positive towards introducing the Nintendo Wii as a tool in future work. While Young (2010) only used the Nintendo Wii in his study, Kolbjørnsen (2012) extends his research to include the PlayStation Move and Microsoft Kinect technologies in addition to the Wii. In his study, Kolbjørnsen (2012) finds that the most promising area of study is the motivational, social and tactile aspects. He also includes a list of guidelines for developing games for the use in physical rehabilitation. Because both of the previous studies has found that the typical commercial games are only to a small extent applicable or not at all applicable for the use in physical therapy, this study will include exergames that are modified or developed especially for the senior user-group as well as focusing more on the motivational aspects of the seniors themselves.

## 1.4 Context of Use and Project Scope

This section will describe the context for the use of the exergames explored in this study, this includes who are the intended users of the games and in what situations of use that are relevant.

### 1.4.1 The Fall Problem

Fall is a very common issue among people in the age group of 65 years and older, and is the most common cause of injury in this age group (Campbell and Robertson., 2003). Statistically, approximately one third of healthy adults in this age group will experience on average one fall incident each year (Campbell and Robertson., 2003). The main concern is that the number of falls and the resulting consequences caused by the falls, increase dramatically with age. Falling can have severe consequences for the individual him/herself as well as imposing enormous costs on the society. Consequences for a senior person's fall includes trauma, pain, reduced functioning, and weakened confidence when performing everyday tasks, loss of independency and even death (Campbell and Robertson., 2003). Economic consequences for the society grows as the frequency of falling increases, because many incidents of fall leaves the individual to be in need of long-term care. These healthcare costs can be largely reduced by exercising and the training of balance to reduce the risk of falling.
Contributing risk factors to most fall incidents are reduced strength, flexibility, reaction time and balance. Seniors, even in their 90's, can reduce the risk factors to gain stability and avoid falling. Other benefits of physical activity include lower death rates and improved physical health and function as well as better sleep and sense of well-beingCampbell and Robertson. (2003). To improve stability, a specific, safe and well tested exercise program is required. It also requires much commitment and compliance by the senior person.
This study explores the opportunity of using step-based exergames as a tool in fall-prevention among seniors.

### 1.4.2 Target Users

For this study the intended end users of the exergames explored are senior citizens above the age of 65, that are in the fall-risk group. This means seniors that are in need of training their stepping-function to prevent future falls. Seniors as target users will be further elaborated on in section 5.

### 1.4.3 Situation of Use

In terms of the context of use of exergames, this study will focus on the games themselves rather than the use situation. The exergames can be used in a clinic or an institutional situation, but the ideal situation of use is in the home. Balance-training should be a frequent activity, and the exergames should be easily available at all times for the user. The usability tests are conducted in a laboratory environment and does not resemble a home environment. The potential of home-use of exergames will be explored only in small detail during the post-test interviews in the usability tests. Researching the use of exergames in a home situation would require extensive field research from senior citizens home environment and is out of scope in this study.

## 1.5 Research Methods

This study will include a range of qualitative as well as quantitative research methodologies in order to collect data. The research will be conducted in two different phases. In the first phase, the primary research will be conducted during actual usability testing sessions with senior people in the age group of 65 and upwards. During the usability tests, data is collected through observations, questionnaires, semi-structured interviews and card rankings. The observation is conducted when participants are asked to play a selection of three step-based exergames and includes participants' movements, conversation and opinions during game-play. The three exergames selected for evaluation are:

1. The SilverFit system with the mini game "the Mole".
2. A modified version of Dance Dance Revolution for PC.
3. The commercial exergame Your Shape with the mini game "Light Race" played on Microsoft XBox with Kinect.

In the second phase of research, a focus group session is held with domain experts in the field of human movement science. In the weeks following the usability tests conducted in the first phase, this focus group will be held to address the potential clinical effects and success factors of step-based exergames from domain experts' point of view. Participating in the session will be domain experts in the field of physical therapy and human movement science. From the focus group session data will be collected through an unstructured/semi-structured interview.
A detailed description of research methods used will be given in 7 and the research design of the study will be presented in section 10.

## 1.6 Limitations and Ethical Issues

To avoid the many ethical concerns related to sensitive information and the long process of applying for permission to ask participants to provide information about their health, this study will include research among healthy, active senior citizens only. That is, no actual patients with a specified rehabilitation program will be involved in the research and no sensitive questions about health will be asked. All the senior citizens who participated in this study all attended the usability tests voluntary and were asked to sign a written consent form(see appendix B) at the beginning of each test. In this consent form, the participant gave their consent to be video recorded during the session.
The comments and statements cited by participants in this study have been translated from Norwegian to English, and might therefore not be exact citations directly from the participants. The participants were all very active and eager to try new things, this may not be the case for all people in their age group. The number of participants used in this study is too few to be representative for the whole intended user group. Limitations and validity will be elaborated more on in section 22.
The study protocol for the usability tests was approved by the Norwegian Protection Official for Research(NSD). The application that sent and approved by the NSD is included in appendix C. The video recordings were only used by the people collaborating in the project. All transcriptions and video recordings were kept on private password protected computers, and will be deleted at the end of the project.

## 1.7 Readers Manual

*Part 2 - Background: Games for Elderly* gives a brief introduction into the underlying background theory for this study.

- Section 2: Defines motivation in the relevant context.
- Section 3: Gives a brief introduction to serious games and the concept of gamification.
- Section 4: Describes the concept of computer- and videogames used in the healthcare context.
- Section 5: Explores seniors as target users of exergames specifically.
- Section 6: Presents relevant technologies that have been used for the exergames in health purpose.

*Part 3 - Research Methods and Research Design* Presents how the research of this study was designed.

- Section 7: Describes relevant research methodologies for this study.
- Section 8: Describes the concept of technology acceptance and presents the framework of the Unified Theory of Acceptance and Use of Technology.
- Section 9: Addresses the validity of the research and methods for data collection.
- Section 10: Presents how the research of this study was designed.

*Part 4 - Research Procedure and Results: Usability testing* The procedure and results of the usability tests.

- Section 11: Explains the three different game concepts evaluated in this study.
- Section 12: Describes the planning of the usability tests.
- Section 13: Presents how each of the usability tests were conducted.
- Section 14: Addresses any problems or issues arising in the usability tests.
- Section 15: Presents the findings and results from the tests.

*Part 5 - Research Procedure and Results: Expert Evaluation Workshop* The procedure and results of the workshop held with domain experts.

- Section 16: Describes the participants and location of the workshop.
- Section 17: Presents how each of the workshop was conducted.
- Section 18: Presents the findings and results from the workshop.

*Part 6 - Discussion and Reflections* Analyzes the results from the focus group session and the usability tests.

- Section 19: Discusses the results in relation to the stated research questions.
- Section 20: Discusses the results of the research questions in relations to each other.
- Section 21: Explains how the results compare to prior theory and research.
- Section 22: Addresses the validity of the conclusions and results.
- Section 23: Concludes the study.

# Part II
# Background: Games for Elderly

# 2 Motivation Defined

Why do people behave as they do? To explore how to influence and motivate people to comply with an exercise program, continue to do balance-training, or play an exergame, it is important to address the concept of motivation.
Motivation is defined by the Psychology Dictionary(Cherry, 2010) as:

*The process that initiates, guides and maintains goal-oriented behavior.*

The concept of motivation is often used to describe why a person does something. Motivation involves the biological, emotional, social and cognitive factors that drive peoples behavior and choices every day. Ryan and Deci (2000) argue that people not only have different amounts of motivation but also different orientations of that motivation, which means that the nature and focus of peoples' motivation can differ. The theory of self-determinism(Deci and Ryan, 1985) distinguishes between the concepts of intrinsic and extrinsic motivation. Intrinsic motivation refers to doing something because it is actually is experienced as interesting or enjoyable, while extrinsic motivation refers to doing something because the activity leads to a separate outcome. For example one might exercise with an intrinsic motivation because it is fun and feels good or one might exercise with extrinsic motivation because the exercise makes you fit, or you want to win in a sports contest. Most often it is a combination of both intrinsic and extrinsic motivation that makes us do something. The difference in these two types of motivation has been widely discussed in relation to learning and education(Vallerand et al., 1992; Harter, 1981). In terms of education, intrinsic motivation is defined a student's inner motivation to engage in a task to improve his/her skills, whereas extrinsic motivation refers to the motivation caused by external factors such as rewards(grades, money, etc.) or in threat of a punishment.
The concept of motivation has also been addressed in relation to information systems research. A large amount of research in the field of human-computer interaction supports the importance of perceived ease of use and usability as a construct in motivating users to use a specific information system(Norman and Dunaeff, 1994; Gould and Lewis, 1985). Venkatesh (2000) argue that while much research includes the extrinsic motivation with the perceived ease of use construct, little research has been conducted on the intrinsic motivational factors. Venkantesh(2000) therefore introduces the concept of computer playfulness to describe the user's intrinsic motivation to use a system. Computer playfulness is the concept of using a computer system because one enjoys the process of using it rather that using it because it is effortful.

## 2.1 Player Enjoyment in Games

A person's intrinsic motivation to play a game is related to actually enjoying the process of playing the game. One of the most important factors in why video games and computer games succeed is the that their players actually enjoy playing the game and therefore have an intrinsic motivation to play. If players don't like playing the game, they will not play it. A big challenge for game developers is therefore to make the game as enjoyable as possible, as well as motivating the players to continue playing the game over time.
Radoff (2011) provides four principles that can be used to motivate players in any game. These principles include immersion, cooperation, achievement and competition. Immersion relates to the player's sense of connection to the world of the game. Achievement is the concept of awarding the user with a sense of progress in throughout the game. Cooperation is when the user has the ability to help or interact with other players of the same game. Lastly competition relates to how the players evaluate their game performance in comparison to each other.
Schell (2008) stresses the importance of giving the user an experience during gameplay. The experience of a game is characterized by specified rules, problems or puzzles to be solved, and a consistent theme that unifies the game experience. Giving feedback and rewards as the game experience progresses is also of great importance(Schell, 2008).
One of the biggest challenges in game design is keeping the game interesting and relevant enough to make the user continue playing the game again and again. A technique for this is to make the game personalized based on information that the user provides during game-play. The game can also take the player to new "levels" as he/she masters the concept of the game or reaches specified goals(Khaled et al., 2007). Khaled et al. (2007) also defines two game design techniques called tunneling and reduction. To take the player through events in a specific order is called tunneling, while reduction is defined as removing unnecessary information.
The use of game design elements depends on the focus one has. The purpose of drag-and-drop and timers is interaction, while learning is the focus of quests and repetition. Lastly some elements such as tunneling, reduction and personalization has the goal of persuasion.

While the above mentioned theory presents heuristics about gameplay, Sweetser and Wyeth (2005), presents a model that can be used for the purpose of designing, evaluating and understanding the concept of enjoyment in games. This model is called the *GameFlow* model and is based on the concept of flow. Flow was defined by Scsikszentmihalyi (1990) as:

*An experience that is so gratifying that people are willing to do it for their own sake, with little concern for what they will get out of it, even when it is difficult or dangerous.*

Scsikszentmihalyi (1990) presents eight elements which, if combined, results in a strong feeling of enjoyment for a person. Based upon these eight elements, Sweetser and Wyeth (2005) presents eight elements applicable for enjoyment in games:

- Concentration
  Some kind of stimuli must be provided by the game, such that the player finds it feasible and worth paying attention to.

- Challenge
  The player should feel challenged when playing the game, and the level of challenge should increase as the player's skill-level increases.

- Player Skills
  Games should be easy to learn, and should support increasing the player's skill as the game progresses.

- Control
  Players of the game should feel in control of the activity in the world of the game. This means that players should feel like they have control of their interaction with the game.

- Clear Goals
  The aims of the game should be stated clearly at the right times.

- Feedback
  Information about the player's progress towards the stated goals should be given along the way. A score or status should be known at all time.

- Immersion
  The player should be able to "get lost" in the game, so that the surroundings around the player get less important.

- Social Interaction
  Games should support interaction with other players.

Chen (2007) describes how combining the above elements will bring the player into a Flow Zone. An illustration of the Flow Zone is shown in figure 1.

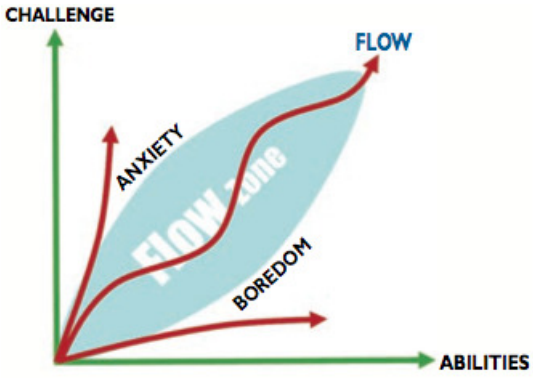


Figure 1: Flow Zone

Sinclair et al. (2007) provides a modified version of the flow model specifically for exergames, this model will be described in section 4.4.

# 3 Serious Games and Gamification

In the previous section intrinsic and extrinsic motivation was defined. This section explores how a combination of these two types of motivation can be used in games to encourage other purposes than the purpose of just playing games for fun.
Playing computer- and video games has for several years been a very common leisure activity, especially for children and young adults. As the technology has advanced in recent years, electronic games have also captured the attention of researchers. Research shows that the intrinsic motivation(see section 2) that the young people show towards these electronic games can be combined with educational and serious elements into what Prensky calls "digital game-based learning" (Prensky, 2001).

## 3.1 What is Gamification?

An emerging trend in today's consumer market is software that takes inspiration from video game design. This trend has been identified as the phenomenon of gamification. Deterding et al. (2011a) defines gamification as:

*The use of game design elements in non-game contexts*

Gamification incorporates the idea of using game design elements to motivate and increase user activity in software. By non-gaming contexts Deterding et al. (2011b) refers to using games in contexts other than just for simple entertainment. Gamification has been used in several different fields, including education, military defense training, finance, exercise and productivity. Currently the term "gamification" compromises two concepts.
The first concept is the incorporation of video games into people's everyday life. When the social adoption of video games to shape our daily life is increasing, this is a trend referred to as Gamepocalypse by Schell (2010):

*"When every second of your life you're actually playing a game in some way"* .

Secondly, the term compromises the use of elements from game design that originally are intended for the purpose of entertainment primarily, to motivate and engage users in non-gaming software. Deterding et al. (2011a) argues that gamified applications only incorporate elements of game design, and may not be full-fledged games. A figure explaining Deterding et al.'s definition of gamification is shown in figure 2.


Figure 2: Detering's definition of Gamification

Deterding et al. (2011a) describes game elements in five abstraction levels than can be used in gamification:

1. Level 1: Game interfaces and design patterns
   The use of previously used successful interaction design elements and solution to known problems. This could be elements such as different levels, badges or high-score lists.

2. Level 2: Game design patterns and mechanisms
   Parts of game design that reoccur often in game-play. Examples are timers, resource restraints, and the taking of turns between players.

3. Level 3: Game design principles and heuristics.
   Following guidelines to approach a design problem. Continuing game-play, clearly stated goals and several choices of how to play the game are examples of this.

4. Level 4: Game models
   Themes or conceptual models of gaming experience. This could be challenge, adventure, fantasy or curiosity.

5. Level 5: Game design methods
   Use of game specific development practices such as play-testing or play-centric design.

### 3.1.1 Example of Gamification: Badges and Rewards

Awarding badges as rewards for user activity is one example of gamifying online experiences (Antin and Churchill, 2011). Antin and Churchill (2011) define badges as digital artifacts seen as virtual goods that are awarded to users who complete specified activities. Badges are extrinsic elements created to increase the user's intrinsic motivation. Sites such as Wikipedia, StackOverflow and Fitocracy use badges as a way of motivating users to engage. Fitocracy(www.fitocracy.com) is an online exercise forum that engages users to track their exercise routines by rewarding badges and levels as the user reaches goals. For example is the user rewarded a badge when he/she has run 32km.

Antin and Churchill (2011) combines the psychology and human-computer interaction field and finds five functions for these types of reward systems. The primary function of the badge is goal-setting. The badge motivates the user to reach some predefined goal. Users get motivated by getting feedback on their progression towards the goal, and may increase their effort when they know that they are close. Badges can also be instructive, by providing information about how to use a system or show what activities that are possible to perform. Antin and Churchill argue that badges can represent the social norm of the system by guiding the user to activities that are valued highly. Thirdly, badges represent the individual user's experience with the system or his/her set of skills which again represent a reputation among the other users of the system. Badges can also help create status for a user. It is a way to remind the user of his/her achievements and show their success of to others . Lastly, badges contribute to group identification as a common set of goals that bind the users together.

## 3.2 Serious Games

The notion of games used for serious purposes has been around since the 1980's (Abt, 1987). Abt (1987) explores how games can inform and instruct as well as being enjoyable, both at the same time. Bergeron (2006) gives these types of games the name serious games. Serious games are defined by Ritterfeld (2009) as:

*ÒAny form of interactive computer-based game software for one or multiple players to be used on any platform and that has been developed with the intention to be more than entertainmentÓ.*

Serious games are by this definition games that serve more serious purposes than just entertainment. These purposes can include education, advertisement, health

and research. Wiemeyer and Kliem (2012) argue that compared to normal games, serious games has the potential to increase competencies such as strategic thinking, emotional control and motor control, while at the same time giving the player a sense of fun, motivation, flow, immersion, presence, and challenge.
Serious games have also taken new technology into use. New motion-sensing technologies such as the Nintendo Wii and the Microsoft Kinect(see section 6 for a description of these technologies) has given rise to the concept of full-body games. Full-body games lets the player control the game with movements with his/her body. Full-body games can be used for the serious purposes of for example exercise or rehabilitation. When used for exercise, these full-body games are called exergames(Sinclair et al., 2007). Exergames will be further elaborated on in section 4.4.

# 4 Health Games

Computer- and video games has in recent years been used in several different areas of health care (Papastergiou, 2009). Health games is a collective term used to cover all games that are designed or used for all types of healthcare purposes. These types of games are serious games(see section 3.1) used for some kind of healthcare purpose. The medical objective can either be intrinsic, as part of the game's theme or extrinsic as a totally separate part of the game.

Lieberman (2001) highlights six potential benefits for using electronic games in health:

1. Games can incorporate interactive actions. Experimental learning can help enhance the player's self-efficiency and behaviors related to health.

2. Games can be more motivational than traditional health care education when it comes to young people.

3. Games can provide individual feedback to the player.

4. Games can support individual progression at the player's own pace.

5. Games can provide external motivation by providing social interaction and social support with the game and with others around it.

6. Games can support unlimited repetition of exercises and skills that can later be used in real life.

The target users for health games can be narrow or broad(McCallum, 2012), depending on the desired health outcomes that will be achieved by using the game. Health games can be designed for a specified outcome such as rehabilitation from a specific injury, or it can be designed for a more general outcome such as increased physical activity. Although much research has been conducted on using games in healthcare, Kharrazi et al. (2012) finds that most of this research focuses on the younger male demographic and stresses the importance of focusing on females and elderly as well. Health games can come in several different forms: educational games, behavioral games, cognitive games, exercise games and rehabilitation games. The differences between these types are not absolute. For example a game designed for the purpose of exercise, can include educational aspects.

## 4.1 Educational games

Educational games are serious games that aim to inform or teach the user about something about health. This can include informing the user about different diseases, food and nutrition, or other healthy behavior. These games are often useful as patients with chronic conditions, such as diabetes, often need to take in a lot of new information about their disease.
A variety of different educational games have been developed due to the fact that there are such a large range of different diseases and user groups. Beale et al. (2007) reports on an adventure game aimed to provide young cancer patients with knowledge about their illness. The goal of the game was to complete different missions by killing cancer cells with different kinds of weapons. The game had the look and feel of a commercial video game, and was well-accepted by the sample of patients tested. Munguba et al. (2008) found good results with a game teaching obese children about the food pyramid, where the game's avatar changed with the calorie intake as the player picked food for their daily diet.

## 4.2 Behavioral games

Games that aim to instruct the user in specific behavior are categorized as behavioral games. These games can for example be about instructing users on how to correctly use a medication. Behavioral games are aimed at creating enhanced health-related knowledge, attitudes, independence when it comes self-care behavior, and social interactions for the target audiences. Behavioral games are also called pervasive games(Fogg, 2002), as they persuade the player to change their habits.

Kato et al. (2008) conducted a study that showed increased adherence to medication among young cancer patients using a video game that addressed issues of cancer treatment. Bartholomew et al. (2000) designed an adventure game for improving asthma self-management skills, that showed a reduction in hospitalizations.

## 4.3 Cognitive games

Another category of health games are cognitive games. These are aimed at training the user's cognitive skills. Many games have been developed to improve memory skills. One example is the game "Dakim Brain- Fitness" (Dakim-Inc) that has been developed to slow down the development of dementia with senior users. Other games are targeted at improving cognitive skills as attention focus and the processing of visual information(Brox et al., 2011).

## 4.4 Exercise games

Exercise games are games aiming to improve and increase the user's physical activity. Full-body video games that is used for the purpose of exercise are named "exergames" by Sinclair et al. (2007). These full-body games require physical movement to complete popular or enjoyable activities. This is made feasible by using motion-sensing technology that require to user to move in order to control the game. Exergames are designed specifically to track body motion and provide the player with entertainment during exercise. Brox et al. (2011) notes that exergames also are categorized as behavioral games, as they aim to persuade the player to exercise more.
Wiemeyer and Kliem (2012) states that these types of serious games have much to offer in the field of physical activity as well as rehabilitation. In his literature review, Papastergiou (2009) summarizes three potential benefits of using exergames:

1. Exergames can increase the user's motivation to do exercise.
2. Exergames can support alternative ways to do physical activity.
3. Exergames can help to prevent the obesity-problem.

There are several exergames available as commercial off the shelf(COTS) games today. These includeYour Shape(see section 11.3), Zumba Fitness, River Adventure, UFC, Wii Fit, Get Fit With Mel B, Dance Dance Revolution(see section 11.1) as well as a large assortment of sports games such as Wii Sports and Kinect Sports. The motion-sensing technology that these games can be played on are described in section 6.
Sinclair et al. (2007) proposes a *dual flow model* based on the GameFlow model described in section 2.1, specifically intended on exergames. The dual flow model for exergames is shown in figure 3. The first dimension of the model encompasses the flow model(Scsikszentmihalyi, 1990), balancing the player's skill with the perceived challenge and models the attractiveness of an exergame. The second dimension on the other hand, models the effectiveness of an exergame. The effectiveness balances fitness and intensity.

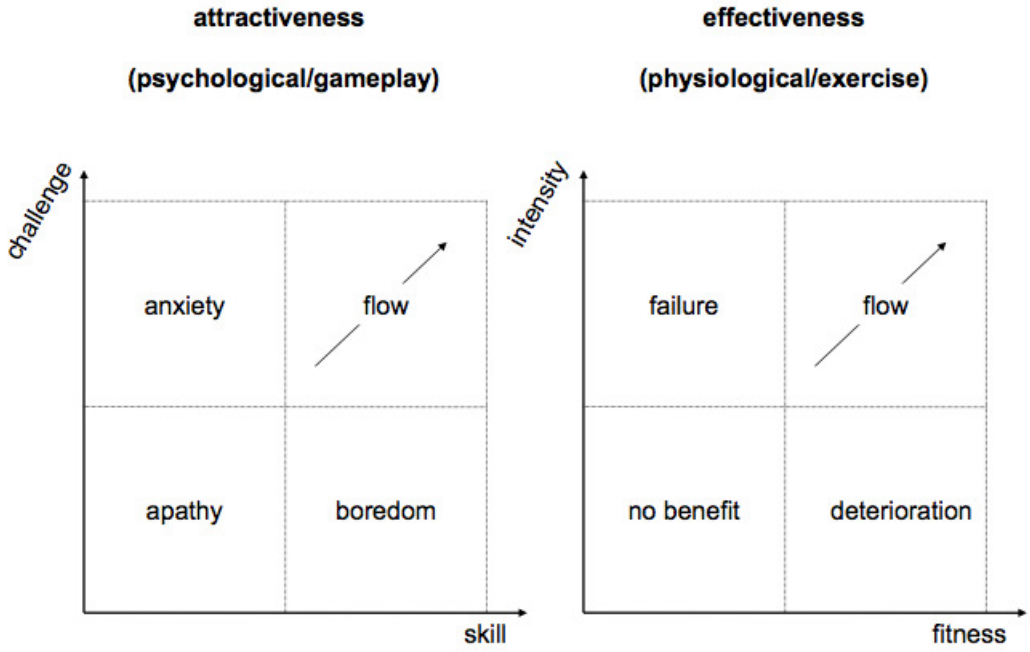


Figure 3: Dual Flow Model

## 4.5 Rehabilitation games

Games developed to help a patient to rehabilitate from a specific injury, are categorized as rehabilitation games. As the technology changes, so does the occupational therapy practice methods. Lange et al. (2010b) has found that using full-body games in physical rehabilitation is a growing trend. Lange et al (2010a) argue that while traditional physical therapy may have poor rates for compliance of the program, therapy related to full-body games are designed to be entertaining and motivational and therefore may increase the amount of time the user spends in physical activity. Patients in need for burn rehabilitation found immersion into the full-body games motivating, as it took the focus away from the players pain of moving, and into the game(Parry et al., 2012). Several studies have also shown good results with using the Nintendo Wii(see section 6.1) as a rehabilitation tool for stroke patients(Saposnik et al., 2010; Deutsch et al., 2009). Deutsch et al. (2009) concluded that the Nintendo Wii technology is a safe, feasible and potentially effective alternative to facilitate rehabilitation therapy and promote motor recovery after suffering a stroke. One

example of a rehabilitation game is the SilverFit system(see section 11.2), that is specifically designed for the intended use in rehabilitation centers. Note that while the games used for this study fall under both the categories of exercise games and potentially rehabilitation games, but they will henceforth be referred to as exergames.

# 5 Seniors as Target Users of Health games

To create efficient health games it is important to identify the target user for the specific game. In this study the target user-group includes senior citizens over the age of 65, which is a broad target audience. This section looks at health games that are specifically aimed at senior citizens and the senior user group as target users for the development of health games.

## 5.1 Designing Game Concepts and Interfaces for Seniors

Because of a big technological gap between the children and young adult user-group and the senior-user group, it is necessary to address preferences and usability specifically for seniors. Aside from the technological gap, the interests of the senior age group are very different to the young age-groups' interests. Brox et al. (2011) emphasizes that the seniors as a target user-group is very different from the young children user-group. While children prefer fancy designs with a lot of information and many alternative paths, the senior user group prefer simple screens with as little information as possible and enough time to get an overview. Although Ijsselsteijn et al. (2007) finds much potential in video games for seniors, it was concluded that many of the commercial games that are available today either experienced as not very enjoyable or unsuitable because of too complicated interfaces. These commercial off the shelf(COTS) games have interfaces that including small objects, fast movement requirements, and fast required reaction times. Complications like these pose a great challenge to the seniors lack of technology experience or functional limitations and can result in large usability problems.
To engage senior users, De Schutter and Vanden Abeele (2008) highlights the importance of intrinsic motivation(see section 2) and flow(see section 2.1). To achieve enjoyment among senior players, De Schutter and Vanden Abeele (2008) argue that digital games should include themes and elements related to elderly life. De Schutter and Vanden Abeele (2008) conducted a field study to discover what passions and enjoyable activities that senior citizens have in their everyday life. It was found that most of the seniors' passions were concerned with being connected with the society and the people around them. To incorporate this connectedness De Schutter and Vanden Abeele (2008) proposes to include multiplayer options. Gerling et al. (2011) finds great opportunities for gamifying seniors' routine tasks to provide an engaging user experience for seniors. Gerling et al. also finds that exergames have the potential to motivate seniors to social interaction as well as providing the medical staff with valuable information about the player. In her research, Gerling et al. developed

the exergame *SilverPromenade* (figure 4) designed to provide frail elderly living in institutions with a form of physical activity. Using the Nintendo Wii(section 6.1) and the Wii balance board(figure 8), SilverPromenade takes the player on a virtual walk in the nature.


Figure 4: SilverPromenade

Gerling et al. (2011) found through the research of SilverPromenade, that the senior users were motivated by garden or nature themed user interfaces as well as the use of animals as main characters. Exploring elderly playing a video game, Gerling et al. (2011) finds differences between seniors that have previous experience with video games and those who don't. It was observed that the inexperienced players had difficulties to understand the connection between the interface and the controller devices. Gerling et al. therefore, proposes that seniors should be engaged in gaming over a longer period of time.

## 5.2 Adaptions to Physical Disabilities

As well as different interests, the people belonging to the senior user group may have a different physical form than people in the younger groups. Aoki et al. (2004) finds that interfaces that are designed for seniors should aim to reduce visual functionality and button presses needed. These interfaces should also be easily adaptable to their age-related limitations such as:

- Reduced sight and hearing functions.
- Short term memory loss
- Less control over movements and longer reaction times.
- Decrements in balance

In addition to the considerations listed above, Gerling et al. (2012) finds that there are a variety of individual differences and range of motion among older adults. Disabilities such as individuals sitting in wheelchairs should be considered with the ability for dynamic versus static movement.

Offering a safe physical activity based on the above considerations for seniors, Gerling et al. (2012) proposes seven guidelines for full-body interaction in games:

1. **Age-Inclusive Design**
   *"Create inclusive games by embracing age-related physical and cognitive impairments."*
   The interaction with the game can be influenced by the player's inability to move some parts of their body. To solve this issue it is proposed to offer gestures that can be performed in different ways. For example a gesture that can be completed either with one or both arms depending on the individual player's impairments.

2. **ROM-Adaptability**
   *"Create interaction paradigms that adapt to individual differences in player range of motion."*
   It is important that the full-body user interface is calibrated according to the user's abilities to account for motion limits and prevent injury.

3. **Exertion Management**
   *"Provide fatigue management and prevent overexertion by appropriate game pacing."*
   Allow the player to relax in periods and reminders to take breaks depending on the player's fitness level.

4. **Dynamic Game Difficulty**
   *"Offer difficulty adjustments between players and individually scale challenges."*
   Allow for different levels of difficulty and challenges, according to the player. The active player must be kept engaged by new challenges and difficulties whereas keeping others from overstraining themselves.

5. **Easy Gesture Recall**
   *"Provide natural mappings and clear instructions that support gesture recall to empower players."*
   The instructions should be easy to understand and use a language that is common for elderly. Avoid additional information and excessive GUI elements. The activities needed for game-play should also easily demonstrated on the

screen and should be closely related to everyday, well-known actives. The users should not have to remember the possible actions from time to time, but should be presented as by affordances in game-elements. It is also recommended to support a small number of gestures that are easily recalled rather than a variety of different possible actions.

6. **Continuous Player Support**
   *"Integrate continuous tutorials and player prompting to facilitate gesture learning and interaction".*
   Let the player have as much time as he/she needs to learn the gestures required in the game.

7. **Simple Setup Routines**
   *"Implement easy menus, startup and shutdown routines to encourage independent play."*
   Prior experience with technology varies with the individual seniors and one cannot therefore assume that there is someone else around to startup the game. There is therefore a need for the game to be easily started up with simple menus.

# 6 Relevant Motion-sensing Technologies

This section will describe a selection motion-sensing technologies that facilitate the use of exergames. This section gives a general introduction to the game-technologies, while the specific exergames that were tested in this study will be described in section 11.

## 6.1 Nintendo Wii

Nintendo released it's fifth gaming console, the Wii(Figure 5), to the consumer marked in 2006(Lee, 2008). With the Wii, Nintendo was the first to introduce affordable motion-sensing controller technology into the homes of people all over the world. One year later the Wii was the market leader, selling over 20 million units around the world (Nintendo, 2008). It's success had much do with the new interactive motion-sensing technology.


Figure 5: The Nintendo Wii

The Nintendo Wii home gaming-console included a motion sensitive controller that can detect three-dimensional movement. The Wii motion controller(figure 6), also called the *Wiimote*, allows the player to control the games by physically moving the remote controller. The Wiimote makes this possible by using a wireless bluetooth technology that allows the remote to connect to the console within a range of 10 meters(Lee, 2008). To infer velocity and position of the Wiimote controller, the controller itself includes a built in accelerometer that sends the acceleration of the

controller to the Wii game console. The second version, Wii Motion Plus, released in 2010 could also detect a player's 3D hand posture. This is made possible by using a three-axis gyro sensor (Tanaka et al., 2012).

Figure 6: The Wiimote

The first attachment to the Wiimote was the Nunchuk controller(figure 7). The Nunchuk can be connected to the Wiimote via a cord to allow the player to interact with the game using both hands. The Nunchuk controller includes a steering stick to allow the player to interact with the game in the same way as previously, for example with the Nintendo 64.

Figure 7: The Nunchuk

The Wii balance board(figure 8) was released on the market in April 2007 (Tanaka et al., 2012) as a part of the Wii Fit package. Wii Fit are activities that are designed

to improve the player's balance as he/she interacts with the game using the Wii controller and the Wii balance board. The balance board is a flat board designed to placed on the ground in front of the game console. It is shaped like a bathroom scale, and includes multiple pressure sensors(Clark et al., 2010) to measure the player's gravity center and weight transitions.

Figure 8: Wii Balance board

## 6.2 Sony PlayStation 3, EyeToy and Move

Sony PlayStation 3 was first released in 2006, as the third game-console in the PlayStation concept. To compete with the Nintendo Wii, PlayStation Move was first revealed in 2009 (Sony, 2009). The PlayStation Move controller interacts with the Sony EyeToy(figure 9).
The EyeToy technology can detect the player's kinematic information using a camera, but due to it's two-dimensional image processing, the information that the PlayStation could use from the camera, was limited.

Figure 9: Sony EyeToy

PlayStation Move also included the Move motion controller(figure 10), which was to be used with the PlayStation EyeToy(figure 9). To track the Move motion controller, the camera detects the size of the sphere attached to the controller to calculate the distance of from the camera. The Move controller also contains a three-axis accelerometer, a three-axis gyro sensor and a geomagnetic sensor to track the rotation and motion of the player (Tanaka et al., 2012)


Figure 10: PlayStation Move controller

The biggest difference between the PlayStation Move and the Nintendo Wii motion-sensing technologies is that the PlayStation Move technology is able to detect

3D positioning.

## 6.3 Microsoft Kinect

The Kinect sensor device was launched in November 2010[1], and consists of an infrared depth-sensing camera, an RGB camera, an infrared laser projector and a multi-array microphone[1]. Microsoft Kinect can be used either with PC or with the game console Xbox 360. The Microsoft XBox 360 motion-sensing technology uses the Kinect sensor device(see figure 11) to track the player's motion.
What differentiates this device from the Nintendo Wii and PlayStation Move described in the above sections, is the Kinect's ability to recognize full-body motion in 3D. It enables the player to control the XBox 360 games without having to hold another controller device. Instead the player's body or speech is the device that controls the games. The Kinect allows the player to control a virtual character on the television screen that directly represents the player's movements and poses in real life. It also differentiates from the Wii and the PlayStation Move in that it only can handle two players at the same time, while four controllers can be used simultaneously with the PlayStation Move. The Microsoft Kinect is also able to recognize voice and facial characteristics.


Figure 11: Microsoft Kinect

In addition to having technical differences with the Nintendo and Sony game consoles, the Microsoft Kinect comes with an open API supported by Microsoft that encourages further development with the device.

[1]http://en.wikipedia.org/wiki/Kinect, Online; accessed 11-February-2013

# Part III
# Research Methods and Research Design

# 7 Research Methods

This section will provide an overview of the research methods used to collect data in this study. Firstly, the overall research methodology will be described, and then the detailed research design will be presented in section 10.

## 7.1 Qualitative and Quantitative Research

Wohlin et al. (2000) presents two main research paradigms; qualitative and quantitative research. Qualitative research concerns the study of objects in their natural environment and seeking to get a better understanding of a case. Quantitative research, on the other hand, is concerned with finding a statistically significant relationship or to compare two or more groups.
Quantitative studies are often conducted by facilitating controlled experiments or collecting data through case studies. Quantitative methods includes survey methods, laboratory experiments, numerical methods and formal methods(Myers, 1997). This can for example be testing a causal relationship by testing hypotheses statistically. Quantitative strategies are appropriate when testing the effects of a treatment or activity, while a qualitative study of beliefs and understandings are appropriate to find out why the results in question are the way they are.
Myers (1997) describes qualitative research as seeking a deeper understanding of a social phenomena, such as human behavior. Qualitative research methods include the use of interviews, documents or observations. In qualitative research, the researcher starts the study with a neutral and open view on the phenomena in question to allow for a theory or context to be revealed by analyzing the data collected(Svanæs, 2000). Methods for conducting qualitative research can include action research, case studies and ethnographical studies. Sources for data collection often includes interviews, questionnaires, participant observations, documents and researcher reactions. The motivation for using qualitative research over quantitative research is for the researcher to get a better understanding of a phenomenon from the target population's point of view. The purpose of qualitative research is finding out what is happening, seeking new insights, asking questions, assessing a phenomena in a new light or generate ideas for future work (Robson, 2002).
This study will use a combination of qualitative and quantitative research methods. The following subsections will describe the methods used.

## 7.2 Usability testing

Usability testing is the most important research method when testing the *usability* of a product. It is a big part of the human-centered design process of interactive systems and the goal is to measure how usable a product is for the intended user-group. The term usability encompasses several concepts. ISO9241(for Standardization., 1998) defines usability as:

*The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use.*

This definition highlights the characteristics that must be measured in order to determine a systems usability. Effectiveness refers to the accuracy in which the users completes specified tasks, this can for example be measured in how many tasks the user can complete. Efficiency is what work is conducted to complete this task, this can be measured in for example time or mouse clicks. Lastly, satisfaction refers to the user's individual attitude towards using the product, this can be measured by using questionnaires or conducting interviews.
The formal method for evaluating these characteristics is called usability testing. A usability test is conducted as a form of experiment where a subject from the potential user-group is set to complete specified tasks using the system being evaluated. In a typical usability test there are three roles that must be filled by facilitators; test leader, observer and wizard of oz. The test leader is responsible for conducting the whole test and describing what the test subject is supposed to do. The person who is observing, takes notes of usability issues and problems with the system during the task completion. Lastly, the wizard of oz has the responsibility of driving the test forward by completing processes from the system side if using an unfinished prototype of the system.
A usability test can either be used for formative or summative assessment (Shneiderman, 1998). Formative testing is used when evaluating what and how to redesign a system and is usually done in the start phase of system development. In this phase a prototype of the system can be evaluated to discover issues with usability and find inspiration for improvements before the actual development of the system starts. Summative usability testing is used when the purpose of the test is to evaluate a complete system through defined measures such as error rate, task time and task completion, rather than finding specific design problems.
The usability tests in this study can be described as being used for formative assessment. The tests aims at discovering usability issues and successes in available exergames, from the senior user-groups point of view. During these usability tests

there will be one facilitator, and two observers, no Wizard of Oz is needed because the systems are fully developed an can run by themselves.

### 7.2.1 Guidelines for Usability tests

When conducting usability tests there are several things that must be considered. A typical usability test include several components. Tognazzini (1992) provides ten guidelines for developers and researchers of how to facilitate a usability test:

1. Introduce yourself and the other facilitators of the usability test.
2. Explain the purpose of the test and specify that it is the product that is being tested, not the participant.
3. Inform the participant that he/she can cancel the test at any time, without any further explanation.
4. Describe the technical equipment in the usability lab, as well as the limitations of the prototype being tested.
5. Teach the participant how to think aloud to get insight into the participants thoughts.
6. Explain that you will not be able to give the participant help during the test.
7. Describe the task given to the participant and introduce the product being tested.
8. Ask if the participant has any questions about the task before conducting the actual test.
9. Wrap up the test by letting the user comment on the product.
10. Use the results.

There are also other things to think about, specifically when doing usability tests with senior citizens, like in this study. In their study, Smeddinck et al. (2012), summarizes a number of challenges that need to be taken into consideration specifically when evaluating video games using senior participants. These were points that were taken into consideration when performing the usability tests:

- Anxiety concerning surrounding technology.
  Smeddinck et al. (2012) found in their experiments that senior citizens showed anxiety and confusion towards equipment present during the experiment. Smeddinck et al. experienced that microphones, cameras and cables scared senior participants even to the extent of withdrawal from the experiment.

- Feelings of personal failure related to performance in games.
  Smeddinck et al. found that many participants got negative feelings and concerns when it came to their performance in the games, instead of relating it to poor game design.

- Social factors.
  When asking senior participants for feedback, it was observed that the research was influenced because the seniors were too polite when facilitators were present.

- Personal fitness.
  Game-play sessions should be carefully suited to each participant's fitness level, to reduce the risk of overstraining the participants.

- Health risks.
  When evaluating exergames, the participants have a tendency to get very focused on the games and may be in risk of falling.

## 7.3 Questionnaires

A heavily used quantitative research method is the use of questionnaires. Oates (2005) defines a questionnaire as a pre-defined set of questions, assembled in a specific order. Subjects that are to answer the questionnaire are selected in order to try to understand the whole population from which the subjects were picked out of. The research subjects are asked to complete the questionnaire by answering the stated questions, giving the researcher data that can be interpreted and analyzed. Questionnaires are heavily used in research because they have the advantage of giving an easy way to gather information from a large amount of people and often provides the researcher with data that can be analyzed statistically.
Two main types of questionnaires exists. Questionnaires can either be self-administered or researcher-administered. When a questionnaire is self-administered, the subject completes the questionnaire without any communication with the researcher. Self-administered questionnaires can either be given in paper form or in electronic forms

such as e-emails, or on webpages. In contrast, when the questionnaire is researcher-administered it is the researcher who asks the subject each question and writes down the answers. Researcher-administered questionnaires can be conducted face-to-face with the subject or by telephone. Advantages of researcher-administered questionnaires are higher response rates than mail surveys, decreased numbers of incomplete and "don't know"-answers, and lastly, possibilities of observation and additional questions (Wohlin et al., 2000). Disadvantages include cost and time, and reaching out to a larger sample size.

### 7.3.1 System Usability Scale

One questionnaire that is much used in usability testing is the SUS questionnaire. Used in usability tests, this questionnaire provides the researcher with qualitative data that can be analyzed statistically. The System Usability Scale(SUS) is a "quick and dirty" survey scale developed by Brooke (1996). The scale makes it very easy for a developer to evaluate the usability of a system. Usability was defined in section 7.2. The SUS has the advantage that it is a low-cost, reliable way to determine usability. It also gives the researchers a way of comparing the usability of one system to another's, as the SUS provides a more generalized subjective assessment of usability.
The SUS form is designed as a "*likert*" scale. Ten items are included in the scale. These items are represented as statements, each with 5 options of agreement or disagreement. The user is asked to indicate how much or how little he/she agrees with each of the statements.
During a usability test the SUS scale is filled out by the participant after completing a set of tasks using the system to be evaluated for a period of time. From a fully filled out SUS scale, a score in the range of 0 to 100 can computed to evaluate the usability of the system. Brooke (1996) describes that the resulting score of the SUS scale is obtained by adding up the score of each of the items, which are worth up to 4 score contribution points, and multiply the sum by 2.5 to get the overall SUS score.
Bangor et al. (2008) established a baseline of 70 for an acceptable SUS score of a product. A system that gets the SUS score of under 70, indicates some kind of usability issues and should be further improved, while very good systems will score in the high 80s.

## 7.4 Observation

Observation is a qualitative research method where the researcher collects data by watching selected participants in natural or structured environments (Johnson and

Turner, 2003). The goal of using observation as a research method is to find out how people actually behave, rather than just listening to how they say they behave themselves. Johnson et Al(2003) highlights the importance of creating an environment where the participants will act as naturally as possible without taking to much notice of the researchers presence, as this might shape their behavior.
There exists two ways of making the distinction between types of observation. Observation can be categorized as overt or covert observation, and as systematic or participant observation(Oates, 2005).
In covert observation, the subjects that are being observed are unaware that they are under observation by researchers. This type of observation can be facilitated with hidden camera equipment or hidden microphones. The advantage of this kind of observation is that the subject's environment is as natural as possible and the subject under observation will not be affected by the researchers presence as the setting is not disturbed or distracted by the observers. Ethical issues are often raised when using covert observation. Covert observation might be deemed unethical because the research subjects have not given consent to being observed. Covert observation can therefore be more ethical when conducted in public places, where people are more aware that strangers might notice their behavior.
Overt observation the opposite of covert observation. During an overt observation, the subjects are completely aware of the fact that they are currently being observed. The advantage of this observation method is that is it more ethical in that the subjects have given their consent to be observed and the observers have more control of the situation at hand. The disadvantage with overt observation is that the presence of the observers might shape the way that the subjects act during the observation, this is known as the 'Hawthorn Effect'(Oates, 2005).
One can also distinguish between systematic and participant observation. Systematic observation is where the observer has planned what type of events that will be observed using a pre-designed schedule. The data collection in systematic observation often includes counting or timing particular events. This could for example include observing a meeting and count how many who show up each time or observing a sample of people, each doing the same thing for the same amount of time.
Participant observation is when the researcher takes part in the situation that is studied, and notice how people around behave in their environment and react to the observers actions. The observer can take on different types of roles in participant observation. He/she can become a complete participant and act as a participant in the environment, or stay impartial and out of the situation as a complete observer. The observer can also be a participant-observer who shadows someone in their environment or a practitioner-researcher who conducts observation in their own environment.

Advantages of using the observation technique includes seeing what people actually do rather what they say they do and generate data about actions that the observed are unaware of. Disadvantages are lack of reliability due to the fact that it is difficult to replicate the exact situations, limited settings open for observation and not knowing what is going on when the observation is over.

## 7.5 Interviews

Oates (2005) defines an interview as a particular kind of conversation between people, which has a set of assumptions that do not apply to a regular casual conversation. The purpose of an interview is for the person conducting the interview to gain information about the other person or persons that are being interviewed. Rubin and Rubin (2011) compares qualitative interviews to night googles, because they "permit us to see that which is not ordinarily on view and examine that which is looked at but seldom seen". This comparison is relevant because researchers can by using qualitative interviews, obtain information about feelings and emotions that one cannot get from a simple questionnaire. The qualitative interview also provides the researcher with a situation where he/she is in control, and is therefore one of the most used methods for collecting data in qualitative research. Several differences exists in the way interviews can be conducted and planned, Oates(2005) divides interviews into three types: structured interviews, semi-structured interviews and unstructured interviews.

- Structured Interview
  During a structured interview the researcher uses a standard, pre-defined set of questions that are the same for each of the subjects being interviewed. The conductor of the interview reads out the questions and take note of the subject's responses. The conductor and the subject does not engage in an active conversation, and structured interviews give little room for improvisation. Structured interviews are like questionnaires, only in a verbal format.

- Semi-structured Interview
  In contrast to structured interviews, semi-structured interviews are more like real conversations between interviewers and interviewees. The researcher can still have prepared a set of questions in advance to bring up with the interview subject, but may change the pace and direction of the interview based on the flow of the conversation. Semi-structured interviews also gives the researcher an opportunity to ask follow up questions depending on the interviewee's answers.

- Unstructured Interview
  The third type of interview is unstructured interviews, where the interviewer only introduces a topic or a theme and lets the subject talk freely about the topic. In this type of interview the researcher is dependent on improvisation.

Interviews can also be categorized as one-on-one or group interviews. A group interview is conducted with three to six people at the same time, and can be either structured, semi-structured or unstructured. The goal is to have a group discussion where all the participants may state their mind and maybe come to an agreement. The advantages of using group interview include help to generate consensus view, more and varied responses as one idea can stimulate another, and help brainstorming. Disadvantages of using a group interview is that dominant participants can take over the discussion, some participants can be reluctant to express their views in front of the other participants and lastly some participants may only give opinions that seem acceptable by the other participants as well.

There are many advantages of using qualitative interviews as means of gathering data. Interviews are well suited when you want to go into a topic in detail, little equipment is needed and interviews can be very flexible. On the other hand, it can be very time consuming for the researcher and is very prone to bias.

## 7.6 Card Ranking

The card sort method, also called the Q-method, is a qualitative research methodology that was first introduced by the psychiatrist William Stephenson(1935). In this method the researcher selects a set of items that are placed on separate cards. These items can be statements, words, pictures, instructions, tasks etc. The people participating in the research are then asked to sort the cards according to the researchers instructions. This can be done according to approval versus disapproval, like versus dislike or lowest versus highest priority(Jahrami, 2012). The card sort method can be used to understand the relationship between items, to group the items into categories or understand the participants' perception of organizing the items. Advantages of using card ranking includes a comprehensive view of the participants' individual perceptions.

## 7.7 Focus Group

A focus group is a type of group interview(section 7.5) that focuses on the communication between the researcher and the participants, with the goal of gathering data(Kitzinger, 1995). The difference between a regular group interview and a focus group session is that in regular group interviews, the session is used as a quick way to gather data from many participants at the same time, while focus group sessions take advantage of the group interaction explicitly as part of the research methodology. It is not only the researcher asking each of the participants questions in turn, but it is rather the researcher that encourages the participants to talk to one another, discuss, and comment on each other's viewpoints and statements (Kitzinger, 1994). Morgan(1996) defines a focus group as a qualitative research technique that aims to gather qualitative data through group interaction on a topic that the researcher has determined. The purpose of a focus group is, according to Sim (2001), to gain insight into the different participants' experience of a product. Kitzinger (1995) highlights that the focus group methodology has especially many advantages in the field of health and medicine because it does not discriminate against people who cannot read or write.

## 7.8 Analysis of Qualitative Data

Qualitative analysis is the process of transforming data into findings(Patton, 2005). In contrast to analyzing quantitative data, qualitative analysis includes analyzing text rather than numbers. One can use quantitative analysis on qualitative data by for example counting words, lines or page(Oates, 2005). The text analyzed can be documents, transcriptions from interviews, or notes from observations.
Schutt (2011) argue that there is not one right way to analyze qualitative data. Miller and Crabtree (1999) provides three different ways of reading a text when interpreting qualitative data; literally, reflexively, and interpretively. When reading the text literally the researcher is focused on the text's content and form, so it is the text that is leading the interpretation. If the researcher is reading the text reflexively, the researcher lets his/her orientation shape the focus of the interpretation. Lastly, when a researcher reads the text interpretively, he/she tries to make own interpretation of what the text conveys.
After reading the data and have gotten a general sense of it, Oates (2005) identify three categories into which sections of text can be placed:

- Sections that have no association to the overall purpose of the research.

- Sections that describe the research context. For example information about participants.
- Sections that seem to be relevant to the overall research purpose.

After having placed the different sections of the text into the above categories, the focus is now on the third category. Each of the sections in this category should be placed under a theme, tags or a heading, depending on the contents of that section. The themes in which one categorizes the sections of text can, according to Oates (2005), be done in two approaches; deductive approach or inductive approach. Deductive approach is when using existing theories one has found in literature or developed beforehand. Inductive approach is using categories observed in the data, when you have an open mind and let the data talk to you. In the inductive approach it is important to be were of the prejudices and tendencies one have when analyzing.
The next step is to refine the themes and categories observed and look for patterns and connections between the sections of text and to build up a theory about the contents of the data.

# 8 Technology Acceptance

In this study, we are concerned with understanding the factors that can provide motivation to a senior citizen in the use of exergames as a means of exercise. As the interactive games and motion sensing technologies will be viewed as any other information system, we could use any of the theories of technology acceptance to measure the degree to which these technologies can be accepted by the senior user-group.

Dillon (2001) defines user technology acceptance as:

*"The demonstrable willingness within a user group to employ information technology for the tasks it is designed to support"*

Models of technology acceptance are based on understanding the factors that impact users to adopt to a new system or technology. The goal of using technology acceptance models is to influence the design and implementation of a technology to minimize the risk of user resistance and rejection.

## 8.1 Innovation and Diffusion Theory

Innovation and diffusion theory seeks to explain why some new innovations are successful and others are not. Criteria for success includes the adoption of the innovation by the intended user group. Rogers (1995) presents five characteristics for user acceptance of a technology:

- Relative Advantage
  This concept concerns the advantages and improvements that the new technology has over the existing products available.
- Compatibility
  How the new technology is consistent with the social norms and practices of the users.
- Complexity
  The ease of use of the technology and the time it takes for the user to learn how to use it.
- Trial ability
  The ability to try out the technology without having to commit to it.

- Observability
  How easy it is to see the gains of using the technology.

Although these variables gives some insight into why some innovations are accepted and some rejected, they say nothing about the attitude of the user. There have developed several models that include the users attitude as a factor in acceptance of new technology.

## 8.2 Technology Acceptance Model

Davis (1989) presents the Technology Acceptance Model(TAM). It focus on two factors that significantly influences a user's acceptance of a technology:

- Perceived Usefulness
  Defined as the degree to which a user thinks that a system will improve his/her performance in the tasks that it is made to support.

- Perceived Ease of Use
  Defined as the degree of effort in which the user thinks that using the system will require.

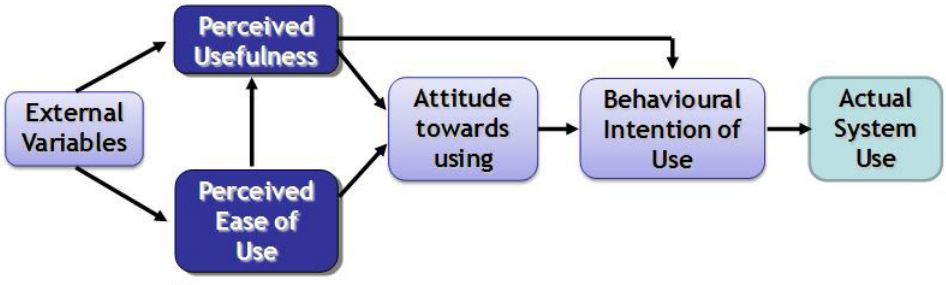


Figure 12: The Technology Acceptance model

Figure 12 is an illustration of the factors that influences the degree to which a user accepts a technology.

## 8.3 TAM 2

In 2000, Venkatesh and Davis (2000), extended the Technology Acceptance Model to to become TAM2(figure 13). The TAM2 included more factors that explain perceived usefulness in terms of social influences and cognitive processes.

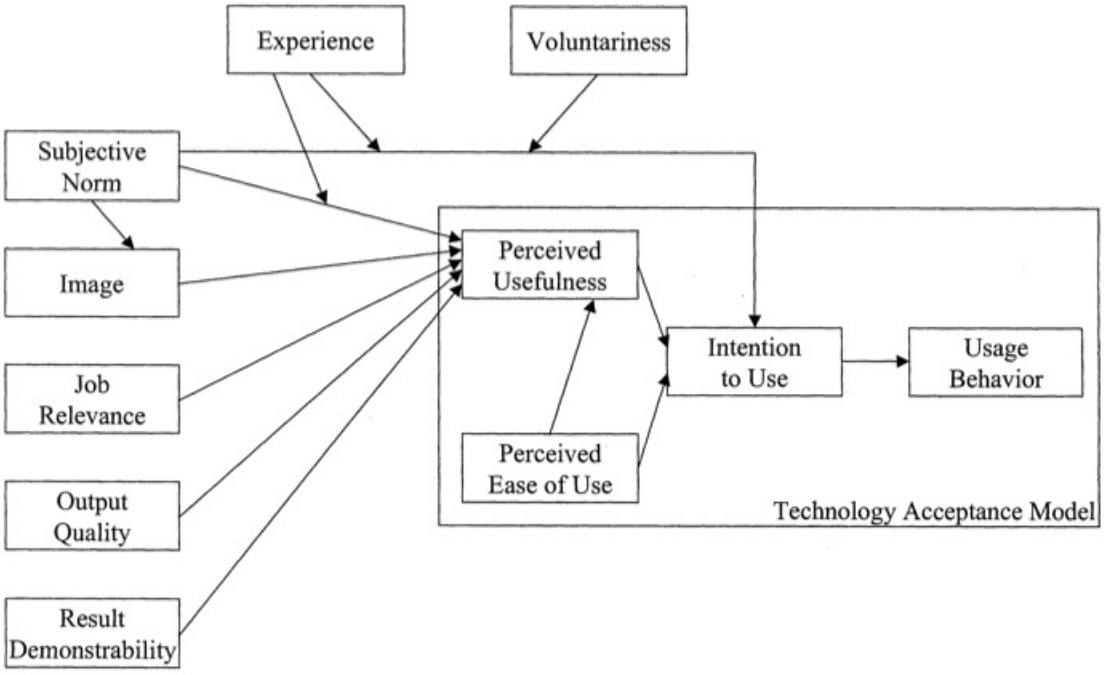


Figure 13: The Technology Acceptance Model: Extended Version

## 8.4 Unified Theory of Acceptance and Use of Technology

Many models have been developed for barriers and intentions for use of technology. The Unified Theory of Acceptance and Use of Technology(UTAUT) model was developed by Venkantesh et Al (2003) with the purpose of creating one unified model for technology acceptance that integrates eight previously developed models into one comprehensive model. The eight models that form the basis for the UTAUT model are the Technology Acceptance Model (Davis, 1989)(see section 8.2), Model of PC Utilization (Thompson et al., 1994), Motivational Model (Davis et al., 1992), Theory of Planned Behavior(Ajzen, 1991), the Social Cognitive Theory (Bandura, 1986), Innovation and Diffusion Theory(Rogers, 1995) (described in section 8.1), Theory of Reasoned Action (Schiff and Sheppard, 1995), and lastly the combined TAM/TPB model(Taylor and Todd, 1995).

Figure 14 represents the UTAUT model and the determinants for use of technology. Venkantesh et al (2003) defines seven constructs to be determinants of user acceptance. Three of the constructs are seen as having a significant role as direct daterminantes on behavioral intention. These are performance expectancy, effort expectancy and social influence. Facilitating conditions is a construct that has a

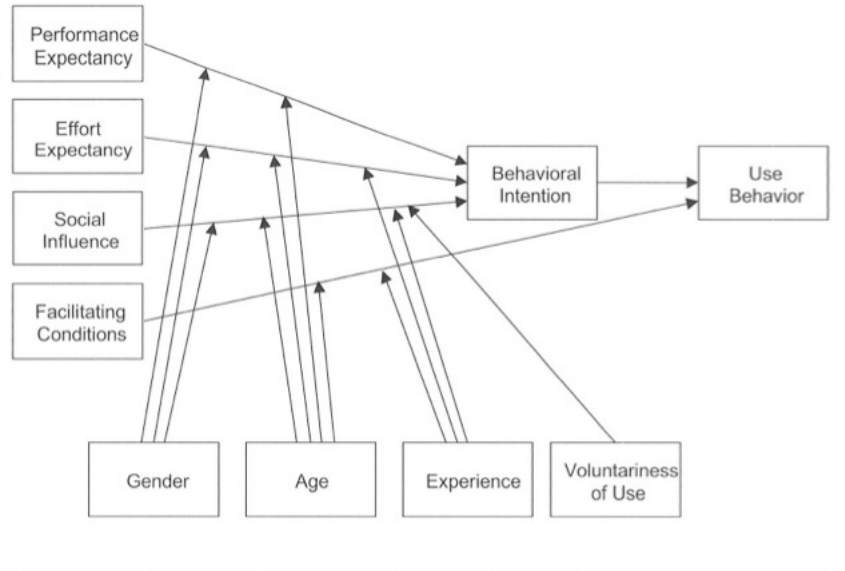


Figure 14: The UTAUT model

direct effect on use behavior. Factors that are not directly impacting use behavior is anxiety, self-efficiency, and attitude towards technology.

- Performance Expectancy
  Venkantesh et al (2003) defines performance expectancy as the degree to which a person thinks that using a particular system will help them attain gains in job performance. In the case of this study, performance expectancy will be the degree to which a senior citizen sees the utility of using the exergames for exercise. This factor is derived from the Technology Acceptance Model (Davis, 1989) and has the root constructs of perceived usefulness, eccentric motivation, job-fit, relative advantage, and outcome expectations.

- Effort Expectancy
  This measures the perceived degree of ease related with the use of the system. The construct of effort expectancy is closely related to the principles of human-computer interaction that make the system easy to use. Effort expectancy has the root constructs perceived ease of use, complexity and actual ease of use. Complexity is derived from diffusion theory (Rogers, 1995) and is described in the previous section. Gender, age and experience are factors that moderate the effort expectancy construct.

- Social Influence

Defined as the degree to which an individual regards that another individual or individuals thinks it is important that he/she uses the system in question. This influence can both be positive with encouragement or negative such as embarrassment. The construct of social influence includes the root constructs of subjective norm(Davis, 1989), social factors(Thompson et al., 1994) and image(Venkatesh and Davis, 2000). Moderating the relationship between social influence and behavioral intention is age, gender and voluntariness.

- Facilitating Conditions
  Facilitating conditions are the degree to which an individual believes that the organizational and technical infrastructures exists to support the use of the system. This construct has direct impact on system usage. The root constructs from which facilitating conditions is derived from are perceived behavioral control, facilitating conditions, and compatibility. Perceived behavioral control is defined by Ajzen (1991) as the user's perception of internal and external constraints on behavior, it encompasses self-efficiency, resource facilitation conditions, and technology facilitation. Facilitating conditions are objective factors in the environment that the user feels support the target task(Thompson et al., 1994). Compatibility is derived from diffusion theory (Rogers, 1995) explained in the previous section.

- Behavioral Intention
  This construct is asserted to have a direct impact on use of the system and concerns to what extent a person actually intends to use the system. Davis et al. (1989) defines behavioral intention as
  *"a measure of the strength of one's intention to perform a specified behavior".*

- Anxiety
  The anxiety construct comes from the Social Cognitive Theory (Bandura, 1986). It is defined as anxious or emotional reactions that are evoked by using technology to accomplish a task.

- Self-efficiency
  Self-efficiency is defined by Bandura (1986) as the user's perceived ability to to use a technology to accomplish a given task.

- Attitude Towards Technology
  First used in the Theory of Reasoned Action(Schiff and Sheppard, 1995), and defined as the user's individual positive or negative feelings about performing

the given task. These feelings can be enjoyment, pleasure, depression or disgust that the user associates with doing a task or using a product.

## 8.5 Technology Acceptance in Healthcare

The Unified Theory of User Acceptance of Technology is widely used in researching information technology in healthcare(Hennington and Janz, 2007; Klein, 2006; Or and Karsh, 2009). Hennington and Janz (2007) applies the UTAUT model(Venkatesh et al., 2003) to the healthcare industry and the phenomenon of physician adoption of electronic medical records technology while Klein (2006) uses the TAM(Davis, 1989) to examine first-time user's attitudes toward Internet-based patient-physician communication applications influence intentions and use. Klein (2006) also incorporates the trust factor into the TAM, highlighting that the trust in the healthcare provider and trust in the vendor of the technology influences the user's system use.

# 9 Validity of Research Methods

When evaluating the qualitative and quantitate data gathered from the usability tests and the focus group, it is important to asses the validity of that data. For this study, there are five main areas of validity to be concerned with: objectivity, internal validity, transferability, ecological validity and triangulation.

## 9.1 Objectivity

When using qualitative research methods such as interviews and focus groups, objectivity must be considered. Objectivity concerns the extent to which the data collected comes from the interview subjects and participants themselves and not from the researchers. To increase objectivity, the goal is to minimize the unintended influence that the facilitators have on the participants and interview subjects. This can be done by being aware of ones behavior and how it effects the participants both during the usability tests and the focus group session. Svanaes and Seland (2004) argue that one way to ensure objectivity is for the researchers to analyze the data by using a video camera to record the session and evaluate their influence afterwards.

## 9.2 Internal Validity

Internal validity is defined by Worthen et al. (1993) as the degree to which the research methods accomplish the purpose for which they are being used. Oates (2005) argue that an experiment has good internal validity if the measurements obtained, are caused by the manipulations provided by the known dependent variable, not by any other factor. Threats to internal validity includes faulty instruments used for measurements, maturation and history. In the context of the usability tests, internal validity concerns the facilitators responsibility of making sure that the participants are talking about what the facilitators think they are talking about. To ensure validity it is important to state the purpose of the tests and make sure that it is understood by all participants in the beginning of the session.

## 9.3 Transferability

Transferability is a concept that is also referred to as generalization or external validity (Wohlin et al., 2000). The concept concerns wether the results from the workshop

can be generalized over the whole intended population that is being studied. Transferability is often a result of the selection of participants, focus of the research and technology used. Common threats to transferability includes too few participants and non-representative participants (Oates, 2005).

## 9.4 Ecological Validity

Ecological validity is concerned with the world around the research. This means how close the equipment, methods and settings of the study is to the real-life context that is under investigation(Brewer, 2000; Carter et al., 2008). Dahl et al. (2010) argue that a certain degree of ecological validity is needed in usability experiments and investigates the concept of fidelity in usability assessments. The general concept of fidelity is divided into physical and psychological fidelity. Physical fidelity is concerned with the actual equipment and environment of the usability tests, including tools, systems and devices being as close to the intended use situation as possible. (Dahl et al., 2010). Physiological fidelity is about how close to real-life the tasks and functionality in the usability assessments are, and how close the situation is to the "real thing" (Dahl et al., 2010).

## 9.5 Triangulation

Triangulation is defined by Cohen (2000) as:

*"An attempt to map out, or explain more fully, the richness and complexity of human behavior by studying it from more than one standpoint."*

In research, triangulation facilitates validity by providing data from more than two sources. Denzin (1970) describes four types of triangulation in research methods; data triangulation, investigator triangulation, theory triangulation and methodological triangulation. Methodological triangulation means to use different methods and compare the results to see if they are consistent and to support your findings. Using methodological triangulation can minimize the risk of inconsistency.

After all the research has been collected and analyzed the data will be assessed in relation to the five above areas of validity. This will be presented in section 22.

# 10 Research Design

This section describes in detail how the research was conducted in this study. The research methods used in this study includes both qualitative and quantitative research methods. A combination of both qualitative and quantitative methods, aims to get a deep understanding of the senior user-group's preferences and opinions of exergames, in addition to providing data that can be analyzed statistically. Table 1 gives an overview of the primary and secondary research methods used. These will be further elaborated on in the following sections.

| | **Qualitative Methods** | **Quantitative Methods** |
|---|---|---|
| **Primary Methods** | Usability Testing<br>Focus Group | |
| **Secondary Methods** | Observation<br>Semi-structured interviews<br>Card Ranking<br>Unstructured Interview | SUS questionnaire<br>Card Ranking |

Table 1: Research Methods

## 10.1 Usability Testing

The primary research method used in this study is a number of usability tests conducted in the period of 15 April to 23 April, 2013. Participating in these usability tests were 14 senior citizens in the age group of 65 and upwards. Participants attended in one-hour sessions individually. The procedure of the tests will be described in section 13. During the usability testing qualitative data was collected through observation, transcription of conversations and exclamations, card-ranking and a semi-structured interview. Qualitative data was collected through a SUS questionnaire and a card-ranking.

### 10.1.1 Questionnaire: Background Information Form

To gather information on each of the participant's background, all participants were asked to complete a background information form. This form is included in appendix D. The first part of the questionnaire concerned the participant's previous experience with general technology, such as mobile phones and the Internet, as well as their experience with game consoles. The second part of the background information form asked for information about the participant's everyday exercise routines and activity

level. Together these two parts of the questionnaire will provide information about the average participants' experience with technology and a general insight to his/her fitness level.

### 10.1.2 Questionnaire: System Usability Scale

A system usability scale(see section 7.3.1) was used to collect qualitative data that could be used to compare three different exergames. The participants were asked to evaluate each game by filling out a modified version of the systems usability scale(Brooke, 1996), directly after playing each of the three games. See appendix E for the SUS questionnaire that was used. The original version of the questionnaire was translated from English to Norwegian by Professor Dag Svanæs. For this study, this translated SUS questionnaire was modified so it would be more understandable for the participants that the system in question was the recently played game.

### 10.1.3 Observation

While the participants play each of the exergames the test facilitators observe their emotions, movements and statements. This will provide qualitative data that can be further analyzed and interpreted and can give an insight into what the participants really feel. The usability tests will also be recorded on video so it can be analyzed further afterwards, and lets the facilitators concentrate on the test without having to do extensive notes of the observations. All audio recorded such as conversation and exclamations from participants and facilitators during the usability testing will be transcribed and used for citations in qualitative analysis after the usability tests are completed.

### 10.1.4 Semi-structured interview

After having gotten the chance to try out all of the three selected exergames, the participants are be asked a range of questions relating to the games by the facilitator. To give an informed evaluation and comparison of the games, the questions in the semi-structured interview are based on the Unified Theory of Acceptance and Use of Technology(see section 8.4). Arranged into the different determinants of the UTAUT model, the questions are presented below. As the interview is semi-structured there is an opportunity for the facilitator to ask follow up questions along the way. The complete interview guide is shown in appendix F.

- **Performance Expectancy**
  To measure the perceived performance of these games, questions were asked

about how do the participants feel that these games can be useful in terms of exercise.

  - What game did you feel would be most efficient when it comes to exercise? Why?
  - Would a game like this fit into your everyday exercise routines? Why or why not?
  - Could any of these games be useful for you? If so, in what way?

- **Effort Expectancy**
  The questions related to effort expectancy were based on the participants ease of use of the games and how they compared to each other.

  - What game was the easiest to use? Why?
  - Which game was the most complicated? Why
  - Did you have problems understanding how to use the game or read what was on the screen? What gave you problems?
  - Did you understand the feedback you were given?
  - Did the feedback you got, match your movements?

- **Social Influence**
  How does social factors contribute to the participants potential use of the games.

  - Would you feel embarrassed or uncomfortable telling your friends/family that you play these games?
  - Do you think you could use these games in a social setting?

- **Facilitating conditions**
  Measuring in what way the home environment effects the participants future use of the games, the questions relating to facilitating conditions are concerned with the potential of a home use situation only.

  - Would you have room for this equipment at home?

- **Behavioral Intention**
  The questions concerning behavioral intention are designed to measure if the participants actually intend to use the system.

- If you had any of these games at home, would you play them regularly?
- What game would be your first choice?

- **Self-efficiency**
  The construct of self-efficiency concerns the participants perceptions that he/she will be able to use the games by him/herself.
  - Do you think you could use these games by yourself?

- **Anxiety**
  These questions measured if the participants experienced any negative feelings during gameplay.
  - Did you ever feel anxious or nervous playing the games?
  - Would you feel anxious playing these games at home?

- **Attitude towards technology**
  To measure the participants attitude towards technology, questions were designed to capture the participants motivational factors to use the game. The concept of *fun* was introduced.
  - What do you think about playing these types of games?
  - What game was the most fun? Least fun?
  - What elements of the game could motivate you to keep using it in the future?
  - How do you picture a game like this should be if you would use it in your everyday life?

- **Safety**
  Due to the fact that the context of use of these games is to train the users balance, the construct of safety was added. This was to measure the participants perceived risk of falling or injuring themselves during the game.
  - After being here for this session, do you think you would be able to use these games at home and feel safe?
  - Were you ever afraid of falling while playing any of the games? Any one more than another?
  - Did you feel in control of your movements while playing the games?

### 10.1.5 Card-Ranking

To get a clear understanding of the individual participant's preference of the exergames, the participant's last task will be a card ranking. The facilitator created three different cards of cardboard, each containing a picture of one of the games. The cards used for the card-ranking are shown in figure 15. Card-ranking is an activity where the main task is for the participant to arrange the cards according to liking as described in section 7.6. For this study, the objective is for the participant to point out which exergame he/she liked the most and which he/she liked the least. The participant is also asked to give an explanation of his/her decision. The ranking-score itself will provide qualitative data to be analyzed statistically, while the participant's reasoning behind the ranking will provide qualitative data for a broader understanding of preference.

Figure 15: Card Ranking

### 10.1.6 Experiment Design

During the usability tests all participants were to play the same three exergames. Wohlin et al. (2000) stresses that the order that a subject tests each product may influence his/her opinion of it. An example from this case, could be that a participant might like the last played game best because he/she had gotten more training from the two first games. To reduce the effect of the order the participants play the games on the results, balancing of the game order was used. The order of the games were balanced(Wohlin et al. (2000)) so that the participants had different orders in

which they played each game. The order is shown in table 2.

| **Subject ID** | **Game 1** | **Game 2** | **Game 3** |
|---|---|---|---|
| ID01 | A | B | C |
| ID02 | A | C | B |
| ID03 | B | C | A |
| ID04 | B | A | C |
| ID05 | C | A | B |
| ID06 | C | B | A |
| ID07 | A | B | C |
| ID08 | A | C | B |
| ID09 | B | C | A |
| ID10 | B | A | C |
| ID11 | C | A | B |
| ID12 | C | B | A |
| ID13 | A | B | C |
| ID14 | A | C | B |
| ID15 | B | C | A |

Table 2: Experiment Design

The letters A, B, and C each represents one of the game concepts described in section 11. In table 2, the games are represented as follows:

**A** - Dance Dance Revolution. Described in section 11.1. This study, used the modified version developed by Schoene et al.. Each participant is asked to play one complete song: "That Old Black Magic" by Frank Sinatra. Total time of play for DDR is 03:12 minutes.

**B** - SilverFit. Participants played two different versions of the mini game "The Mole", lasting one minute each. SilverFit is described in section 11.2

**C** - Your Shape: Fitness Evolved on XBox 360. This game is described in section 11.3. The chosen mini game is called "Light Race". Each participant played one round of one minute.

## 10.2 Focus Group Session

After all the usability tests have been conducted, one focus group session will be held. Attending the focus group will be experts in the field of human movement science and the facilitator of the usability tests. The aim of this focus group is to get an expert evaluation of the three exergames, as well as establishing what criteria that need to be fulfilled for the exergames to be successful in step- and balance training for seniors. All data collected in the focus group session revolves around the video recordings from the usability tests conducted, and questions and discussions will be about the exergames evaluated in these tests.

### 10.2.1 Questionnaire: Background Information Form

To gather information about the expert panel attending the focus group, the participants are asked to fill out a background information form. The form asks for information about the participant's education, occupation and experience in their profession, as well as experience with game consoles. The complete form is shown in appendix J.

### 10.2.2 Unstructured Interview

The main research method for data collection during the focus group session is unstructured interviews. Starting off the session is a discussion around the topic of success criteria of exergames. The attending domain experts will discuss around this theme without a structured form. Post-its will be used to structure the experts opinions during the whole focus group. The goal of this interview is not an interrogation by the facilitator, but rather to encourage the communication between the participants themselves.

### 10.2.3 Observation

The facilitator will observe the focus group session and have as little influence as possible on the discussions. The whole session will be recorded on video to be further analyzed and transcribed to provide qualitative data.

# Part IV
# Research Procedure and Results: Usability testing

# 11 Game Concepts

Combining the intrinsic motivation of fun with the extrinsic motivation of exercise, three exergames were chosen to be evaluated in terms of step-based balance training for seniors. In this section, the three game concepts that were selected for this study will be described. The chosen exergames are Dance Dance Revolution, SilverFit and Your Shape.
Several studies show that the available commercial games are not suitable for use in rehabilitation and for senior users(Ijsselsteijn et al. (2007); Young et al. (2011)). Therefore, it was chosen to include two exergames that are specifically designed for elderly. SilverFit is the only game included that is commercially available as a tool for rehabilitation of seniors. It was also chosen to include a modified version of Dance Dance Revolution that was changed with the intent of conducting research with senior users. Your shape is on the other hand, the only game that is a commercial off the shelf(COTS) game for the XBox 360 game console.
Another reason for the choice of exergames is that they all require the player to use a stepping-movement with a weight shifting which is needed in balance training. The movement in the three games is quite similar, and it is therefore possible to compare the three different exergames against each other.

## 11.1 Dance Dance Revolution

*"Dance Dance Revolution"* (DDR) is an interactive game produced by Konami[2]. It was originally released as an arcade game in 1998, and has since then been released as video or arcade games in 90 official versions internationally(Anders, 2007). DDR has been released for game consoles such as the Sony PlayStation versions, Microsoft XBox and Nintendo Wii as well as on PC.
The user controls the game by stepping on an input device called a dance mat (see figure 16) to music. This mat is connected to a visual display such as a television or a computer screen via a gaming console or PC using a USB cable. Containing several pressure-sensitive panels, the dance-mat registers the players movements by recording the time of the player's foot- lift and landing at each of the panels. The player stands in the small area in the middle of the mat, and the pressure-sensitive panels are located at each side of the player.

[2]www.konami.com

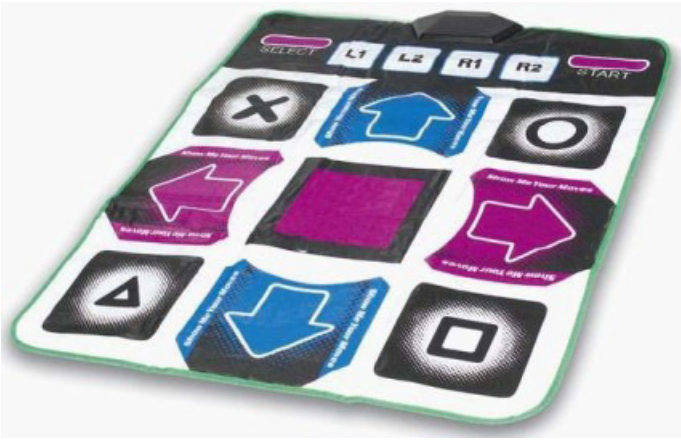


Figure 16: Dance-mat for DDR

The goal of the game is step on the pressure-sensing panels on the dance-mat at the right time. The timing to step is when arrows sliding from the bottom to the top of the display screen meet a set of arrows at the top of the screen. The user is instructed to step onto the corresponding panel on the dance mat to music exactly when the sliding arrow meets the permanent arrows in the top area of the screen. It is the sequence of the arrows and speed of the steps that creates the difficulty of the game.
There is a large selection of music to choose from and the difficulty level ranges from beginner to expert and can be selected by the player him/herself. Timing is also a crucial factor of success in the game, the player needs to step on the correct direction on the mat at the same time as the sliding arrow meets the still standing one. Each time the user steps on the mat, the user is given a feedback on their accuracy presented in words in the middle of the screen such as ”Missed it!”, ”PERFECT” or ”Good”. If the player misses an arrow, the ”life bar” at the top of the screen is reduced, and when the life bar is empty the game is over. If the player manages to keep the life bar, the final score is summarized when the song is completed. The final score is a letter grade and a numerical score, based on the player's accuracy and a number of hits. Some versions of the DDR game has a multi-player functionality where one can use two dance-mats to compete against each other.
As Dance Dance Revolution requires the player to move around, it has been used to promote physical activity. The game can be categorized as an exercise game or exergame(see section 4.4). In virginia a version of DDR was added to the curriculum to encourage kids to exercise(MTV, 2006) and in Norway DDR was registered as a sport under the name ”machine dancing” in 2005(Positive-Gaming, 2005). A range

of studies have been conducted using the original Dance Dance Revolution game. Anders (2007) reports on a study on people in the age group of 12-24 to evaluate DDR's benefit for improving fitness and found an increase in the exercise intensity of the test subjects.

### 11.1.1 Dance Dance Revolution: A modified version

The intended user-group of the original Dance Dance Revolution game is children and young adults. The movement required to succeed in the game are very fast and the accompanying music is based on popular dance-music. Smith et al. (2011) and Schoene et al. (2013) both conducted studies where they modified the original DDR game system to be more suited to the senior user group. It was the open-source version of the Dance Dance Revolution game called Stepmania[3] that was modified. The original version is shown in figure 17 and the modified version of the game is shown in figure 18.

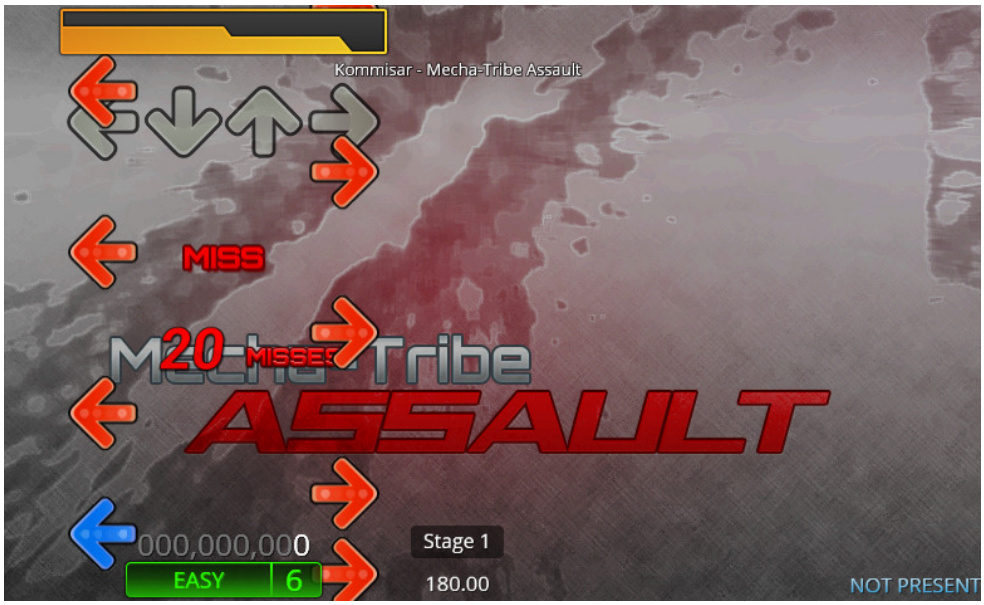


Figure 17: Dance Dance Revolution: Original Version

[3] www.stepmainia.com

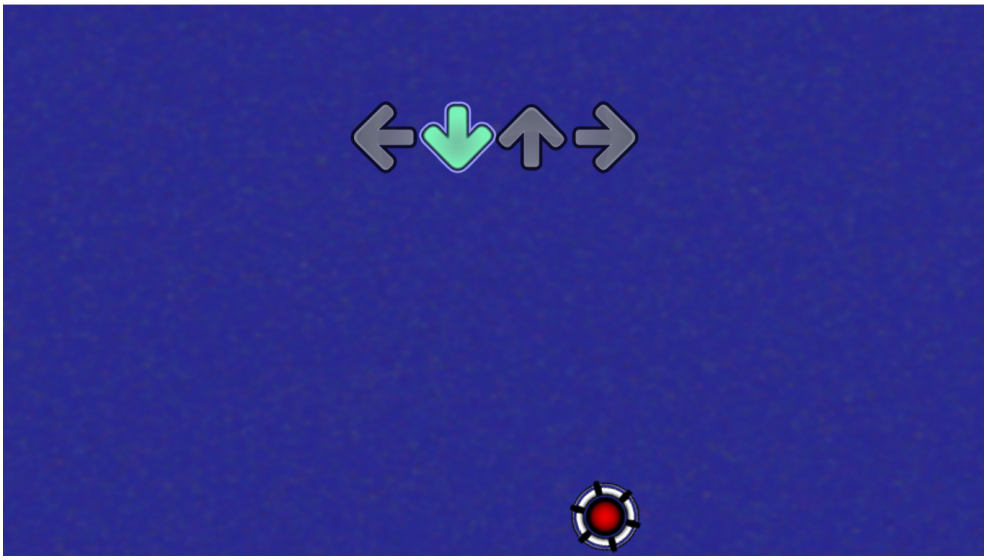

Figure 18: Dance Dance Revolution: Modified Version

To make the Dance Dance Revolution game more suitable for the senior user group, Schoene et al. changed several things:

- Background
  The background of the game was changed from the cluttered image shown in figure 17 to the simple blue colored background shown in figure 18.

- Music
  While the original version[4] is played to accompanying fast, trance music, the modified version is played to a selection of classic songs more likely to be recognized by the senior user group. In contrast to the original music, the rhythm of the music in the modified version is not synchronized with the stepping patterns of the drifting arrowsSchoene et al. (2013).

- Speed
  Three levels of speed are available for the player to choose, easy, medium and hard. These difficulty levels vary in simultaneous objects on the screen, speed of the arrows and numbers of bombs.

- Bomb
  To increase the cognitive load, Schoene et al. added a bomb that is presented

[4] www.stepmania.com

randomly instead of a drifting arrow. The bomb is represented in figure 18 as the object that is closest to the bottom of the screen. The additional bomb required the participants to think about their steps and inhibit their response. If the player step on the bomb, it "explodes" and points are deducted from the final score.

De Bruin et al. (2010) argues that the kind of stepping required by this game, which involves the transfer of body weight, is a way to prevent slips and falls. The stepping movements needed in the Dance Dance Revolution game are similar to the step responses that are often a required reaction to avoid falls.

Schoene et al. (2013) conducted a study where 37 seniors living in a retirement village in Sydney were asked to play the modified version of DDR as much as they liked for eight weeks, with the recommendation of 2-3 sessions of 15-20 minutes game-play each week. The results showed significant improvements in the seniors choice stepping reaction time (CSRT) and confirmed that the use of step-pads in step-training can be used by seniors without major physical impairments in a home environment to prevent the risk of falling.

In this study it is this modified version by Schoene et al. that is used for evaluation. It was chosen to use a song from the easy level of difficulty called "That Old Black Magic" by Frank Sinatra. The song lasts for about 3:18 minutes and all participants are expected to play the game for that whole time.

## 11.2 SilverFit

SilverFit is a virtual reality rehabilitation system (Rademaker et al., 2009) made by SilverFit BV in the Netherlands. The system consists of both hardware and software parts that are designed specifically for seniors that have to exercise regularly as part of their physical rehabilitation[5]. The SilverFit system can therefore be categorized as a rehabilitation game(see section 4.5). The context of use for this system is in a clinical situation, often used in combination of treadmills and other exercise equipment. A variety of different mini games are offered in the SilverFit software, which can be adjusted to the physical and cognitive level of the player. These games include important exercises that are based on scientific guidelines developed by the Royal Dutch Physiotherapy Association[4]. To control the computer games, the player(s) uses body movements to complete different activities.

[5]http://www.silverfit.nl/en/our-products/silverfit-product.html, Online; accessed 06-March-2013

### 11.2.1 Technical Description

To track the player's movements, the SilverFit uses a time-of-flight(TOF) camera technology. TOF technology includes an array of LED lights that produce an invisible light grid that is reflected by the player(s) in front of the camera[6]. This camera technology computes the player's limb positions in 3-dimensional space by measuring the differences in wavelength of the light grid. All player movements in a 5x5 meter area in front of the camera are registered, there is therefore no need for extra controllers such as a mouse, keyboard or remote controller (Rademaker et al., 2009).

### 11.2.2 SilverFit Exercises and Games

The SilverFit system includes several exercises in the categories of seated exercises, walking exercises, balance exercises, upper extremity exercises, cardiovascular exercises, wheelchair navigation exercises and objective measures and tests. The system includes exercises that can be defined as cognitive, exergames, rehabilitation games (see section 4 ) or combinations of these.

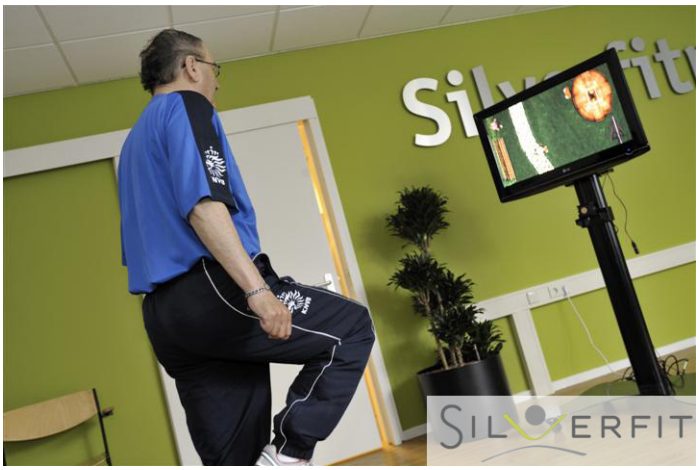


Figure 19: Senior playing SilverFit

### 11.2.3 The Mole

The mini game that has been selected to be evaluated in this study is The Mole. *The Mole* is a balance exercise that trains the dynamic balance of the player. The

[6]http://www.silverfit.nl/en/our-products/silverfit-product.html, Online; accessed 06-March-2013

game can be used for fall prevention or to train the general short-distance mobility of the player. SilverFit specifically recommends to use this game with patients with parkinson, post-orthopedic surgery or patients with multiple sclerosis. Two versions of the The Mole were chosen to be played.


Figure 20: The Mole 1

The first version of the game, shown in figure 20, is a simple, one-minute game where the player is instructed to step on the moles that appears on different areas of the screen. Time left to play is represented as a green bar at the right side of the screen. The score is based on the number moles the player can step on within the one minute time-frame. During the game, the score is shown in the upper right hand corner at all times. No music is accompanying the game, but feedback is given as an affirmative sound when the player has stepped on a mole.

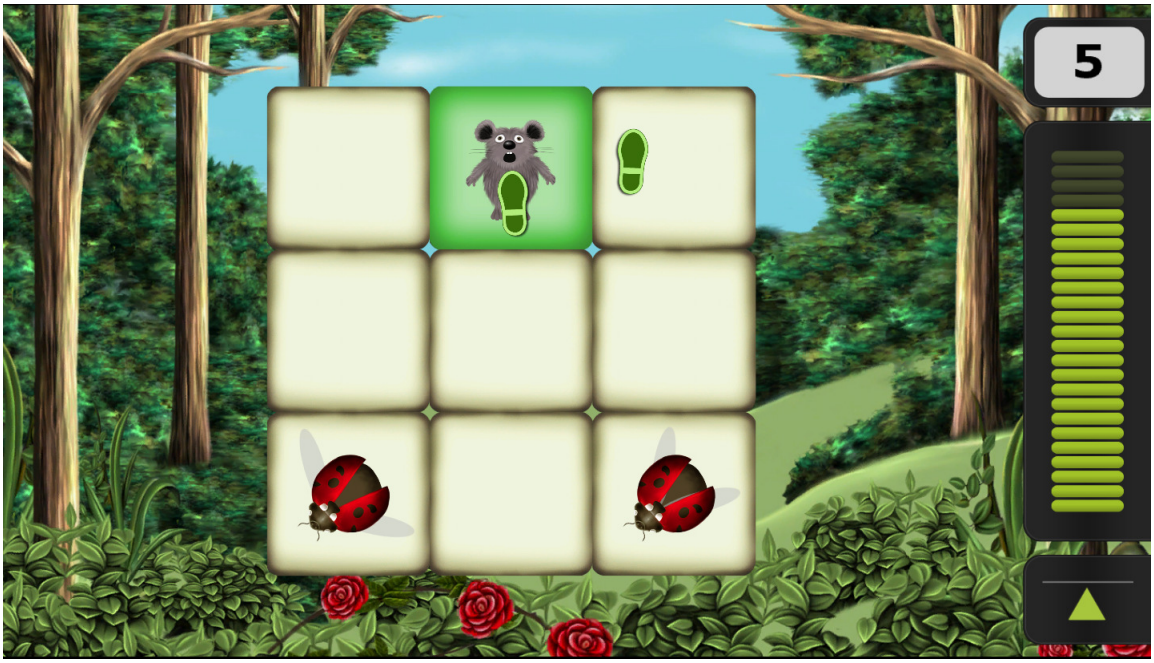


Figure 21: The Mole 2

Shown in figure 21 is the mole: precision control, which is the second version of the game. Similarly as in the first version, a mole appears in different areas of the screen, but in contrast, in this version a ladybugs and mice will also appear on the screen. The goal is now for the player to step on both the moles and the moving mice that appear, but to avoid the ladybugs. The score is now calculated on how many mice and moles the player stepped on, while the player is given minus-points for stepping on the ladybugs. This second version requires more attention and accuracy from the player.

The participants in this study are expected to play both two versions described of the mini game "the Mole". As noted each game lasts for one minute each, so the total time spent on playing silverFit will be two minutes.

## 11.3 Your Shape: Finess Evolved on Kinect

*Your Shape: Fitness Evolved*[7] is a fitness game developed for PC, Microsoft Kinect(see section 6.3) and the Nintendo Wii(see section 6.1). Your Shape: Fitness Evolved was

[7]http://yourshapegame.ubi.com/fitness-evolved-2012/

released in 2010 for XBox 360 used with the kinect technology. This game targets strength, balance and cardiovascular training. The game gives the choice of either having a personal training session, playing a boxing, a zen program or playing a selection of short gym games.

### 11.3.1 Light Race

For this study, one of the included gym games were chosen, it is called Light Race. The concept of Light Race(figure 22) is to use your feet to step on the area that lights up on the areas around you on the floor at the right time. As in one can see in the figure 22, the player's movement is mirrored on the screen and the player can se him/herself during the whole game-play.


Figure 22: Your Shape - Light Race

The player is expected to play for one minute, and the time left is shown to the right of the screen. The faster you step on the area, the faster a new area lights up and the more points you get. Feedback is given with sounds and visual effects. Stepping on the right area makes the area green and an affirmative sound is given. If you step on the wrong area it will light up in the color red instead of green. Three difficulty levels of the game is available, easy, medium and hard. For our study we chose easy, as the other levels require the player to jump onto two of the areas at the same time, which is not a desired movement for balance training.

# 12 Planning

This section will present how participants were recruited to the usability tests, who they were and where the tests were held.

## 12.1 Recruitment of Participants

For this study, the desired people to recruit to participate in the usability tests should be mostly representative of the intended user-group of the selected exergames. To be in the intended user-group meant that the participants should be senior citizens over the age of 65 and preferably be in the fall-risk group. Due to Norwegian laws and ethics concerning the collection of sensitive health information, it was concluded to perform the usability tests with healthy seniors to avoid a long procedure of applying for permission to ask participants for information concerning their health. The usability tests were approved by the Norwegian Protection Official for Research(NSD) before starting the recruitment.
The people who participated in the usability tests were selected by convenience sampling (Wohlin et al., 2000). Convenience sampling is when the most convenient and nearest persons are selected as test subjects. Participation in the usability tests was voluntary and the subjects were recruited by expressing their interests at several different senior fitness classes around in Trondheim, that the test facilitators attended. Some participants were also recruited through local connections of the researchers involved in this study and the FARSEEING[8] project.
To provide information to potential participants, an information form was handed out at the above mentioned fitness classes. The information form is included in appendix A. The only criteria to participate in the usability tests was that all the participants must be over 65 years old. For this study, it was not a goal to look for the typical senior citizen, but rather to recruit seniors that were healthy, active and creative and would provide good feedback and new inputs during our usability tests. It was desired to have about 20 participants in the study in total, but it was only managed to get 14 participants due to time constraints and fall-outs.

## 12.2 Location and Equipment

The usability tests were conducted in the Faculty of Medicine, NTNU at the usability lab NSEP(Norwegian Center for Electronic Patient Journal), in Trondheim. This usability lab has two main rooms, one observation room and one test-area. During

[8]http://farseeingresearch.eu/

the usability tests the main test area was set up with gaming equipment and a table to conduct interviews. The test-area is also equipped with cameras mounted in the ceiling to cover the whole area. The recordings from the test-area can at all times be viewed on the screen in the observation room. Figure 23 shows how the usability tests are viewed from the observation room.

Figure 23: Observation Room

Excluding the equipment needed for video-recording, the other equipment needed to conduct the usability tests were:

- One big flat screen television to display all games
- A standard windows PC(with an HDMI to connect to the screen) to run both the SilverFit(see section 11.2) and the Dance Dance Revolution(see section 11.1) games.
- A commercial dance mat for PC to control Dance Dance Revolution(see section 11.1).

- The XBox 360 game console with the commercial game Your Shape(see section 11.3)
- The Microsoft Kinect(see figure 11), to control the Your Shape game(see section 11.3).
- A time-of-flight(TOF) camera technology for the SilverFit system(see section 11.2).

## 12.3 Participants

A total of 14 healthy, active seniors citizens aged 65 and up, participated in the usability studies. To make the selection of test subjects as representative for the whole user group as possible, it was desired to recruit an equal number of male and female participants. Due to difficulties of recruiting male participants, the majority were female. Only 36 % of the participants were male and 64 % were female. The average age of the participants attending the usability tests was 73 years. The average fitness level was relatively high, with the average exercise frequency of two to three times a week. Many participants also reported exercising almost every day. Table 3 shows the average values of the participants. These values are given based on the information given by the participants in the background information form(see appendix D).

| **Background Variable** | **Value** |
|---|---|
| Average age | 73 (sd=5.7, low=65, high=85) |
| Gender distribution | 5 male and 9 female |
| Average internet use | Once a day |
| Average use of mobile phone | Several times a day |
| Experience with game consoles | 1 of 14 participants |
| Average exercise frequency | Two to three times a week |
| Average exercise intensity | I get sweaty or feel out of breath without taking myself all out |
| Average exercise duration | 30 to 60 Minutes |
| Average number types of exercise | Two different types |

Table 3: Participant Background

# 13 Procedure

The usability tests took place during the period of the 17th of April until the 23rd of April, 2013. Before the actual usability tests were conducted, three pilots test were conducted in the week before. The pilot tests were conducted with acquaintances of the test facilitators. These were people that did not match the age requirements to participate in the actual usability tests.
Each of the tests took slightly less than an hour. A timetable with estimated times for one individual usability test is presented in table 4 below.

| **Activity** | **Expected time duration** |
|---|---|
| Introduction to usability test and completion of consent and background form | 10 Minutes |
| Demonstration of first game | 3 Minutes |
| Participant game play | 5 Minutes |
| Completion of SUS form | 3 Minutes |
| Demonstration of second game | 3 Minutes |
| Participant game play | 5 Minutes |
| Completion of SUS form | 3 Minutes |
| Demonstration of third game | 3 Minutes |
| Completion of SUS form | 3 Minutes |
| Semi-structured interview | 10 Minutes |
| Card ranking | 5 Minutes |
| **Total time** | **53 Minutes** |

Table 4: Time Table for a Usability Test

The procedure for the usability tests were roughly based on the guidelines provided by Tognazzini (1992) and took considerations for the guidelines by Smeddinck et al. (2012) presented in section 7.2.1. The complete protocol is included in appendix G.
Each usability was started by introducing the participant to the facilitators. Three facilitators attended the each of the usability tests. The facilitators had separate roles and responsibilities. There was one main test leader, one observer and one moderator. The moderator had the responsibility of filming the sessions from the observation room.
The test leader introduced all three at the very start of the test, before asking the participant to sit down at the table across from the facilitator. Next the facilitator explained the upcoming activities as well as assuring the participant that the purpose

of the test was to test how the users felt about each of the game, not testing how well they performed. As each of the sessions were recorded on video tape, the camera was pointed out to the participant and he/she was asked to sign a written consent form after being informed that the videos would be deleted after the research was completed. Each of the participants were also asked to fill out a background information form(see appendix D), containing questions about age, technological experience and fitness level.
Before the facilitator started to demonstrate the exergames, the participant was given information about what equipment that was needed to use the game and was instructed to wear a belt containing a smartphone for measuring movement. The smartphone had the application *uFall* running while the games were played. uFall is an application made by developers in Italy as a part of the FARSEEING[9] project and the data will in later studies be analyzed to see difference in the movement required by each of the exergames.
The next step was for the facilitator to demonstrate how to play the first game. The order in which the participants played each game varied from participant to participant(order seen in table 2). Each of the elements on the screen was described as well as the game purpose before the facilitator played the game for a short period of time, to demonstrate how the game worked in practice. Before the participant him/herself was to try out the game, he/she was instructed in thinking aloud and was asked if there were any questions.
The participant then played the game all the way through and was given helping instructions if needed along the way. Figure 24 shows a typical game-play scenario. One facilitator standing on the side and setting up the games and the other facilitator standing(not shown) behind the participant during game-play incase of a fall situation.

[9]http://farseeingresearch.eu/

Figure 24: Participant playing the SilverFit

After playing one game the player was asked to sit down again to fill out the SUS questionnaire(see appendix E) for the most recently played game.
The steps of demonstration, game-play and filling out the SUS form was then repeated for the two remaining games, until the participant had played through SilverFit, Dance Dance Revolution and Your shape, as well as filled out a SUS form for each of the three exergames.

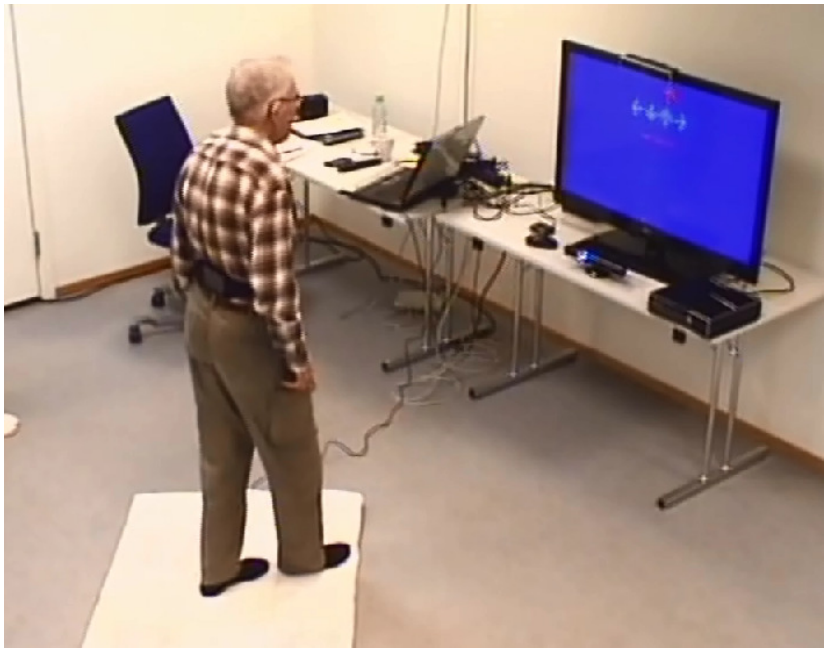

Figure 25: Participant playing Dance Dance Revolution

Figure 25 and 26 shows participants playing Dance Dance Revolution and Your Shape respectively.

Figure 26: Participant playing Your Shape

When the participant had completed the SUS questionnaire for the third and last game, the facilitator conduced a semi-structured interview(see appendix F) based on the UTAUT model(see section 8.4). This gave the participant the opportunity to express opinions and experiences that were not covered by the SUS questionnaire.
Ending the workshop was the card-ranking. The participants were shown the three cards (see figure 15), and he/she was asked to arrange them in the order of liking. This method was explained in section 10.1 and figure 27 shows a participant completing the card-ranking.

Figure 27: Participant Completes Card Ranking

# 14 Problems and Challenges

This section will address problems that occurred and challenges posed when conducting the usability tests.
One issue that came up was the number of participants attending the usability tests. 18 people were in total recruited to participate in the usability tests, but due to other commitments, three of the original participants cancelled, while one participant did not meet the age requirements of participation.
No issues with fall-risk raised during game-play. So there were no adverse events or injuries during the study.
Another issue that occurred, was with the equipment that was used. During the usability test there were some problems with the technical equipment and video recording. Firstly, due to lack of time, we did not manage to get the right dance-mat for the Dance Dance Revolution game. It was therefore, used a dance mat that is originally used for PlayStation 2. This dance mat was not recognized properly by the PC, so the dance mat was modified to function with the game. The modified dance-mat functioned as a prototype and is shown in figure 28.

Figure 28: Modified Dance-Mat

Secondly, a technical issue that is meaningful to address is the delay and lack of accuracy experienced with the TOF-camera technology for the SilverFit system. It was commented by some of the participants that their foot position was not correctly represented on the screen.

Lastly, an issue occurred with the video recording during one of the usability tests. All activity of this test was not recorded, but the facilitator took extensive notes during the interview.

# 15 Findings and Results from Usability Tests

This section will present the results of the first phase of the study, the usability tests. Firstly, the quantitative results from the SUS questionnaire and card-rankings will be presented with relevant statistical calculations and interpretations. Secondly, the qualitative data derived from the semi-structured interviews will be presented in subsection 15.4 categorized into the motivational constructs of the UTAUT model(see section 8.4). Lastly, in section 15.5 the qualitative analysis performed on the transcriptions of the interviews will be described, and the resulting themes of game elements will be presented. The results presented in this section and their impact on the research questions stated in section 1.2 will be discussed to a larger extent in section 19.

## 15.1 User Preference: System Usability Scale

The primary function of the System Usability Scale is to measure a systems general usability, this was described in section 7.3.1. A questionnaire containing the modified System Usability Scale(appendix E) was filled out by the participants after playing each of the three selected exergames. This means that for Dance Dance Revolution, SilverFit, and Your Shape, an individual average SUS-score could be calculated, giving an indication of each of the game's general usability.
The resulting SUS scores for each individual exergame, as well as average score, standard deviation and confidence interval is shown in table 5.

| **Participant** | **A: DDR** | **B: SilverFit** | **C: Your Shape** |
|---|---|---|---|
| ID1 | 90 | 87.5 | 80 |
| ID2 | 62.5 | 97.5 | 87.5 |
| ID3 | 50 | 97.5 | 97.5 |
| ID4 | 35 | 92.5 | 82.5 |
| ID5 | 67.5 | 85 | 65 |
| ID6 | 70 | 70 | 80 |
| ID7 | 57.5 | 65 | 65 |
| ID8 | 75 | 97.5 | 65 |
| ID9 | 100 | 100 | 100 |
| ID10 | 95 | 87.5 | 87.5 |
| ID11 | 85 | 80 | 97.5 |
| ID12 | 45 | 97.5 | 82.5 |
| ID13 | 70 | 85 | 95 |
| ID14 | 72.5 | 75 | 87.5 |
| **Average SUS score** | 69.64 | 86.96 | 83.75 |
| **Standard Diviation** | 18.9 | 11.1 | 12.1 |
| **95% Confidence Interval** | 9.9 | 5.8 | 6.3 |

Table 5: SUS-score Results

From the table shown above, it can be derived that the exergame with the highest overall SUS score is the SilverFit system with the mini game "the Mole". With a score of 87 points, SilverFit has the highest usability out of the three selected exergames, from the senior user-group's point of view. The exergame with the lowest score on the other hand, is the modified version of Dance Dance Revolution, with a score of just under 70 points. Dance Dance Revolution was also the exergame with the highest standard deviation and the most varied scores. For a more detailed view of each participant's given SUS scores with each games upper and lower confidence interval see appendix H. A graphical representation of the results of the SUS questionnaires are shown in 5. In table 5, the 95% confidence interval is calculated with the values alpha=0.05 and n=14.

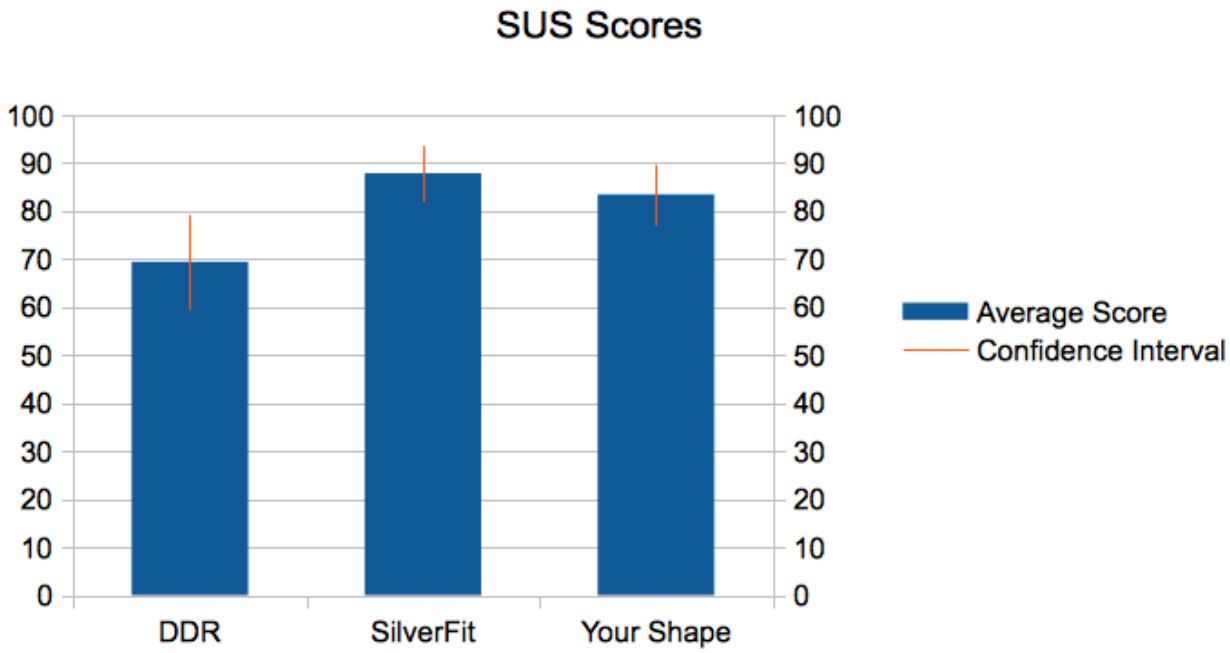


Figure 29: Average SUS Score with Confidence Interval

To compare more than two groups, the ANOVA test was used to analyze wether there was a significant difference in the SUS scores. The ANOVA test is a generalization of the t-test to more than two groups (Wohlin et al., 2000). An ANOVA test conducted on the SUS scores, gives a power value of $p = 0.016$. Such a low p-value, concludes that there is a statistically significant difference in the SUS scores, and the scores are not a result of random coincidences. After having done the ANOVA test, one can conclude that the exergame with the highest usability is indeed the SilverFit system.

### 15.1.1 Validity of SUS results

The SUS scores may not give a comprehensive view of what the participants preferred, because the SUS scale is designed for standard information systems. Using it for games will give an indication of preference of game, but it needs to be interpreted in combination with the card-ranking. Some of the statements in the SUS questionnaire can be ambiguous when in relation to games. One example could be the SUS statement number 8: *"I thought the game was difficult to use"*, which with a

high score contributing negatively for the SUS score for some of the participants, was contributing positively to their preferred choice of game during the card-ranking.

## 15.2 User Preference: Card Ranking

Use of the card-ranking method(described in section 7.6) showed a clear difference in user preference in terms of comparing the three different exergames. Table 6 gives a presentation of the results of the card ranking. The average rank for an exergame is calculated from what rank the participants gave the exergame according to their individual preference. The score is given either 1, 2 or 3, where 3 is the highest preference.

| **Game** | **Average Rank** |
|---|---|
| Dance Dance Revolution | 1.9 |
| SilverFit | 2.4 |
| Your Shape | 1.8 |

Table 6: Results of Card Ranking

In figure 30, a graphical representation of the average score from the card ranking is presented. For a calculation of the confidence interval the values of alpha=0.05 and n=14 were used.

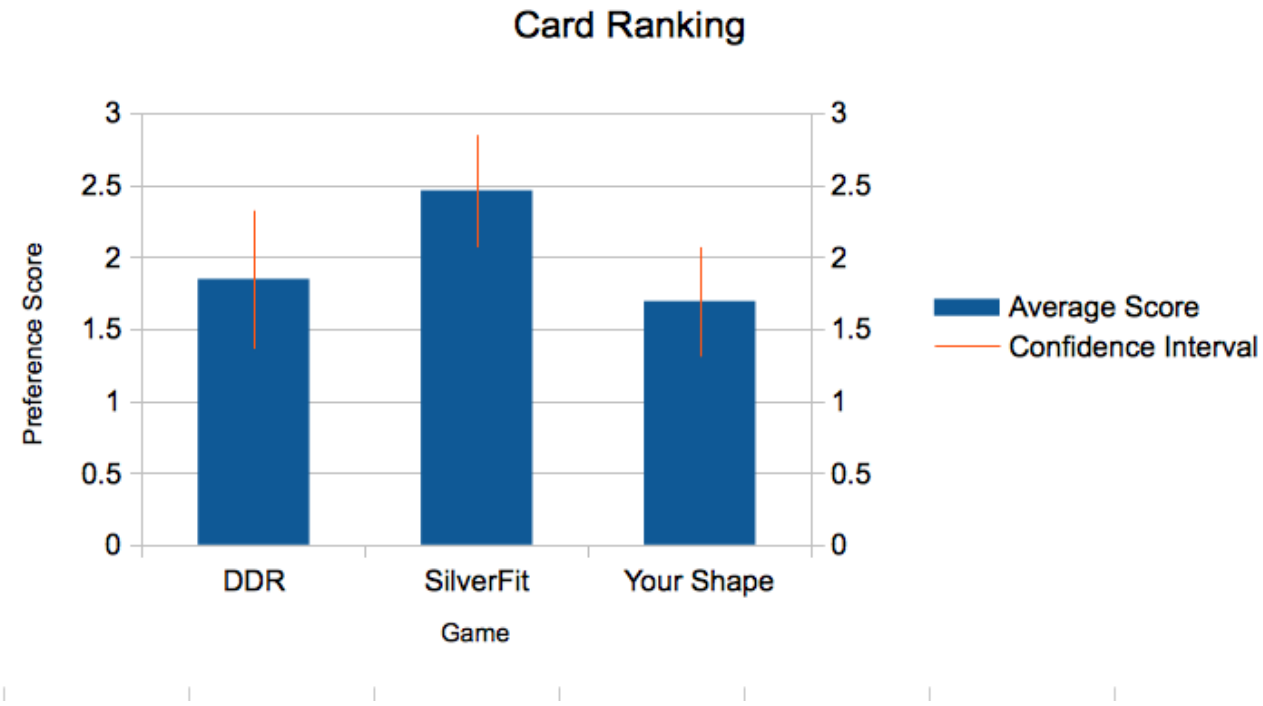


Figure 30: Average User Preference with Confidence Interval

To analyze the data from the card-ranking, a Friedman test was used. The Friedman is a similar test as the ANOVA, but for data in ranks. A simple Friedman test performed on the card ranking values gave a power value of p= 0.26, which means that the results of the card ranking can not be seen as statistically significant. Therefore, the results for the card-ranking can only be seen as an indication of a tendency that SilverFit was the most preferred exergame over the other two, but there is such a small difference between the two other games, that it can not be concluded which game is the least preferred. It therefore makes no sense to analyze which of the two exergames Your Shape or Dance Dance Revolution that is more preferred than the other. A complete representation of the results of the card-ranking and the Friedman test is included in appendix I.

## 15.3 Summary of User Preference

Table 7 provides an overview of the qualitative data collected on user preference in the study.

| Category | Game |
|---|---|
| Highest SUS score | SilverFit |
| Highest Card Rank | SilverFit |
| Performance Expectancy | SilverFit - 57% |
| Easiest | SilverFit - 50% |
| Hardest | Dance Dance Revolution - 71% |

Table 7: Comparison of User Preferance

## 15.4 Semi-structured interview: Motivational Factors

This section will present the results directly derived from the semi-structured interview conducted at the end of each usability test. The semi-structured interview was organized into the UTAUT constructs (see section8.4) and gave an insight into why the participants preferred one game over another, and what motivational factors that were important if they were to play these exergames on a regular basis. The questions asked during the interview were presented in section 10.1. The interview was semi-structured so the questions were not always posed in the same order, and follow-up questions were asked where it seemed relevant.
The results are presented in relation to the motivational factors from the Unified Theory of Acceptance and Use of Technology presented in section 8.4.

### 15.4.1 Performance Expectancy

One of the most important factors for users to take a new system into use is performance expectancy. The performance expectancy in this case is defined as how well the exergames perform in terms of exercise. It was very important to measure wether the participants saw the utility and exercise effect of these exergames or not. All participants said that they saw the potential benefits of using these games for exercise. When asked if they could see these exergames as useful answers included:
ID10: *Yes, to improve my balance and reaction.*
ID3: *It is a good way for keeping myself in shape.*
ID6: *I think that it is possible to train a bit of balance and control of movements with such games.*
ID14: *I can feel that I have exercised today. It feels good.*
ID1: *It would absolutely be useful, now I am thinking about people that are older and have a low mobility, because it is entertaining and because you are in fact moving.*

Several of the participants also recognized that the exergames required cognitive attention as well physical movement.
ID7: *Yes, to the highest degree. Reaction is what it is about!*
ID10: *I think I could use these games to improve my balance as well as my ability to react.*
ID13: *I think it would be useful. Especially in our age, we need to train our concentration and exercise reacting in a decent time frame. And if you use these games consistently, you could probably delay the slowing down of the mind for a while.*

Overall it was found that the perceived performance expectancy is a positive contributor to future use of exergames, as the participants could easily see potential benefits coming from it.

### 15.4.2 Effort Expectancy

Effort expectancy is concerned with the ease of use and how much perceived effort the exergames need in order to use them. During the usability tests it was found that the senior participants managed to very easily understand the concepts of the different exergames after the short demonstration by the facilitator. All participants managed to complete all three exergames, although some participants experienced more difficulty than others while playing. Most of the problems that the participants experienced occurred when the participants did not know how to or manage to perform the required movements correctly. Some usability issues with Dance Dance Revolution and Your Shape were uncovered:

- One usability issue that was found was with the dance mat for Dance Dance Revolution. It was observed that many of the participants had a hard time with stepping on the mat at the correct time, and managing to step in the small rectangle of the mat.

  ID13: *It was a bit tricky to step exactly on the area of the arrows. In the other game(referring to Your Shape), the sensitive area was much larger so it was easier to hit the targets.*
  ID4: *I couldn't concentrate on where they were.* One participants said while pointing at the arrows.
  ID9: *You had to estimate where to step, and it was a bit too far between the arrows.*

- There were also signs that the feedback given when the participants missed the arrow was not completely understandable. Observation showed that participants understood if they had missed an arrow, but not why they had missed it. All participants reported in the interview that they understood the given feedback and what to do better if they missed, that it was only their performance that was wrong, but some comments made it seem like the provided feedback was unclear to the player:

  ID5: *I wonder, why did I miss it? Was I too slow, or was it that I misstepped on the squares?*
  ID4: *What did I do wrong now?*

- Observing the game-play sessions, it was also found that several of the participants had problems with the mini game "Light Race" on Your Shape. Several of the participants stepped back when the instructions on the screen showed to step forward. This indicates a usability issue with the Your Shape "Light Race" mini game. Some participants reported that this confusion was one of the reasons why they disliked the game and therefore ranked it the lowest.

  ID 8: *I found it confusing, even though i knew that I wasn't supposed to step back, i thought the area was behind me. It was opposite.*
  ID12: *This one wasn't hard, I just didn't understand what was in front and was was behind me.*
  ID12: *This one was an irritation for me, because I didn't feel in control. I didn't manage what was front and back.*

- Another statement concerned the language that the instructions and feedback are given in.

  ID6: *Yes, it looked very okay. A requirement for a game like this should be that it has norwegian subtitles. If you are serving this to seniors in Norway, I think you should ensure that it is in norwegian. But otherwise I don't think it is difficult to understand the commands that appear.*

### 15.4.3 Social Influence

The questions concerning social influence was about how the people around the participants could influence their potential use of exergames. When it comes to negative influence, the general opinion from the participants was that it would not be embarrassing or uncomfortable to tell the people in their life about playing exergames, whatsoever:
ID8: *Oh no, on the contrary, everything I do to move my body I'm not afraid to share.*
ID12: *I would have encouraged them(others) to do the same.*
ID13: *No, today you can use pads, television and what not. I don't think anyone would have reacted negatively to that, most people would just be curious.*

When it comes to positive influence from others, it was found that the way the exergame could promote social interaction had a lot to say.
ID13: *I could play this with the wife.*
ID12: *Absolutely. It would be fun to play with my grandchildren!*
ID1: *If you could compete with a grandchild for example. That would be fun. We could se who could step on the most mice. Look what Grandma can do!*

It was also mentioned that exergames could be used in group training sessions.
ID14: *I think it should be played in a group, a place where I meed other people.*

Other participants mentioned that they would use the exergames if they were recommended to them by others.
ID1: *Depends on how it was introduced. I would maybe not tell people if it was introduced as: you're getting old and chubby, you should try this out!*
When asked if it would be better if it was recommended by a physical therapist:
ID1: *Oh, yes. It was recommended by my physical therapist!*
ID14: *Someone had to start me off. That this is offered around in the city and presented in the papers.*

This indicates that the social influence of other seniors as well as family would be positive in terms of playing exergames.

### 15.4.4 Facilitating Conditions

Questions relating to the construct of facilitating conditions concerned if the situation around the participants could be suitable for the use of exergames. When asked if they had room for the exergame equipment at home, many participants reported that they didn't. It was found that many seniors have small apartments with lots of furniture that would not be large enough to play these games. Some argued that the size and quantity of equipment needed to play was a barrier of the use of exergames.
ID1: *I think I would have room for it. If I make one room a permanent fitness room, but if you have to clear your living room each time, i don't know*
ID3: *The problem lies with all the equipment. I mean, most people have a lot of furniture. It would require a bigger operation to move things around, which is more problematic.*
ID5: *No, you know in a normal apartment. I can't think of how I would fit it in.*

Some participants were also concerned about falling while playing the games in a home-situation.
ID3: *I wouldn't be safe playing these games at home with a some kind of furniture behind be if I lost my balance, so it should be placed in front of a wall or something.*

### 15.4.5 Behavioral Intention

Behavioral intention concerns wether the participants actually would use the exergames if they had them available. When asked if they would use it regularly many participants said yes, on the basis of exercise.
ID8: *Yes, I think so. Both the dancing game and the second game(referring to SilverFit).*
ID7: *Yes, I would probably have played it several times.*
ID12: *Yes, I know I would continue using it.*

Although all participants said they saw potential benefits of using the exergames, some were skeptical of the level of exercise that these games could provide for themselves. Most of the participant were active and exercised 2-3 times a week or more.
ID13: *If you are used to doing more active exercise, it is clear that this will fall through.*
ID14: *I think this could be useful for me when I am not able to get out of the house anymore, but as the situation is today, I would rather go out to exercise.*
ID5: *No, I would not use it regularly. I have two workouts a week, and the other*

*days if it is nice weather I cycle and take walks in the forest. It will be used when I have nothing else to do.*

### 15.4.6 Anxiety

Anxiety was concerned with wether the participants felt nervous or uncomfortable while playing the exergames. Questions relating to anxiety were also concerned with the fear of falling during game-play. None of the participants in the usability tests claimed to be anxious while playing the exergames. No anxiety was observed by the facilitators either. When asked if they felt nervous or uncomfortable during game-play, answers included:
ID10: *No, I just think it was fun.*

Questions concerning wether the participants were afraid of falling while playing the exergames were also posed. The participants said that they were not afraid, but that other seniors might be.
ID12: *No, absolutely not. I crossed my feet, but that was just comfortable and amusing.*
ID1: *I am not afraid of falling, but I think that for example my mother in law, it would be nice to start very slow in the beginning. Like the slow melody in the dance game.*

### 15.4.7 Self-efficiency

Questions about self-efficiency was concerned with if the participants thought they would be able to use the exergames on their own. It was found, as noted previously, that the participants to a large extent, easily managed to play all the exergames after the demonstration. When asked if they would have been able to use these games on their own, the participants gave the impression that they would be able to use the games, given that somebody set up the technical equipment for them:
ID1: *I din't really pay attention to how you set them(referring to the games) up. But if someone had done it for me, then yes I think so. It has to be simple, but it seemed simple.*
ID3: *Yes, it can't be tremendously complicated to set up something like this.*
ID4: *Yes, after a while.*
ID7: *Yes, I think so.*

ID10: *I just have to learn the technical part. If someone just sets it up for me.*

### 15.4.8 Attitude Towards Technology

Attitude towards technology is concerned with the participants perception of playing exergames as an activity in general. During the usability tests it was found a general positive attitude towards the use of exergames. Many stated that it was a fun activity:
ID7: *I like these sorts of games. Competing in different things, I like that.*
ID9: *It was very fun.*
ID11: *It is fun when you feel like you are using your mind a bit more.*

While the majority of the participants were positive towards using these exergames at a regular basis, it was experienced that many of the senior participants in the usability tests lacked the motivation to use this game in a home setting without any external instructions for use. Although all participants said they saw potential benefits of using the exergames, some were skeptical of the level of exercise that these games could provide for themselves. Most of the participant were active and exercised 2-3 times a week or more. Others did not have the right attitude towards exergames.
ID6: *It was fun, but i don't think I would use it. I would rather take a walk. It would be a long process to change my attitude towards these things, it not about the games themselves.*
ID3: *No, I don't think I would use it regularly, but that is because I am lazy.*
ID4: *I don't like computer games. Although I might think about using game number one(referring to SilverFit) and three(referring to Your Shape).*
ID14: *I don't know if elderly people would take this out when they are home. It is something about mastering computers.*

## 15.5 Qualitative analysis

All statements and exclamations said during the usability tests were transcribed in order to be further analyzed. To uncover what game elements that were indicated as important in the semi-structured interviews, the transcribed data was analyzed as qualitative data with the procedure described in section 7.8.
To start off the qualitative analysis of the transcriptions, the individual statements needed to be categorized into themes depending on the content of them. To organize

all the statements, each of the statements were categorized with one or more tags. The tags were small descriptions of the contents of the individual statement. Tags found were for example speed, level of difficulty, engaged by animals as main characters.
To organize the tags, the HyperRESEARCH[10] tool was used to analyze the transcribed data. This research tool provided the possibility to give selected sections of the text different tags. After all statements were given one or more tags, they were analyzed in relation to each other. All the tags that came up were bundled under main categories depending on their connection to each other. A mind map of the tags and themes was made showing the main categories and subcategories. The mind map is shown in figure 31.

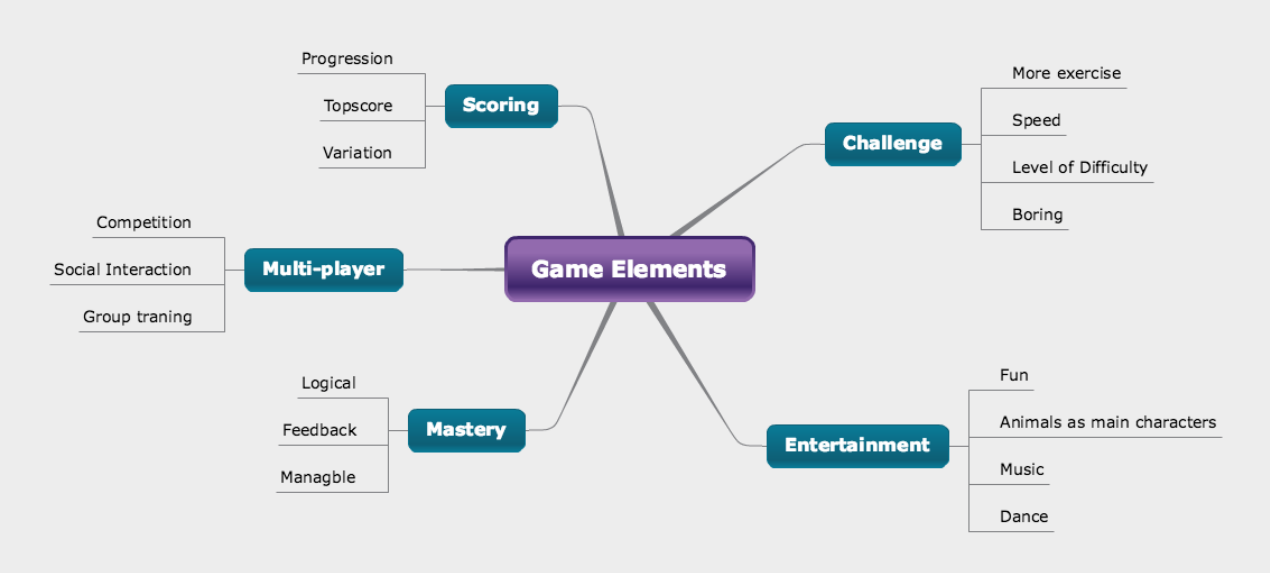


Figure 31: Mind Map of Categories in Transcriptions

When refining, the statements were analyzed for connections and were organized into themes. Five themes emerged from the tags and were formulated into five game elements of exergames that influence the seniors preference in the use of exergames. These game elements are presented in the five following subcategories.

[10]http://www.researchware.com/

### 15.5.1 Challenging Level of Difficulty

To create a successful exergame for seniors, it is important for the game to provide the player with enough challenge. This element of exergames was formulated because it was observed that the participants often preferred the game that they found the most demanding. Statements from the senior participants in which this element emerged from include:

ID5: *Fun and fun, it is the difficulty that matters. I would say the last one(referring to DDR) because it was the hardest.*
ID14: *If I had kids at my house I would choose this one(referring to SilverFit), but I choose this one (referring to DDR), it was the most exciting, the most demanding, and the most difficult, but also the best.*
ID11: *It has to be challenging. Not too hard, but so you don't get bored.*

The level of difficulty in this context is, in addition to challenging game aims and goals, also related to how challenging the physical movement required by the exergames are. It was found during the usability tests that the participants felt like the most demanding exergame would have the highest exercise effect and therefore ranked these exergames the highest. Higher perceived exercise effect will positively effect the motivation to use the exergame, as mentioned in section 15.4.1. A challenging level of difficulty should include:

1. Large movements.
   Many participants felt the exergames with the largest movements were the most demanding.
   ID6: *I would think that the second game was most demanding, because then I couldn't just throw my foot out if I had to move over a ladybug.*
   ID10: *It was more complicated to watch out for the ladybugs, you had to move a bit more.*
   ID8: *You used your upper body and the feet more.*

2. Balance and Concentration.
   One of the mentioned criteria for a demanding exergame in terms of movement was balance and movements using the feet. Participants had arguments such as:
   ID14: *I had to be more concentrated, to go both back and forth. With my balance, this was the most challenging game(referring to DDR).*

ID4: *The last one(referring to SilverFit). I had to think a bit more, that is important. To get the feet and the head to cooperate.*

3. Speed.
   Some participants noted that it was the speed of the movement was important for their choice of game.
   ID1: *I have to say the last one(Your Shape), because if you increased your speed, the speed of the game increased as well.*
   ID9: *I liked this, because It went a bit faster.*

A combination of a challenging concept, large required movements, balance and concentration as well as the speed of movement is needed to create an overall challenge in an exergame for senior citizens.

### 15.5.2 Mastery of game aims

The second theme that emerged from the qualitative data was the mastery of game aims. In addition to a giving the player enough challenge to motivate further play, it is important to create goals and aims that can be mastered by the senior citizen. From the qualitative analysis, it was experienced that if the game was to hard, the participants got demotivated and wanted to give up on the game and said things like ID7: *How much longer do I have to play?* and ID4: *I am never going to use this.*

The game element of mastery of game aims includes that the goal of the game should be felt as it is in the player's reach. If the goal of the game is seen as completely out of reach for the player, they will not continue playing it. A manageable goal should require movements that can be manageable by senior citizens. Manageable movements were found to effect the preference of exergame positively:
ID12: *It must be the last one, because it was the one that I managed the best. I never got the hang of the two others.*
ID1: *I have tried some video games before but I have more faith in these, because they are easy, as well as fun.*

When the aim of the game didn't seem like it was in the participant's reach, it effected the preference negatively:
ID4: *I didn't like this(referring to DDR). Because i didn't hit them (talking about the arrows).*
ID3: *Even old people get mad if they don't get it right when they have really tried.*

### 15.5.3 High-scores and Progression

From the qualitative data from transcriptions of the semi-structured interview, the use of high-scores was a recurrent theme. Participants expressed that a necessary game element to include in an exergame was a way of scoring the players performance. This will provide a motivation for the player to do even better the next time he/she plays the game.
ID7: *I would like to compare my score from one time to another. Where I stand in terms of memory and reaction. I usually compare the number of steps I can do in a time frame.*
ID8: *You don't have to compete against any one other than yourself, but that is a big motivation for me. Doing it better than yesterday.*
ID12: *You get points, we are competitive people, no matter what we say. In this case you are competing with yourself, and it is fun to see that you are doing it right.*
ID13: *You saw how you did. Especially in the last one(referring to SilverFit) you saw if you got plus points or minus points.*

Aside from the exergames giving the player scores for their performance, another recurrent theme was progress and variation. It was found that there should be a variety of different difficulties or levels of the game. Giving the player an opportunity to develop new skills and progress in the game. Progression was often mentioned by the participants as important:
ID1: *I liked that the fist game(referring to DDR) had the possibility of more melodies and increased speed. If you like to dance, i liked the dance game because you can se progression in each of the different melodies. If you have stepped on a thousand moles it might get boring.*
ID3: *It has to show progression, you always compete with yourself, you do that from you are born. After the first few times you play these, it will be the same and the interest will taper off.*
ID7: *You learn this (referring to the games). If you play it everyday, you would want to buy a new one.*
ID1: *Progression is important. Like I said, if you have stepped on a thousand moles.*
ID12: *A goal for the next time I play. Something to strive for. To see that you are scoring and doing good. That doesn't diminish with the years.*
ID14: *I want to see that I am getting better and better.*

### 15.5.4 Entertaining Game Concept

While analyzing the transcriptions, it was observed that the elements in the user interface had a lot to say for the senior participant's preference of exergame. The garden and animal theme of the SilverFit games, seemed to have a positive effect on the players motivation, and many positive comments were given during game-play. This concept got a lot more comments and participants showed more enthusiasm when playing SilverFit than while playing the other two exergames. Participants commented a lot on the animal characters:
ID1: *It's good it is not a cat, then I wouldn't want to step on it! But this one is cute as well.*
ID1: *I think the game with mice, ladybugs and moles was the most fun.*
ID12: *I liked the childish one. It had a pleasant atmosphere. These other ones had a more plain environment. You felt like you were in a gym in this one. (referring to Your Shape).*
ID2: *The one with the animals was the most exciting one.*
ID14: *I liked the one with animals. Ladybugs, moles and mice. It's also pleasant when it is animals.*

Another emerging theme was accompanying music. It was observed that many of the participants enjoyed playing Dance Dance Revolution because of the music accompanying the movements. Music can therefore have a positive effect on the player's perception of the game.
ID1: *I think this game would be fun, especially if you like to dance, because you get the music. So in the longer term I think this would be the more fun. I think about my mother I law, she loved to dance, if we could have motivated her through this.*
ID14: *Music has a big significance when I'm moving my body.*

Another observation in relation with the music, is that the sounds accompanying the game should be specifically suited for the game play. The fact that the pace of the arrows and speed of the movement in Dance Dance Revolution did not match the music, was a negative factor for the participants:
ID12: *This one was just out of pace.*
ID3: *I felt like it did not match the rhythm in the music. When it doesn't match the music it gets illogical, and you get irritated over things that don't fit. That was definitely the vulnerability of this game..*

### 15.5.5 Multi-player functionality

The social aspect of competing with others in the exergame was also mentioned as a requirement to continue playing. It was argued that these games would be good in a social setting. Many of the participants stressed the importance of the social aspect with exercise.
ID13: *I could play this with the wife.*
ID14: *I think it should be played in a group, a place where I meed other people.*
ID12: *Absolutely. It would be fun to play with my grandchildren!*
ID1: *If you could compete with a grandchild for example. That would be fun. We could se who could step on the most mice. Look what Grandma can do!*

Because of this enthusiasm towards cooperation and competition, it would be very beneficial to include a multi-player functionality in the exergame so that the user can play with others, and see how they compare in score.

# Part V
# Research Procedure and Results: Domain Expert Evaluation

# 16 Planning

This section will describe how the focus group session conducted with domain experts was planned, this includes where it was held and who participated.

## 16.1 Location

To get an expert opinion on the three selected exergames, a focus group session with participants from the health domain was held. The small focus group session was conducted the 13 of May, 2013, and it was, like the usability tests, held at NSEP usability lab at the Faculty of Medicine at NTNU. The NSEP lab was used because it contained all the necessary equipment needed for the session. The whole session was also recorded on video, to be analyzed further afterwards. The lab was set up with one table in front of a large screen television connected to a computer. The setup of the lab is shown in figure 32.

Figure 32: Setup at NSEP for Focus Group Session

## 16.2 Participants

Present during the focus group session was the domain expert panel consisting of two experts in the field of human movement science, as well the author acting as the facilitator of the session. To provide information about their backgrounds, as well as to ensure that these were the correct experts to use in this evaluation, the participants were asked to fill out a background information form. This form is included in appendix J. The expert panel consisted of one professor in human movement science and one physical therapist, with 22 and 5 years of experience in the field of movement science, respectively. None of the participating experts had much experience with video consoles, but had previously tried out some Wii and PlayStation.

# 17 Procedure

This section describes how the focus group session was conducted. A timetable for the session with estimated use of time is shown in table 8.

| **Activity** | **Estimated time use** |
|---|---|
| Introduction and completion of forms | 5 Minutes |
| Brainstorming: success criteria | 15 Minutes |
| Presentation of game number 1: DDR | 5 Minutes |
| Discussion of game 1 | 10 Minutes |
| Presentation of game number 2: SilverFit | 5 Minutes |
| Discussion of game 2 | 10 Minutes |
| Presentation of game number 3: Your shape | 5 Minutes |
| Discussion of game 3 | 10 Minutes |
| Brainstorming: success criteria | 10 Minutes |
| **Total time** | **90 Minutes** |

Table 8: Timetable for Focus Group Session

Before starting off the focus group session, the two experts were, as noted in the previous section, asked to fill out a background information form. The participants were also asked to sign a written content form(see appendix B), as the whole focus group session was recorded on video.
With the aim for the focus group being to define what factors a step-based exergame must have in order to be a successful tool in balance training for seniors, the session was started off with a small brainstorming session. The facilitator asked the experts to picture that they were in the situation where they were investing in an exergame system for their physical therapy clinic or recommending it for home-use for a patient in need of balance training. Given this situation, the participants were asked to write down the success factors and requirements that they saw as important when making such an investment or recommendation. These requirements were each written down on post-its and hung up on a white board by the facilitator. The discussion of these criteria was left to the two participants, and they collaborated to establish them without any influence from the facilitator.
After establishing the initial general success criteria for exergames, the facilitator played three separate video clips of five minutes each. The clips were edited clips of the original videos of each individual exergame that was used in the evaluation in the usability tests(see section 13). The videos presented how the exergames were

played by a selection of the usability test participants categorized into the three exergames. In between showing each of the videos, the experts were asked to evaluate the exergame in question in terms of the success criteria established before watching the video clips. Both negative and positive comments were written down on post-its, represented with a plus or a minus depending on wether the comment was a pro or a con. The post-its were hung upon the whiteboard under the relevant criteria for that exergame. A figure of the whiteboard with success criteria and comments is shown in figure 33.


Figure 33: Requirements, positive and negative factors on post-its.

After having seen all the video footage and discussed pros and cons of each game, an unstructured interview as a discussion was conducted by the facilitator. The experts summarized the positive and negative factors and came up with a game that would be most suitable, as well as improvements that could be made. The domain experts talked freely and discussed among themselves with as little influence from the facilitator as possible.

# 18 Findings and Results: Focus Group

In this section, the results found during the focus group session will be presented.

Given the situation of recommending an exergame to a patient, the experts came up with six main success criteria for exergames in use for balance training for senior citizens.

- **Fun**
  The patients should have fun while playing the game. The game concept as well as the required movements should be enjoyable to perform.
- **Safety**
  The patient should be able to play the game safely, without posing a larger fall-risk than everyday activities.
- **Shifting of body weight**
  To train the balance, a shift of body weight from one foot to another is required.
- **Independent use**
  It should be possible for the patient to use the system without the constant presence of a physical therapist.
- **Full-body movements**
  The game should provide as big training effect as possible to the whole body as well as the stepping with both feet.
- **Challenge**
  The level of difficulty of game exercises should be challenging to the patient. The game should also provide progressive difficulty.

Dance Dance Revolution, SilverFit and Your Shape were each evaluated in terms of positive and negative factors of the stated success criteria. These negative and positive factors are shown in table 9, categorized into the relevant criteria. Factors contributing positively towards the requirement are represented with a plus sign(+) and factors contributing negatively to the requirement is represented with a minus sign(-).

| **Success Criteria** | **Dance Dance Revolution** | **SilverFit** | **Your Shape** |
|---|---|---|---|
| *Fun* | + Accompanying Music<br>- Boring, simple steps | + Interactive<br>+ Dynamic Movement<br>- No music | + Feedback<br>+ Some music<br>- Not suitable music |
| *Safety* | - Dance-mat provides an additional and unnecessary fall-risk | + No extra equipment<br>- Risk of stumbling in own feet | + No extra equipment<br>- Risk of stumbling when confusing back and front |
| *Shifting of weight* | + Present | + Good | + Ok |
| *Independent use* | + Easy menu<br>- Dance-mat<br>- Instructions in english | + No extra equipment<br>+ Easy menu<br>- Instruction in english | + No extra equipment<br>- Complicated menu<br>- Instructions in english |
| *Full-body Movement* | + Upright standing<br>- Often stiff movements | + More possible way to perform movements<br>+ More dynamic movements | + Upright standing<br>- Simple taps of the feet are enough to score points |
| *Challenge* | + Cognitive: use of the bomb<br>+ Possible levels of progression<br>- Timing is not an aim of balance training<br>-Timing of steps not in rhythm with music<br>- Small arrow area makes steps hard to hit<br>-Same step-movements through all levels | + Cognitive: use of ladybug and moving mice<br>+ Some progression available<br>- Progression possible only to a small extent | - Not cognitive<br>- The progression available consist of jumping, not good<br>- Not challenging enough |

Table 9: Results for expert evaluation

# Part VI
# Discussion and Reflections

# 19 Discussion

In this section the results presented in section 15 and 18 will discussed in detail. These results will be discussed in terms of the relevant research questions stated in 1.2 that they aim to answer. The results will also be discussed in terms of existing research and theory and in relation to each other in the upcoming sections.

## 19.1 Research Question 1: User Preference

The first research question asked:

*Which of three selected exergames are preferred by senior citizens?*

Research question number one was concerned with which of the three exergames SilverFit with the mini game "The Mole", Your Shape with the mini game "Light Race", and Dance Dance Revolution that was preferred by senior citizens. The question was addressed by conducting 14 usability tests with older adults with the age of 65 years and over. During the usability tests the senior participants played all of these three exergames. The answer to this research question is based on the quantitative data collected during the tests, which includes the analyzation of a card-ranking of each participant's preference of the exergames and system usability scale questionnaires(see section7.3.1) filled out by each participant for each individual exergame.
Results from the card-rankings as well as the SUS questionnaires filled out for each of the three selected games were presented in section 15. Both of these measures of user preference and usability gives the indication that senior citizens prefer the SilverFit and the mini game "the Mole" over the two other exergames Dance Dance Revolution and Your Shape.
With a total SUS score of 87 points from the system usability scale questionnaire, SilverFit can be concluded to have a very good, above average usability score. As noted in section 7.3.1, Bangor et al. (2008) provides a baseline of 70 points as an acceptable SUS score for usability, which means that SilverFit has a relatively high usability score, much higher than the baseline value. Dance Dance Revolution on the other hand, has an average SUS score of right under 70 points, which according to Bangor et al. (2008), is less than an acceptable score. SilverFit was also reported by the participants as the easiest exergame to use during the semi-structured interviews, which is in accordance with the SUS result.
A card-ranking of user preference showed that SilverFit was the most often highest

ranked exergame. Although it was calculated that the statistical significance of the rankings was too small, the SilverFit exergame was ranked the highest by 7 out of 14 participants.
On the basis of the quantitative data collected from a card-ranking of exergames as well as SUS questionnaires, it can be concluded that it is SilverFit and the mini game "The Mole" that is preferred by senior citizens.

## 19.2 Research Question 2: Motivational Factors

The second research question asked:

*What motivational factors exists for senior citizens in the use of exergames and how do these factors contribute negatively or positively to future use?*

To answer this question, the motivational factors from the Unified Theory of Acceptance and Use Technology model were addressed to get an insight into what factors that motivate the seniors to use exergames in the future. The motivational constructs of the UTAUT model were addressed in a semi-structured interview, where each question related to one of the motivational constructs. The answer to this research question will be based on the qualitative data derived from this interview. The motivational factors that were found to have a significant impact were:

- Performance Expectancy
  Performance expectancy is the perceived utility senior citizens can see in terms of potential health benefits coming from the use of exergames. To increase and encourage this use, there needs to be a high perceived utility in the use of exergames. The potential health benefits should be clear to the player once he/she has started to play.

- Effort Expectancy
  To motivate senior user's to play exergames it is an important factor that the game is easy to use. This includes that the movement required should be easily understandable as well as the game concept itself. The feedback given to the user should be clear and should express how the player is doing in the game. The language of the instructions and feedback should also be in the native language of the user-group as many seniors don't speak english fluently. A high degree of effort expectancy will contribute negatively to the user's motivation to play an exergame.

- Social influence
  The social influence of others is a construct that was found to contribute positively to seniors future use of exergames. The potential of promoting social interaction would be a positively contributing factor for the senior user group, giving the possibility to play with family, friends or other seniors. Group training as well as recommendation from others are factors that will increase the motivation to use exergames.

- Facilitating conditions
  The construct of facilitating conditions was found to give negative contribution to motivation. Although many senior citizens live in big houses and will have space for the required technology, many seniors have moved into small apartments and nursing homes with a lot of furniture and that leave little room for the needed equipment. The equipment needed for the exergame should therefore be set up in a permanent area so the senior citizen doesn't have to move around furniture and clearing the living room each time he/she wants to play.

- Attitude Towards Technology and Behavioral Intention
  The largest barrier for the use of exergames is the negative attitude that some seniors expressed towards video game technology. Healthy active seniors see the benefit of using exergames, but would rather exercise outside in the nature or at fitness classes.

## 19.3 Research Question 3: Game Elements

The third stated research question was:

*What game elements contributes positively and negatively to the senior user group's motivational factors towards the use of exergames?*

This research question addresses what elements that impacts senior user-group's like or dislike of exergames. A qualitative analysis was performed on the transcribed data from the usability tests. Derived from this analysis several game elements were highlighted as important when it comes to senior's preference of exergames:

1. Challenging Level Of Difficulty
   Senior citizens prefer games that give them a challenge. If games can be completed without too much effort, they are perceived as less exciting. Games can be challenging in terms of:

- Lage movements
- Balance and concentration
- Speed

2. Mastery of Game Aims
   Although a challenge is an important requirement of an exergames for seniors, if the game aims are experienced as unachievable the player gets demotivated and can contribute to the dislike of the overall exergame.

3. High-scores and progression
   It should be possible to rate the performance of the player in points or scores. This is to allow the player to evaluate his/her performance to previous performances. To ensure a continuos use of the exergame, a progression through the game should be available in the form of higher levels of difficulty, concentration or varieties in movements.

4. Entertaining game concept
   The user interface presented to the player should be pleasant and eventful. Positive reactions are given to the representation of animal characters in colorful, natural surroundings. Exergames for senior citizens should also use sound effects such as movements to music to engage the player.

5. Multi-player functionality
   Social interaction was found be of great importance for the senior citizens. To enable the possibility of engaging in social interaction as well as playing exergames to train balance, multi-player functionality should be included.

## 19.4 Research Question 4: Domain Expert Evaluation

The final research question asked:

*What success factors exists for exergames for seniors from domain experts point of view and how do the three selected exergames score in terms of these criteria?*

To answer this question, an expert evaluation in the form of a focus group with domain experts in the field of human movement science was conducted. Six success factors were established for exergames used in balance training for seniors:

- Fun
  An entertaining and enjoyable game concept should be provided to the patient.

- Safety
  A patient should be able to play the exergame safely.

- Shift of Body Weight
  The exergame should include movements that requires the patient to completely shift his/her body weight from one foot to another.

- Independent Use
  The patient should be able to use the exergame without needing constant help and supervision from a practitioner.

- Full-body movement
  The movements required by the exergame should promote the patient to move the whole body.

- Challenge
  The exergame should provide the patent suitable challenge as well as an opportunity to progress in the game.

In terms of these above mentioned success criteria, experts found that the most suitable step-based exergame in the use for balance training with seniors was the SilverFit, "The Mole", exergame. It was found that it gave the most full-body movement, was most fun, easy to use and gave a challenge.
Although SilverFit was chosen as the most suitable, the experts expressed that it was not optimal. Balance training requires exercising for a longer period of time, and the SilverFit game consists of mini games and should be extended to provide progression to motivate the patients to continue with the training. The exergame that scored the lowest in terms of the established requirements was Your Shape with the mini-game "Light Race".

# 20 Research Questions Relation to Each Other

When discussing the results several connections between each of the research questions were found.

- A challenging level of difficulty was one of the game elements mentioned as important in the qualitative data for research question two. Challenge was also one of the success criteria found for exergames mentioned in by domain experts in relation to research question 4. Challenge is therefor a recurring theme that will have a positive effect on the perceived effort expectancy mentioned under research question two.
- SilverFit with the mini-game ”the Mole” was picked as the most preferred exergame by the participants, got the highest usability score and was identified as the most suitable exergame for balance training for seniors by domain expert. This connection provides the indication that exergames should be specifically developed for the senior user group.
- The game element for multi-player functionality is in strong relation to the motivational factor of social influence.

That there is such a strong coherence between the research conducted in this study is gives the research a stronger validity. This will be discussed in section 22.

# 21 Research in relation to prior theory

This section will address the results provided in this study in relation to the prior theory presented in the background chapter.
One of the relations found is the element of social influence. The element of multi-player functionality and other social interaction was mentioned as a factor of great importance for the participants during the usability tests. This corresponds to the concept of connectedness found in researching senior citizens passions by De Schutter and Vanden Abeele (2008) described in section 5.
A connection was also found in the research relating to user interfaces in section 5. Gerling et al. (2011) found that senior citizens were motivated by animals main characters of games and garden or nature themed user interfaces, which was one of the established factors in research question three of this study. Entertaining game concept was one of the factors contributing to the participants in this study's preference of the SilverFit exergame over the other two exergames that had a more neutral background and theme.
The success criteria of individual use and challenge provided by domain experts in this study is in accordance with the two prior guidelines of simple setup routines and dynamic game difficulty respectively, found by Gerling et al. (2012) described in section 5.2.
A strong relation between the results of the qualitative analysis in research question three and the GameFlow model described in section 2.1, was also found. Each of the game elements in the qualitative analysis can be seen in relation to one or more of the GameFlow concepts. This is shown in table 10.

| **Exergame Elements found in research** | **Relating Concepts of GameFlow** |
|---|---|
| Challenging level of difficulty | Challenge |
| Mastery of Game Aims | Control, Player Skills, Clear Goals |
| High-scores and Progression | Feedback, Player Skills |
| Entertaining Game Concept | Immersion, Concentration |
| Multi-player Functionality | Social Interaction |

Table 10: Game Elements found in research compared to GameFlow model

The close relationship that was found between the GameFlow model(Sweetser and Wyeth, 2005) designed for regular users and the game elements found for senior

users in this study is an indication that the senior users are not very different for users in younger age groups.

# 22 Validity

This section includes a discussion of the results derived in this study in relation to validity. The validity will be addressed in terms of objectivity, internal validity, transferability, ecological and triangulation, which are all described in section 9.

## 22.1 Objectivity

In this study, much research was based on semi-structured interviews, and the facilitator had the risk of influencing the participants answers. Myers and Newman (2007) highlights how the interview can be very artificial, and the participant is asked to come up with an answer in a short amount of time. The researcher also runs the risk of contracting knowledge that is not really there.
To ensure the objectivity of the research conducted in this study, extensive video recording was used. All usability tests as well as the domain expert focus group was recorded. This made it possible for the facilitator to analyze if the participants were influenced in their behavior. However, it is not possible to completely eliminate the influence of the facilitator. It was experienced that most participants seemed sincere in their answers, although there is a possibility that some of the participants wanted to be "good participants" and were very positive towards all three exergames. During the focus group with domain experts, the participants were given a chance to talk freely with as little input from the facilitator as possible.

## 22.2 Internal Validity

By making the order in which the participants played each exergame balanced, some of the threats to internal validity was reduced. Known models and theories for conducting research were used to collect data. To measure usability the System Usability Scale was used(see section 7.3.1). To create the semi-structured interview for the usability test the Unified Theory of Acceptance and Use of Technology(see section 8.4) model was used. The research from this study was also compared in relation to prior research in section 21.
Another aspect is that the participants in the usability test only got to play a selected part of the game. In the SilverFit the participants played the mini game "the Mole" and in Your Shape "Light Race" and one song of the Dance Dance Revolution. As the participants only experienced parts of the game, this can not be seen as an evaluation of the games in whole, but only gives an indication of what seniors like and dislike in general.

## 22.3 Transferability/External Validity

One important issue to address in this study is wether it would be valid for the whole intended senior user-group. Only 14 senior citizens participated in this study, and this might be a too small sample to make generalizations about the whole intended user group of senior citizens. The participants were also active healthy seniors exercising on average two to three times a week, and there is a risk that the results might have been different if less active, isolated seniors were used in the study. This situation can be described as what Oates (2005) refer to as over-reliance on a special type of participant and what Myers and Newman (2007) refer to as an *elite bias*. It is also worth noting that all the participants were healthy, if participants with chronic diseases(such as dementia etc.) were used in the tests, the outcomes and requirements for exergames might have been very different. As the participants were recruited with convenience sampling, the result could also be different if random sampling was used.

## 22.4 Ecological Validity

The ecological validity of the usability tests conducted are addressed in relation the fidelity concept described in section 9.4. During the usability tests the focus was more on testing the actual games rather than testing the correct use situation.
Most of the equipment used was as it would be if used in a real-life context. Both of the games SilverFit and Your Shape are released and available games. Dance Dance Revolution on the other hand, reduces the equipment fidelity of the tests as the mat, as well as the game itself were only prototypes. The prototype of the dance mat was also discussed as a challenge in section 14.
The environment fidelity of the usability tests is also a threat to the overall ecological validity, as the tests were conducted in a lab-situation in contrast to a real home or clinic situation.
When it comes to psychological fidelity, the biggest threat is to task fidelity. This is because in a real-life situation the user would not play one minute sessions of three different games, but use one specific exergame for a longer session.

## 22.5 Triangulation and constancy of results

Methodological triangulation was used in this study. Several methods were used to support the conclusions that were drawn from the results. Even though used for different research questions, many of the observances and conclusions drawn from

the usability tests were also mentioned in the focus group session with the expert panel. The relation and consistency between the results were discussed in section 20.

# 23 Conclusion

With the aim of exploring step-based exergames in balance training for senior citizens, two phases of research was conducted.
In the first phase, 14 usability tests were conducted with participants in the age of 65 and over. The participants evaluated the three exergames Dance Dance Revolution, SilverFit with the mini game "the Mole" and the commercial game mini game "Light Race" included on Your Shape. Data collected during these usability tests provided the answer to three out of four research questions in this study. The first research question concerned senior user's preference in exergames. Based on SUS questionnaires and card-rankings, it was concluded that the senior users preferred the SilverFit exergame above the two other games.
Secondly, the motivational factors of the unified theory of acceptance and use of technology was addressed in terms of exergames. It was found that most seniors are motivated to take the game technology into use, but that facilitating conditions at home and a negative attitude towards video games can become a barrier in future use of exergames.
The third research question was concerned with what game elements are important to user preference and motivation to play exergames. Five elements of exergames were found to be of great importance to the senior user-group's preference win exergames; a challenging level of difficulty, mastery of game aims, high-scores and progression, entertaining game concept, and multiplayer functionality.
Lastly, the fourth research question sought out to see the three exergames from a domain point of view. It was therefore, in the second phase, conducted a focus group session with two domain experts in human movement science. These domain experts provided six success criteria for an exergame for balance training for seniors. Fun, safety, shift of body weight, independent use, full-body movement, and challenge were pointed out as requirements for this type of game. After watching video clips of all the three exergames evaluated in the fist phase of research, the domain experts found that it was the SilverFit game that met the requirements the best. It was pointed out by the experts that this game was not perfect, as it did not motivate to long term use and needed more challenge and a way to progress to the game.
Several implications for practice was found in this study. Derived form the answers to the research questions in this study, it can be concluded that for exergames to be used in balance training for seniors, new exergames must be developed. The exergame that the senior user-group preferred was the only game that was specifically developed with the intent of senior users. In addition, SilverFit was the same game that was evaluated by expert as the most suitable exergame for balance train-

ing. Based on these results, one can recommend that a new exergame should be developed that resemble SilverFit, "the Mole", but including a way of progressing to new levels and higher difficulty levels. Elements from the two other exergames Your Shape and Dance Dance Revolution can also be used in a new exergame, including music and increasing speed.

## 23.1 Further Research

The research conducted in this study provides a basis for further research on exergames for elderly. The next step in researching step-based exergames for seniors can be threefold.

- Testing home situation
  The training of a senior citizen's balance is a longterm process. This means that the training should be readily available for the senior, preferably in his/her own home. To make it feasible to use exergame systems in an home situation for regular use, it would be necessary to conduct field studies in actual seniors' homes and conduct usability tests with exergames in what resembles a home setting. Further, safety equipment needed for home use should be evaluated.

- User Centered Design Process
  After having confirmed that step-based exergames for seniors should be specifically developed for the senior user-group, a user centered design process can start. With focus on the senior user-group a new specified adaptable exergame can be developed to motivate to longterm balance training. A recommended approach would be to start off with an brainstorming session with senior citizens and/or physical therapists where they can try out the SilverFit game and come up with a similar concept that can be played for a longer period of time and includes variety, individual feedback and progression to new levels. From there, the new concept can be refined by developers into a prototype exergame, that can be further tested for usability and so on.

- Clinical testing
  Another aspect to consider when it comes to the use of step-based exergames in balance training is to conduct usability tests with actual senior patients in the fall-risk group. Movement data should be collected for the game SilverFit game or even a newly developed exergame

To conclude the study it can be stated that the use of step-based exergames in balance training for senior citizens has a lot of potential, but before such a game can be taken into use regularly further research and development of new games is needed.

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# Part VII
# Appendix

# A Intvitation

## Vil du være med å prøve "kroppstyrte" dataspill?

Som en del av min avsluttende masteroppgave i datateknikk på NTNU ønsker jeg å invitere deg til å delta i et forskningsprosjekt som handler om å bruke tv-spill som en aktiv treningsmetode for seniorer. Vi vil her teste ut ulike tv-spill som kan være et alternativ til fysisk aktivitet, og ønsker din hjelp for å finne det beste alternativet.

Oppgaven jeg skriver handler om "kroppsstyrte" tv-spill i trim for seniorer. Din oppgave er å prøve ut et par spill og gi oss din mening om spillene og om tv-spill er noe som virker motiverende og kunne passet inn i din treningsrutine.

Vi ønsker å invitere deg til en evaluering av spillene som vil foregå i NSEP brukbarhetslab på Det Medisinske Fakultet på St.Olavs Hospital en av dagene i uke 16, i dagene 17 til 19 April, og vil ta rundt en times tid.

Det krever ingen forkunnskaper i data eller dataspill for å være med, og fokuset er på motivasjon. Det skal være gøy å holde seg i form!

Hvis du er interresert, meld deg på ved å ringe meg på telefon 97985548.
Du kan også sende en mail til kristiy@stud.ntnu.no, så avtaler vi et passende tidspunkt.

Håper du ønsker å bidra til mitt forskningsprosjekt.

Med vennlig hilsen,
Kristine Ystmark

# B Written Consent Form

**Samtykkeerklæring**

*Dataspill for seniorer.*

Jeg har mottatt informasjon om forskningsprosjektet, og har fått anledning til å stille spørsmål. Jeg er klar over at det er frivillig å delta på denne samlingen, og at jeg kan trekke meg når som helst uten å oppgi noen grunn.

Det vil bli tatt video- og lydopptak av samlingen. Dette gjøres for at vi skal kunne analysere det som har skjedd i etterkant og for å sikre oss at vi har forstått utsagn og handlinger riktig. Vi vil sørge for at materiale vil bli anonymisert slik at det ikke vil være mulig å føre opplysningene tilbake til enkeltpersonene som deltar i prosjektet. Det er kun de involverte i prosjektet som vil kunne se opptakene i ettertid.

Jeg samtykker i å delta i studien.

Trondheim,_____

_____
*Underskrift*

# C Application to the NSD

# MELDESKJEMA

Meldeskjema (versjon 1.4) for forsknings- og studentprosjekt som medfører meldeplikt eller konsesjonsplikt (jf. personopplysningsloven og helseregisterloven med forskrifter).

## 1. Prosjekttittel

| | | |
|---|---|---|
| Tittel | Brukbarhetstesting av dataspill for eldre | |

## 2. Behandlingsansvarlig institusjon

| | | |
|---|---|---|
| Institusjon | NTNU | Velg den institusjonen du er tilknyttet. Alle nivå må oppgis. Ved studentprosjekt er det studentens tilknytning som er avgjørende. Dersom institusjonen ikke finnes på listen, vennligst ta kontakt med personvernombudet. |
| Avdeling/Fakultet | Fakultet for informasjonsteknologi, matematikk og elektroteknikk | |
| Institutt | Institutt for datateknikk og informasjonsvitenskap | |

## 3. Daglig ansvarlig (forsker, veileder, stipendiat)

| | | |
|---|---|---|
| Fornavn | Dag | Før opp navnet på den som har det daglige ansvaret for prosjektet.Veileder er vanligvis daglig ansvarlig ved studentprosjekt.<br><br>Veileder og student må være tilknyttet samme institusjon. Dersom studenten har ekstern veileder, kan biveileder eller fagansvarlig ved studiestedet stå som daglig ansvarlig.Arbeidssted må være tilknyttet behandlingsansvarlig institusjon, f.eks. underavdeling, institutt etc.<br><br>NB! Det er viktig at du oppgir en e-postadresse som brukes aktivt. Vennligst gi oss beskjed dersom den endres. |
| Etternavn | Svanæs | |
| Akademisk grad | Doktorgrad | |
| Stilling | Professor | |
| Arbeidssted | Institutt for Datateknikk og Inf. vit, | |
| Adresse (arb.sted) | IDI, NTNU | |
| Postnr/sted (arb.sted) | 7491 NTNU - Trondheim | |
| Telefon/mobil (arb.sted) | 73591842 / | |
| E-post | dags@idi.ntnu.no | |

## 4. Student (master, bachelor)

| | | |
|---|---|---|
| Studentprosjekt | Ja ● Nei ○ | NB! Det er viktig at du oppgir en e-postadresse som brukes aktivt. Vennligst gi oss beskjed dersom den endres. |
| Fornavn | Kristine | |
| Etternavn | Ystmark | |
| Akademisk grad | Høyere grad | |
| Privatadresse | Dybdahlsvei 5 | |
| Postnr/sted (privatadresse) | 7051 Trondheim | |
| Telefon/mobil | 97985548 / | |
| E-post | kristiy@stud.ntnu.no | |

## 5. Formålet med prosjektet

| | | |
|---|---|---|
| Formål | Formålet med prosjektet er å sammenligne brukervennligheten og opplevd nytteverdi av tre forskjellige dataspill for fysisk trening for eldre. Dette gjøres gjennom s.k. brukbarhetstester der testdeltagerne får prøve ut og gi tilbakemelding på tre forskjellige dataspill. Dataspillene bruker forskjellige type teknologi for å registrere brukernes bevegelser, som for eksempel infrarøde kamera i produktet Microsoft Kinect. Resultatene fra disse brukbarhetstestene vil siden brukes som utgangspunkt for design av dataspill for å motivere eldre til å være mer fysisk aktive. Prosjektet er et samarbeid med Det Medisinske Fakultet (DMF) ved NTNU i Trondheim, og EU-prosjektet FARSEEING. Kontaktperson DMF: Dr. Jorunn Helbostad. | Redegjør kort for prosjektets formål, problemstilling, forskningsspørsmål e.l.<br><br>Maks 750 tegn. |

## 6. Prosjektomfang

| | | |
|---|---|---|
| Velg omfang | ● Enkel institusjon<br>○ Nasjonalt samarbeidsprosjekt<br>○ Internasjonalt samarbeidsprosjekt | Med samarbeidsprosjekt menes prosjekt som gjennomføres av flere institusjoner samtidig, som har samme formål og hvor personopplysninger utveksles. |
| Oppgi øvrige institusjoner | | |
| Oppgi hvordan samarbeidet foregår | | |
| **7. Utvalgsbeskrivelse** | | |
| Utvalget | Et representativt utvalg av friske personer av begge kjønn over 65 år. | Med utvalg menes dem som deltar i undersøkelsen eller dem det innhentes opplysninger om. F.eks. et representativt utvalg av befolkningen, skoleelever med lese- og skrivevansker, pasienter, innsatte. |
| Rekruttering og trekking | Personene rekrutteres gjennom det pågående prosjektet "Generasjon 100" ved Det Medisinske Fakultet ved NTNU (CERG). | Beskriv hvordan utvalget trekkes eller rekrutteres og oppgi hvem som foretar den. Et utvalg kan trekkes fra registre som f.eks. Folkeregisteret, SSB-registre, pasientregistre, eller det kan rekrutteres gjennom f.eks. en bedrift, skole, idrettsmiljø, eget nettverk. |
| Førstegangskontakt | Kontakt skjer gjennom henvendelse på e-mail fra prosjektet "Generasjon 100" til et utvalg deltagere. "Generasjon 100" er et pågående prosjekt som allerede har godkjennelse fra Regional Etisk Komite Sør-Øst datert 15.08.2012 (Prosjektleder: Dorthe-Stensvold, NTNU). | Beskriv hvordan førstegangskontakten opprettes og oppgi hvem som foretar den.<br><br>Les mer om dette på temasidene Hva skal du forske på? |
| Alder på utvalget | □ Barn (0-15 år)<br>□ Ungdom (16-17 år)<br>■ Voksne (over 18 år) | |
| Antall personer som inngår i utvalget | 20 | |
| Inkluderes det myndige personer med redusert eller manglende samtykkekompetanse? | Ja ○ Nei ● | Begrunn hvorfor det er nødvendig å inkludere myndige personer med redusert eller manglende samtykkekompetanse.<br><br>Les mer om Pasienter, brukere og personer med redusert eller manglende samtykkekompetanse |
| Hvis ja, begrunn | | |
| **8. Metode for innsamling av personopplysninger** | | |
| Kryss av for hvilke datainnsamlingsmetoder og datakilder som vil benyttes | ■ Spørreskjema<br>■ Personlig intervju<br>□ Gruppeintervju<br>■ Observasjon<br>□ Psykologiske/pedagogiske tester<br>□ Medisinske undersøkelser/tester<br>□ Journaldata<br>□ Registerdata<br>■ Annen innsamlingsmetode | Personopplysninger kan innhentes direkte fra den registrerte f.eks. gjennom spørreskjema, intervju, tester, og/eller ulike journaler (f.eks. elevmapper, NAV, PPT, sykehus) og/eller registre (f.eks. Statistisk sentralbyrå, sentrale helseregistre). |
| Annen innsamlingsmetode, oppgi hvilken | Det gjøres bruk av video for å filme personenes bruk av teknologi. | |
| Kommentar | | |
| **9. Datamaterialets innhold** | | |
| Redegjør for hvilke opplysninger som samles inn | Personene som tester dataspillene vil bli filmet på video.<br>De vil fylle ut spørreskjemaer om bakgrunnsdata og deres subjektive vurdering av spillenes brukervennlighet. | Spørreskjema, intervju-/temaguide, observasjonsbeskrivelse m.m. sendes inn sammen med meldeskjemaet.<br><br>NB! Vedleggene lastes opp til sist i meldeskjema, se punkt 16 Vedlegg. |
| Samles det inn direkte personidentifiserende opplysninger? | Ja ● Nei ○ | Dersom det krysses av for ja her, se nærmere under punkt 11 Informasjonssikkerhet. |

| | | |
|---|---|---|
| Hvis ja, hvilke? | □ 11-sifret fødselsnummer<br>■ Navn, fødselsdato, adresse, e-postadresse og/eller telefonnummer | Les mer om hva personopplysninger er<br><br>NB! Selv om opplysningene er anonymiserte i oppgave/rapport, må det krysses av dersom direkte og/eller indirekte personidentifiserende opplysninger |
| Spesifiser hvilke | Navn, kjønn, alder, e-post, telefon. | |
| Samles det inn indirekte personidentifiserende opplysninger? | Ja ○ Nei ● | En person vil være indirekte identifiserbar dersom det er mulig å identifisere vedkommende gjennom bakgrunnsopplysninger som for eksempel bostedskommune eller arbeidsplass/skole kombinert med opplysninger som alder, kjønn, yrke, diagnose, etc.<br><br>Kryss også av dersom ip-adresse registreres. |
| Hvis ja, hvilke? | | |
| Samles det inn sensitive personopplysninger? | Ja ○ Nei ● | |
| Hvis ja, hvilke? | □ Rasemessig eller etnisk bakgrunn, eller politisk, filosofisk eller religiøs oppfatning<br>□ At en person har vært mistenkt, siktet, tiltalt eller dømt for en straffbar handling<br>□ Helseforhold<br>□ Seksuelle forhold<br>□ Medlemskap i fagforeninger | |
| Samles det inn opplysninger om tredjeperson? | Ja ○ Nei ● | Med opplysninger om tredjeperson menes opplysninger som kan spores tilbake til personer som ikke inngår i utvalget. Eksempler på tredjeperson er kollega, elev, klient, familiemedlem. |
| Hvis ja, hvem er tredjeperson og hvilke opplysninger registreres? | | |
| Hvordan informeres tredjeperson om behandlingen? | □ Skriftlig<br>□ Muntlig<br>□ Informeres ikke | |
| Informeres ikke, begrunn | | |

## 10. Informasjon og samtykke

| | | |
|---|---|---|
| Oppgi hvordan utvalget informeres | ■ Skriftlig<br>□ Muntlig<br>□ Informeres ikke | Vennligst send inn informasjonsskrivet eller mal for muntlig informasjon sammen med meldeskjema.<br><br>NB! Vedlegg lastes opp til sist i meldeskjemaet, se punkt 16 Vedlegg.<br><br>Dersom utvalget ikke skal informeres om behandlingen av personopplysninger må det begrunnes.<br><br>Les mer om krav til samtykke |
| Begrunn | | |
| Oppgi hvordan samtykke fra utvalget innhentes | ■ Skriftlig<br>□ Muntlig<br>□ Innhentes ikke | Dersom det innhentes skriftlig samtykke anbefales det at samtykkeerklæringen utformes som en svarslipp eller på eget ark. Dersom det ikke skal innhentes samtykke, må det begrunnes. |
| Innhentes ikke, begrunn | | |

## 11. Informasjonssikkerhet

| | | |
|---|---|---|
| Direkte personidentifiserende opplysninger erstattes med et referansenummer som viser til en atskilt navneliste (koblingsnøkkel) | Ja ● Nei ○ | Har du krysset av for ja under punkt 9 Datamaterialets innhold må det merkes av for hvordan direkte personidentifiserende opplysninger registreres.<br><br>NB! Som hovedregel bør ikke direkte personidentifiserende opplysninger registreres sammen med det øvrige datamaterialet. |
| Hvordan oppbevares navnelisten/ koblingsnøkkelen og hvem har tilgang til den? | Det lages en koblingsnøkkel som kun prosjektleder og studenten har tilgang til. Filene på datamaskin heter kun FP01, FP02 o.s.v., og persondata finnes kun på papir. | |

| | | |
|---|---|---|
| Direkte personidentifiserende opplysninger oppbevares sammen med det øvrige materialet | Ja ○ Nei ● | |
| Hvorfor oppbevares direkte personidentifiserende opplysninger sammen med det øvrige datamaterialet? | | |
| Oppbevares direkte personidentifiserbare opplysninger på andre måter? | Ja ○ Nei ● | |
| Spesifiser | | |
| Hvordan registreres og oppbevares datamaterialet? | ■ Fysisk isolert datamaskin tilhørende virksomheten<br>□ Datamaskin i nettverkssystem tilhørende virksomheten<br>□ Datamaskin i nettverkssystem tilknyttet Internett tilhørende virksomheten<br>□ Fysisk isolert privat datamaskin<br>□ Privat datamaskin tilknyttet Internett<br>□ Videoopptak/fotografi<br>□ Lydopptak<br>□ Notater/papir<br>□ Annen registreringsmetode | Merk av for hvilke hjelpemidler som benyttes for registrering og analyse av opplysninger.<br><br>Sett flere kryss dersom opplysningene registreres på flere måter. |
| Annen registreringsmetode beskriv | | |
| Behandles lyd-/videoopptak og/eller fotografi ved hjelp av datamaskinbasert utstyr? | Ja ● Nei ○ | Kryss av for ja dersom opptak eller foto behandles som lyd-/bildefil.<br><br>Les mer om behandling av lyd og bilde. |
| Hvordan er datamaterialet beskyttet mot at uvedkommende får innsyn? | Datamaskinen er passordbeskyttet, står i et avlåst rom, og lagringsserveren er fysisk frakoblet fra Internett. | Er f.eks. datamaskintilgangen beskyttet med brukernavn og passord, står datamaskinen i et låsbart rom, og hvordan sikres bærbare enheter, utskrifter og opptak? |
| Dersom det benyttes mobile lagringsenheter (bærbar datamaskin, minnepenn, minnekort, cd, ekstern harddisk, mobiltelefon), oppgi hvilke | Data lagres kun som angitt over. | NB! Mobile lagringsenheter bør ha mulighet for kryptering. |
| Vil medarbeidere ha tilgang til datamaterialet på lik linje med daglig ansvarlig/student? | Ja ○ Nei ● | |
| Hvis ja, hvem? | | |
| Overføres personopplysninger ved hjelp av e-post/Internett? | Ja ○ Nei ● | F.eks. ved bruk av elektronisk spørreskjema, overføring av data til samarbeidspartner/databehandler mm. |
| Hvis ja, hvilke? | | |
| Vil personopplysninger bli utlevert til andre enn prosjektgruppen? | Ja ○ Nei ● | |
| Hvis ja, til hvem? | | |
| Samles opplysningene inn/behandles av en databehandler? | Ja ○ Nei ● | Dersom det benyttes eksterne til helt eller delvis å behandle personopplysninger, f.eks. Questback, Synovate MMI, Norfakta eller transkriberingsassistent eller tolk, er dette å betrakte som en databehandler. Slike oppdrag må kontraktsreguleres<br><br>Les mer om databehandleravtaler her |
| Hvis ja, hvilken? | | |
| **12. Vurdering/godkjenning fra andre instanser** | | |
| Søkes det om dispensasjon fra taushetsplikten for å få tilgang til data? | Ja ○ Nei ● | For å få tilgang til taushetsbelagte opplysninger fra f.eks. NAV, PPT, sykehus, må det søkes om |

| | | |
|---|---|---|
| Kommentar | | dispensasjon fra taushetsplikten. Dispensasjon søkes vanligvis fra aktuelt departement. Dispensasjon fra taushetsplikten for helseopplysninger skal for alle typer forskning søkes<br><br>Regional komité for medisinsk og helsefaglig |
| Søkes det godkjenning fra andre instanser? | Ja ○ Nei ● | F.eks. søke registereier om tilgang til data, en ledelse om tilgang til forskning i virksomhet, skole, etc. |
| Hvis ja, hvilke? | | |
| **13. Prosjektperiode** | | |
| Prosjektperiode | Prosjektstart:12.03.2013<br>Prosjektslutt:01.09.2013 | Prosjektstart<br>Vennligst oppgi tidspunktet for når førstegangskontakten med utvalget opprettes og/eller datainnsamlingen starter.<br><br>Prosjektslutt<br>Vennligst oppgi tidspunktet for når datamaterialet enten skal anonymiseres/slettes, eller arkiveres i påvente av oppfølgingsstudier eller annet. Prosjektet anses vanligvis som avsluttet når de oppgitte analyser er ferdigstilt og resultatene publisert, eller oppgave/avhandling er innlevert og sensurert. |
| Hva skal skje med datamaterialet ved prosjektslutt? | ■ Datamaterialet anonymiseres<br>□ Datamaterialet oppbevares med personidentifikasjon | Med anonymisering menes at datamaterialet bearbeides slik at det ikke lenger er mulig å føre opplysningene tilbake til enkeltpersoner.NB! Merk at dette omfatter både oppgave/publikasjon og rådata.<br><br>Les mer om anonymisering |
| Hvordan skal datamaterialet anonymiseres? | Alt datamateriale vil bli anonymisert før publikasjon. Etter prosjektslutt vil nøkkelen bli destruert, og alle data vil bli slettet. | Hovedregelen for videre oppbevaring av data med personidentifikasjon er samtykke fra den registrerte.<br><br>Årsaker til oppbevaring kan være planlagte oppfølgningsstudier, undervisningsformål eller annet.<br><br>Datamaterialet kan oppbevares ved egen institusjon, offentlig arkiv eller annet.<br><br>Les om arkivering hos NSD |
| Hvorfor skal datamaterialet oppbevares med personidentifikasjon? | | |
| Hvor skal datamaterialet oppbevares, og hvor lenge? | | |
| **14. Finansiering** | | |
| Hvordan finansieres prosjektet? | Dette er et studentprosjekt ved NTNU uten ekstern finansiering. | |
| **15. Tilleggsopplysninger** | | |
| Tilleggsopplysninger | Ettersom vi ønsker å starte allerede i midten av mars hadde det vært fint om denne søknaden kunne behandles relativt raskt.<br><br>Det er kun friske eldre som deltar i studiet, og uttestingen av dataspillene vil ikke medføre noen helserisiko for dem. | |
| **16. Vedlegg** | | |
| Antall vedlegg | 3 | |

# D Background Information

**Deltaker ID:**

**A. Bakgrunnsinformasjon**

Alder:

Kjønn: ( ) Mann ( ) Kvinne

**B. Spørsmål om bruk av teknologi**

1. Har du PC eller nettbrett?

( ) Ja

( ) Nei

2. Hvor ofte bruker du internett? (i gjennomsnitt)

( ) Flere ganger om dagen

( ) En gang om dagen

( ) 2-3 ganger i uken

( ) Et par ganger i måneden eller færre

( ) Jeg bruker ikke internett

3. Til hvilket formål bruker du Intrnett?

| | Sjelden eller aldri | Noen ganger i måneden | 2-3 ganger i uken | Flere ganger om dagen |
|---|---|---|---|---|
| Skype | | | | |
| Email | | | | |
| Nyheter | | | | |
| Spill | | | | |
| Nettbank | | | | |
| Annet (Vennligst spesifiser aktiviteter) | | | | |
| | | | | |
| | | | | |

2. Jeg har mobiletelefon

( ) Ja ( ) Nei

Hvis ja: hvor ofte bruker du mobiltelefon?

( ) Flere ganger om dagen

( ) En gang om dagen

( ) 2-3 ganger i uken

( ) Et par ganger i måneden eller færre

( ) Jeg bruker ikke mobiltelefon

6. Jeg har erfaring med spillkonsoller (PlayStation, Xbox, Nintentdo etc.)

( ) Ja

( ) Nei

6a. Hvis ja:

Vennligst spesifiser navnet eller beskrivelse av spill og hvor ofte du har spillt.

| Spill | Sjeldent | 2-3 ganger i uken | Flere ganger om dagen |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |

**C. Treningsrelaterte spørsmål**

Med mosjon mener vi f.eks går tur, går på ski, svømmer eller driver trening/idrett

7. Hvor ofte driver du mosjon? (ta et gjennomsnitt)

( ) Aldri

( ) Sjeldnere enn en gang i uken

( ) En gang i uken

( ) 2-3 ganger i uken

( ) Omtrent hver dag

8. Dersom du driver mosjon så ofte som en eller flere ganger i uka: Hvor hardt mosjonerer du? (ta et gjennomsnitt)

( ) Tar det rolig uten å bli andpusten eller svett

( ) Tar det så hardt at jeg blir andpusten eller svett

( ) Tar meg nesten helt ut

9. Hvor lenge holder du på hver gang? (Ta et gjennomsnitt)

( ) Mindre enn 15 minutter

( ) 16 - 30 minutter

( ) 30 minutter - 1 time

( ) Mer enn 1 time

10. Hvilke typer mosjon driver du med?

( ) Går tur

( ) Løping/jogging

( ) Gruppetimer (yoga, seniortrim, spinning)

( ) Utendørs aktivitet (ski, sykkel, annen idrett)

( ) Svømming

( ) Annen aktivitet: ……..

# E System Usability Scale

## Noen spørsmål om spillet du har spillt. ID: Spill:

Vennligst sett kryss i kun en rute per spørsmål.

| | Sterkt uenig | | | | Sterkt enig |
|---|---|---|---|---|---|
| 1. Jeg kunne tenke meg å bruke dette spillet ofte. | 1 | 2 | 3 | 4 | 5 |
| 2. Jeg synes spillet var unødvendig komplisert. | 1 | 2 | 3 | 4 | 5 |
| 3. Jeg synes spillet var lett å bruke. | 1 | 2 | 3 | 4 | 5 |
| 4. Jeg tror jeg vil måtte trenge hjelp fra en person med teknisk kunnskap for a kunne bruke dette spillet. | 1 | 2 | 3 | 4 | 5 |
| 5. Jeg syntes at de forskjellige delene av spillet hang godt sammen. | 1 | 2 | 3 | 4 | 5 |
| 6. Jeg syntes det var for mye inkonsistens i spillet. (Det virket “ulogisk”) | 1 | 2 | 3 | 4 | 5 |
| 7. Jeg vil anta at folk flest kan lære seg dette spillet veldig raskt. | 1 | 2 | 3 | 4 | 5 |
| 8. Jeg synes spillet var veldig vanskelig å bruke. | 1 | 2 | 3 | 4 | 5 |
| 9. Jeg følte meg sikker på hva jeg gjorde da jeg brukte spillet. | 1 | 2 | 3 | 4 | 5 |
| 10. Jeg trenger å lære meg mye før jeg kan komme i gang med a bruke dette spillet på egen hånd. | 1 | 2 | 3 | 4 | 5 |

# F Semi-structured Interview

# Semi-strukturert intervju

**Deltaker ID:** **Dato:** **Kl:**

**1. Forventning av utførelse**

Hvilket spill følte du var mest effektiv i forhold til trening? Hvorfor?

Tror du du kunne brukt noen av disse spillene til trening i hverdagen? Hvorfor? Hvorfor ikke?

Kunne disse spillene vært nyttig for deg? På hvilken måte?

**2. Bruker forventning/brukeropplevelse**

Hvilket spill var enklest å bruke? Hvorfor?

Hvilket spill var mest komplisert?

Hadde du problemer med å finne ut av hvordan du skulle bruke spillet eller lese det som sto på skjermen? I så fall, hva ga deg problemer?

Hvor godt skjønte du hva du gjorde? Stemte bevegelsene i forhold til tilbakemeldingen?

Hvis du fikk dårlige tilbakemeldinger på skjermen, skjønte du hva du skulle gjøre for å gjøre det bedre? Var det forskjell på spillene?I så fall, hvilke var best/dårligst?

**3. Holdning mot teknologi (motivasjon)**

Hva synes du om å spille slike spill?

Hvilket spill var artigst å spille? Hvorfor?

Hvilket spill var minst artig? Hvorfor?

Hvilke egenskaper/detaljer i spillet kan motivere deg til å bruke det i fremtiden?

Hvordan ser du for deg at et slikt spill må være for at det skal være motiverende for deg å bruke det i hverdagen?

**4. Sosial påvirkning**

Ville det vært flaut å si til andre (venner/familie) at du spiller disse videospillene?

Tror du spillene kunne blitt brukt i en sosial setting?

**5. Tilretteleggende forhold**

Har du plass hjemme for utstyret?

**6. Selvstendighet**

Tror du du kunne brukt spillet på egenhånd?

**7. Angst**

Var du nervøs eller ukomfortabel når du spilte noen av spillene? Hvilke?

Ville du følt deg ukomfortabel med å bruke disse spillene hjemme? Hvilke?

**8. Intensjon om bruk**

Hvis du hadde disse spillene hjemme nå, ville du spilt regelmessig?

Hvilket spill ville vært ditt førstevalg?

**9. Sikkerhet**

Etter denne timen, tror du at du ville kunne brukt disse spillene hjemme og følt deg trygg?

Var du redd for å falle når du spilte spillene? Var det et spill som du følte det var større sjanse for å falle enn andre?

Følte du du ikke hadde kontroll når du spilte noen av spillene? Hvilke?

# G Test Protocol

**Før testperson kommer inn**

1. Sette opp utstyr
2. Sette kamera i riktig posisjon
3. Sjekke rekkefølge på spillene
4. Finne frem rett spill
5. Hente deltaker

**Manus for brukertester**

1. Introduksjon av oss selv, takke for deltagelse. Be deltakeren sette seg ned. Testleder/observatør.

2. Forklaring av hva testen går ut på, og at det er spillene som testes ikke deltaker.

3. Gi deltakeren samtykkeerklæring og bakgrunnskjema

4. Gi en kort beskrivelse av utstyret som er i rommet, viktig å forklare at det blir brukt videokameraer, hvorfor og at videoklippene vil bli slettet etterpå.

5. Feste Iphone på deltakeren, denne slås på og kan være på til siste spill er utført.

6. Finn frem første spill, og gi deltakeren en demonstrasjon av spillet. Si at det er lov å stille spørsmål til oss. Hva er poenget med spillet? Hva slags bevegelser skal testpersonen utføre? Gi også informasjon om lengden på spilletid.

7. Forklare deltaker at det er helt ok å avbryte testen når som helst dersom han/hun ønsker, uten å måtte gi en forklaring på hvorfor.

8. Si til deltaker at det er en fordel hvis de underveis i spillet "tenker høyt" for å gi oss et innblikk i hvordan deltakeren opplever spillet.

9. Spør om det er noe de lurer på før første spill begynner.

10. Deltaker spiller første spill.

11. Etter endt spilletid får forsøksperson tilbud om å sitte.

12. Still noen få spørsmål for etter det enkelte spillet, noter ned.

13. Neste spill demonstreres.

14. De 5 siste stegene over gjentas, til alle tre spill er utført.

15. Utfør et semi-strukturert intervju baset på forberedt spørreskjema.

16. Utfør en kort-rangering.

17. Stopp videoopptaket og avslutt testen. Takke for deltakelse.

Etter test

1. Lagre det i samme mappe. Sørge for å laste over fra telefon hver dag

# H SUS Score

| | DDR | SilverFit | Your Shape |
|---|---|---|---|
| ID1 | 90 | 87.5 | 80 |
| ID2 | 62.5 | 97.5 | 87.5 |
| ID3 | 97.5 | 97.5 | 50 |
| ID4 | 35 | 92.5 | 82.5 |
| ID5 | 67.5 | 85 | 65 |
| ID6 | 70 | 70 | 80 |
| ID7 | 47.5 | 65 | 60 |
| ID8 | 65 | 97.5 | 45 |
| ID9 | 100 | 100 | 100 |
| ID10 | 95 | 87.5 | 70 |
| ID11 | 85 | 70 | 97.5 |
| ID12 | 45 | 97.5 | 82.5 |
| ID13 | 70 | 85 | 95 |
| ID14 | 72.5 | 75 | 87.5 |
| Gjennomsnitt | 71.60714286 | 86.25 | 77.32142857 |
| Standardavvik | 20.22962277 | 11.91919912 | 17.11005906 |
| Konfidens Intervall | 10.59672972 | 6.243543592 | 8.962632346 |

# I Card-ranking

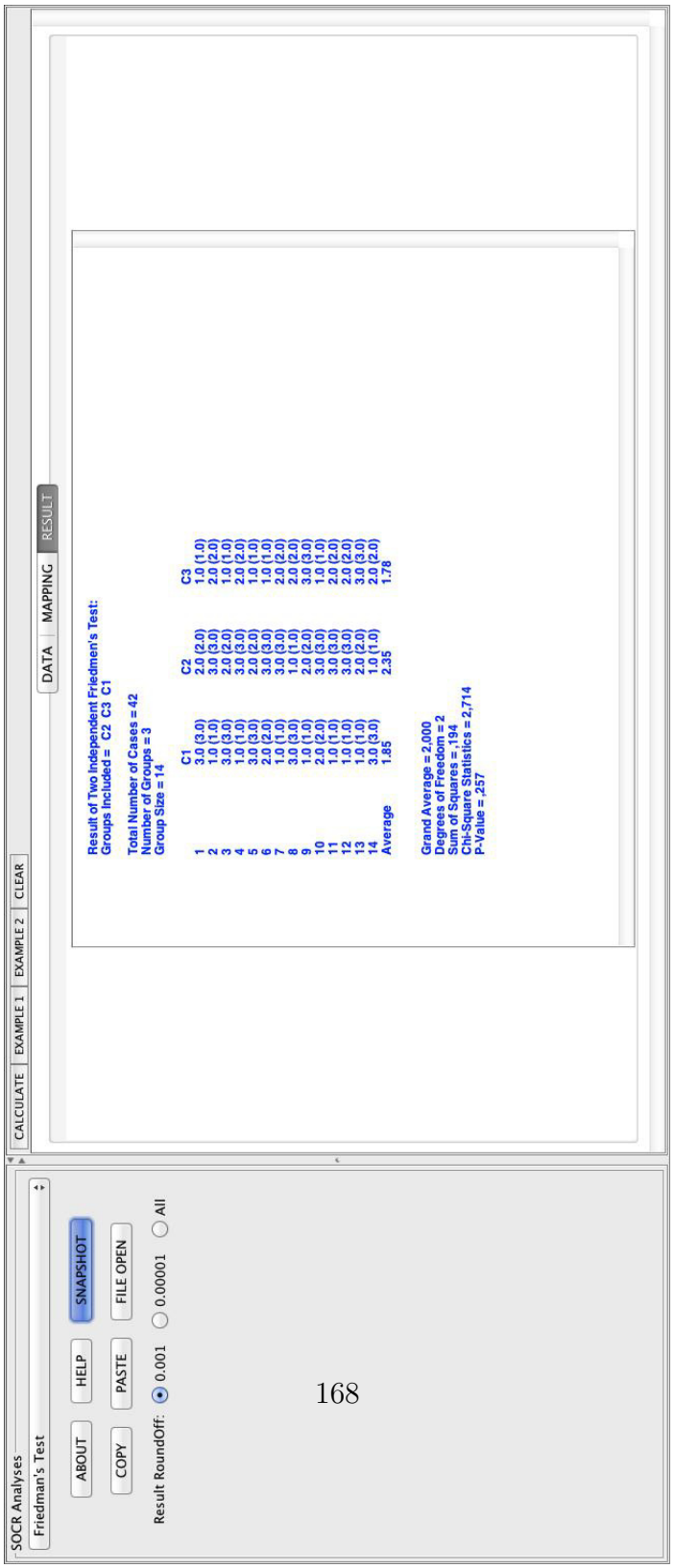


Figure 34: Results of card-ranking

# J Background Information Form 2

Informasjon om workshop-deltakere

1. Alder: _____
2. Kjønn: ( ) Mann ( ) Kvinne
3. Utdanning:
4. Yrke og fagområde:
5. År med erfaring fra yrket:
6. Erfaring med spillkonsoller: