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Full Body Computer Games for Physical Rehabilitation in Elderly People's Homes: Physical and Social Challenges and Opportunities

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Master of Science in Informatics
Submission date: May 2018
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Preface

This thesis is the final part of a two-year Master of Science in Informatics, specializing in interaction design, game and learning technology. The study is a part of the EXACT research project at the Department of Computer Science at the Norwegian University of Science and Technology, and was done in collaboration with the Department of Neuromedicine and Movement Science. The thesis was carried out over the fall of 2017, and the spring of 2018.

I would like to thank my supervisor, Dag Svanæs for his help and guidance through the past year. I would also thank Nina Skjæret Maroni for helpful insight in physiotherapy, and other medical fields. Thanks to Terje Røsand, head of IDI's UX-lab for help with the lab and recording equipment. Thanks to Sruti Subramanian for letting me use her game for the tests.

I would also like to thank my fellow students, Dag Frode Solberg, Håkon Solbjørg, and Jie Li for helping me with everything from recruiting to assembling IKEA furniture.

Lastly, I would like to thank everyone who participated in the study.

Ole Martin Knurvik
Trondheim, May 31, 2018

Abstract

The use of exercise games has proven beneficial and engaging for elderly people. Studies also suggest that rehabilitation programs using exercise games have higher adherence than traditional rehabilitation. With the aging population and growing need for healthcare, there is also an increasing need for solutions which reduces the cost of healthcare. The use of exercise games can help reduce this cost by allowing elderly people to stay active in their own homes. Despite this, little research has been conducted towards how this type of technology can be incorporated into elderly people's homes, and what needs to be taken into consideration when making games for this setting.

This thesis conducts two studies, one field study, and a lab experiment. The field study looks at how elderly people live and furnish their homes, to establish what limitations and possibilities exist when incorporating exergames. The lab experiment will aim to confirm these limitations and possibilities. The experiment also aims to identify differences between game behavior in a simulated home and a more traditional lab setting, and see how exposure to exercise games affect elderly people's attitude towards it.

The field study generated data which was used to make a generalized living room for elderly people, which could be simulated in a lab. It also revealed that most elderly people do not have sufficient available space to play traditional full body computer games without moving at least a table. The lab experiment suggests that people are generally open to move enough furniture to make room for exercise games, given that they want or need it. The lab experiment was not able to detect any differences in game behavior between the simulated home and the traditional lab. The exposure to exercise games was proven to have a positive effect on their attitude towards it, meaning that their interest in this type of technology could increase over time as it becomes more common.

Oppsummering

Bruk av treningsspill har vist seg å være nytteverdig og engasjerende blant seniorer. Studier har også vist at flere fullfører rehabiliteringsprogrammer som bruker treningsspill, enn tradisjonelle øvelser. Med en stadig aldrende populasjon, og et økende behov for helsetjenester, øker også behovet for løsninger som reduserer kostnadene ved helsetjenester. Bruk av treningsspill kan hjelpe å redusere disse kostnadene ved å tilrettelegge for at seniorer kan være aktive i sine egne hjem. Til tross for dette er det gjort lite forskning på hvordan denne typen teknologi kan integreres i seniorers hjem, og hva som må tas i betraktning når man lager spill til dem.

Denne avhandlingen består av to studier, en feltstudie og et eksperiment i lab. Feltstudien ser på hvordan seniorer bor og møbelerer hjemmene sine, for å kartlegge hvilke begrensninger og muligheter som finnes når man skal implementere treningsspill i eldres hjem. Eksperimentet brukes til å bekrefte disse begrensningene og mulighetene, identifisere forskjeller i spilloppførsel mellom et simulert hjemmemiljø og en mer tradisjonell lab situasjon, samt se hvordan eksponering til treningsspill påvirker seniorer holdning til dem.

Feltstudien generete data som ble brukt til å lage en generalisert stue for seniorer som kan simuleres i en lab. Det kom også frem at de fleste seniorer ikke har tilstrekkelig plass til å spille tradisjonelle treningsspill hjemme uten å minst flytte et bord. Lab eksperimentet antyder derimot at seniorer ikke har noe problem med å flytte tilstrekkelig med møbler for å kunne spille treningsspill, gitt at de ønsker, eller trenger det hjemme. Lab eksperimentet detekterte ingen forskjeller i hvordan seniorer spiller i en simulert stue, i mot en tradisjonell lab. Eksperimentet viste derimot at eksponering til treningsspill har en positiv effekt på seniorers holdning til konseptet, som på sikt kan gi en økning i interessen for denne typen teknologi over tid.

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Chapter 1

Introduction

To meet the increasing demand for healthcare, people have started looking into how elderly people can stay independent longer. Some of the initiatives are senior housing and home care (Daatland, 1999), but in more recent years more technical aids like fall detectors (Abbate et al., 2012) and wireless emergency buttons have become more common.

A crucial factor in enabling elderly people to stay home is physical activity. One of the major risks for elderly people are falls, as falls often results in permanent mobility reduction(Tinetti et al., 1988). The falls are also connected to inactivity and balance issues (World Health Organization et al., 2010).

As people age, they spend an increasing amount of time in or around their homes (Daatland, 1999). This means they will need to find ways to stay active at home. The use of exergames can help solve this problem and has shown great potential (Agmon et al., 2011; Uzor and Baillie, 2014; Alankus et al., 2010). However, the focus of previous studies seem to be on the feasibility of the concept and the effect it has on patients, and little research is done on how this can be incorporated into elderly peoples lives.

This thesis is a part of the EXACT research project at NTNU (further explained in Subsection 1.1.6) and aims to answer what obstacles and possibilities exist when moving exergames from labs and institutions, into elderly people's homes. The project is under the Department of Computer Science (IDI) and was conducted in cooperation with Department of Neuromedicine and Movement Science (INB).

1.1 Background

To better understand the motivation for this study, it is important to have a fundamental knowledge of the aging population, the health implications of physical activity, and the potential of exergames. The following sections aim to give a brief introduction to these topics, and defines some terminology used throughout the thesis.

1.1.1 Aging population

The life expectancy around the globe has been increasing as a result of increased income, nutrition, sanitation, education, and many other factors. In 1840 the record for highest average life expectancy was held by Swedish women, with 45 years. In 2002 the record was held by Japanese women, with almost 85 years. Meaning the record has nearly doubled in just 160 years (Oeppen and Vaupel, 2002).

This continuously increasing life expectancy comes with a growing need for healthcare, as the number of elderly people (people over 65 years) keeps increasing. In Scandinavia, geriatric care was almost synonymous with nursing homes until the 1950s. However, nursing homes are not the most cost-efficient solution, and not everyone needs all the help a nursing home provides. Besides, most elderly people wish to live in their own homes as long as it is practical. As a result, home care and technical aids to help elderly people stay independent longer have been a growing subjects (Daatland, 1999).

1.1.2 Exercising for better health

Inactivity is a growing problem, and the health risks associated with inactivity are comparable to those of cigarette smoking, high blood pressure (hypertension), and high cholesterol (hypercholesterolemia) (Pate et al., 1995). In 2010 inactivity was defined as the fourth leading risk factor for global mortality (World Health Organization et al., 2010). As small changes as a 1000 kcal[1] per week increase in activity level can decrease the mortality rate by as much as 20% (Myers et al., 2004), and has shown to reduce the risks associated with overweight, even without any weight loss (He and Baker, 2004).

For adults and elderly people (age 18 and up), it is recommended to have at minimum of 150 minutes of moderate-intensity or 75 minutes of vigorous-intensity aerobic physical

[1] A 178cm tall person weighing 73kg spend about 4.2kcal per minute walking. Meaning it would take just under 4 hours of walking to burn 1000 kcal. Evenly distributed over a week this equals an average of 34 minutes per day (Lester et al., 2009).

activity every week, with additional benefits of up to twice this amount. The scale of intensity used is relative to the individual's physical fitness, meaning the intensity needed to meet the recommendations will vary from person to person (World Health Organization et al., 2010). Pate et al.'s study also shows that many of the health benefits can be achieved with 30 minutes of moderate-intensity physical activities most days a week (Pate et al., 1995), and it is not necessary to have long high-intensity sessions. Since the intensity scale used is relative, achieving this goal could, for those with sedentary lifestyles, be as simple as walking to the store or work, and other everyday activities.

Studies have also shown that those who are functionally independent and cognitive intact before an injury, recover faster and achieve greater functional levels (Hershkovitz et al., 2007). There has also been found correlations between physical activity and reduced symptoms of aging. This includes muscle decay, reduced bone mineral density (Chodzko-Zajko et al., 2009), as well as increased life expectancy and greater cognitive performance (Penedo and Dahn, 2005).

1.1.3 Falls among elderly people

Physical trauma as a result of falls is a big problem for elderly people, and can be very costly. In 2015, the total cost of lethal and non-lethal falls in America alone were over $30billion (Burns et al., 2016). Another American study found that almost one third of the population over 65 years experience at least one fall every year (Prudham and Grimley Evans, 1981). A range of factors including age, gender, and living arrangements affects the fall statistics. The group with the least fallers were men age 65-70 living in community homes, with 13.1% experiencing one or more falls each year. While the groups experiencing most falls were women age 75-80, and men 85-90 living at home, with almost 50% of them falling at least once every year (Rapp et al., 2014).

About 10-15% of falls among elderly result in serious injuries, including fractures and head injuries (Peel, 2011). Many elderly people have their mobility and independence permanently reduces as a result of this, making falls count for as much as 40% of admissions to nursing homes (Tinetti et al., 1988).

The falls are mainly caused by balance problems, which can be reduced or partially avoided by staying active and exercising. Regular physical activity is found to reduce the risk of falling by nearly 30%, with focus on balance training and leg strengthening for best effect (World Health Organization et al., 2010).

1.1.4 Physical rehabilitation

Many injuries like physical trauma, overloads, and strains, require rehabilitation in order to get back to normal function. Typically a physiotherapist, or similar health personnel, will examine the injury and provide a program to follow in order to get better. Depending on the severity of the injury, the patient may also require additional treatment or guided rehabilitation sessions with appropriate health personnel (Maroni, 2017).

In addition to rehabilitation from injuries, many require rehabilitation as a result of diseases and medical conditions, such as dementia, cancer, and strokes. Physical activity can reduce or postpone many symptoms, increasing the patient's life quality (Penedo and Dahn, 2005). For example, exercising has proven to both increase the general life quality among cancer patients (Blanchard et al., 2004), as well as reduce and postpone the symptoms of chemotherapy (Headley et al., 2004). Physical activity is also important in order to rebuild strength and regain energy from conditions or the treatment.

Despite all evidence pointing towards physical activity and rehabilitation being essential to regain and maintain your health, many don't comply with the rehabilitation program provided(Uzor and Baillie, 2014; Jurkiewicz et al., 2011; Daly et al., 2002). In some cases, people are too tired, sick, or don't have the time to prioritize the program (Jurkiewicz et al., 2011), but studies also find lack of motivation, not seeing any progress, depression, and finding the program boring to be common barriers across different types of rehabilitation (Jurkiewicz et al., 2011; Daly et al., 2002). Daly et al. also points out that with rehabilitation programs which can not be done at home, distance and transportation is often an important factor.

1.1.5 Exergames

Exercise gaming, or exergames for short, refers to digital games used for physical exercising. Atari, Nintendo, and others were experimenting with combining games and exercise as early as the 1980s, although not all of which made it to the commercial market. Throughout the 1990s more commercial products were launched, and possibly one of the most iconic; Dance Dance Revolution (DDR). This arcade machine became very popular and an important sales point in marketing for many arcades and similar (Finco and Maass, 2014).

Later in 2006, Nintendo released their Nintendo Wii game console with motion controllers, which made at-home exergaming accessible and affordable (Sinclair et al., 2007). Today the Nintendo Wii consoles, and later introduced Microsoft Kinect, are the most common platforms for at-home exergaming. On the commercial market, the games for these plat-

forms mainly target children and families with children, as a fun way of staying active. Figure 1.1 shows a family playing Kinect at home, using their bodies and movement to play the game.

Exergames can help people exercise at home in a more engaging and entertaining way. A study on the long-term use of exergames in homes of elderly as fall prevention showed that exergames have the potential to increase adherence over traditional training(Uzor and Baillie, 2014). The participants highlighted interactivity and measurable progress as very motivating factors to using the games. The control group on the other hand, which was provided with a booklet with exercises, pointed out that it was boring and not very motivating to follow the instructions.

Figure 1.1: Picture of a family playing Kinect. Reprinted from Sahel (2013)

In addition to injury preventive exercise, this technology could be used for rehabilitation after an injury, condition, or treatment. By incorporating the right movements into a game, the patient could potentially forget that they are doing the repetitive movements required for rehabilitation (Maroni, 2017).

Another potential benefit of exergames is the possibility of customizing the games, both manually and automatic. A physiotherapist could, for example, adjust the game and exercises based on the patient's specific needs to optimize the effect of playing. It is also possible to include dynamic difficulty adjustment (DDA), which could help the user achieve flow[2] (Sinclair et al., 2007). Studies have been conducted on the use of customiz-

[2]Flow refers to a state where the user perceives a balance between their own skills, and the challenges the game presents (Chen, 2007)

able games for stroke patients, with positive results, showing potential in customizing the games both manually, as well as using DDA (Alankus et al., 2010).

1.1.6 EXACT and Ethics committee approval

EXACT is an interdisciplinary research project between the Department of Computer Science (IDI) and the Department of Neuromedicine and Movement Science (INB) at NTNU. The primary objective of the project is to explore the use of exergames combined with social media in physical rehabilitation. Using this type of technology physiotherapists can follow up on patients exercise regime outside the clinic and potentially increase the adherence and quality of the therapy.

The secondary objectives of the project are: (I) developing a design methodology, and theoretical foundation for exergames in rehabilitation, (II) solving technical challenges related to applying the technology, and (III) evaluate the effect of exergames for rehabilitation.

This thesis focuses on the first and second of the secondary objectives, in regards to elderly people. An application for collecting data was approved by the ethics committee (NSD) and can be found in Appendix A. IDI has also granted access to use their UX-Lab for testing during this project.

1.2 Usability

In 1993, Nielsen defines the usability of a system using five properties; easy to learn, efficient to use, easy to remember, few errors and subjectively pleasing to the user (Nielsen, 1993). Later in 1998, the International Organization for Standardization (ISO) defined usability in ISO9241-11 (1998) 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" (ISO9241-11:1998(E), 1998). In many ways, these definitions overlap, but what Nielsen's definition does not include, is the specification of context of use, which is defined as the "characteristics of the users, tasks and the organizational and physical environments".

In his lecture on *interaction design and human-computer interaction*, Svanæs uses eating utensils as an example, illustrating the importance the context of use plays in regards to usability. Chopsticks have high usability when eating sushi, but is not very good for eating soup. Although it is possible to eat sushi with a spoon, it is not a very practical way

of eating it. Thus you can't say that either of them have a higher usability than the other, without knowing what you are going to eat. The context of use is needed for the usability of a product to have any useful meaning (Svanæs, 2018).

1.2.1 User-centered design

User-centered design is an approach to developing systems, which aims to increase the usability of the system by focusing on the user's needs and requirements (ISO9241-210:2010(E), 2010). As shown in Figure 1.2, this is achieved by first defining the context of use, followed by the requirements, before making and evaluating the system. This should be repeated until it satisfies the user and organizations needs.

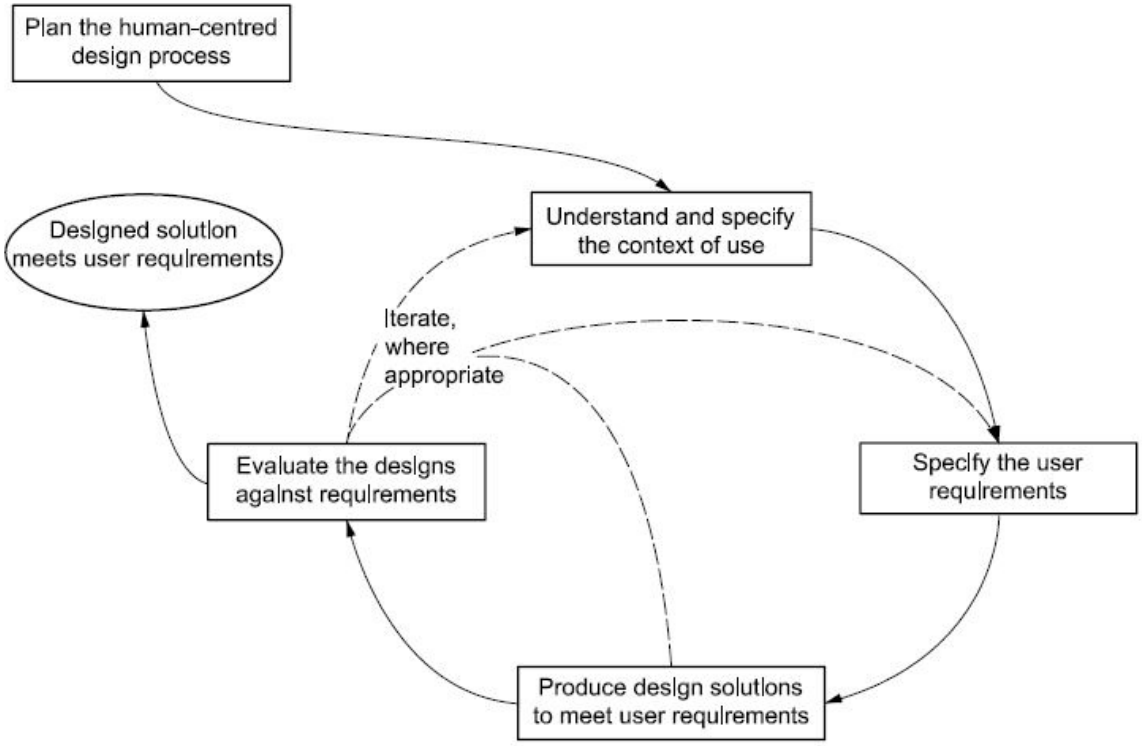

Figure 1.2: Interdependence of human-centered design activities. Reprinted from ISO9241-210:2010(E) (2010)

Brox et al. conducted a study on the use of User-centered design when creating serious games for older adults. This study showed that by using this method and including them in the process, they made both small and big changes to the system, making the games better, safer and more fun to play. Concluding that when making exergames for this target group, involving them in the process is essential (Brox et al., 2017).

1.2.2 Usability testing

System testing is as old as software, and is vital to ensure that a system works as intended. Different testing models focus on making sure the system meets its specification, detect faults, and to prevent faults (Gelperin and Hetzel, 1988).

> *As computer applications increase in number, cost, and complexity, testing came to assume more significance because of greater economic risk*
> Quote from Gelperin and Hetzel (1988).

As stated in the quote above from Gelperin and Hetzel, already back in 1988 computer applications had such significant economic impact that testing was essential. Forward 14 years to 2002, the importance of software has just continued to grow, and Tassey (2002) claim that virtually every American business, in every sector depends on it.

In software development, it is possible to conduct a series of automated tests to ensure that the software behaves as intended. However, it is not possible to make automated tests for how humans interact with a system or evaluate its usability. In order to validate this, tests with real humans are required. These tests are often conducted in labs in order to have more control, however, tests in a lab create an artificial situation which is often far from the real setting for the system. While testing in field yield a more accurate setting, it is often more costly (Oates, 2006). The differences between field and lab are described in more detail in Subsection 3.2.2.

The extent to which a test or study replicates the real world use of a system is called its ecological validity (Carter et al., 2008). This includes having the right users, performing the right task, in the right environment (Kieffer et al., 2015). Many different definitions of ecological validity have been proposed (Schmuckler, 2001), however, this thesis uses the definition by Carter et al. (more on ecological validity can be found in Subsection 1.2.3).

When using exergames in rehabilitation and exercise for elderly people, both the users and tasks are defined. Leaving only the environment undefined, as the games could potentially be played in different places. Exergames have been tested for this purpose in some institutions (Gerling et al., 2010), and some few studies have looked at the feasibility of including it in elderly people's homes (Ejupi et al., 2016; Flynn et al., 2007). However, to our knowledge, there has not been made any guidelines for how to design and test exergames for elderly people's homes.

1.2.3 Ecological validity

The concept of ecological validity has a long history in psychology (Schmuckler, 2001), and its definition has been argued back and forth. As mentioned in Subsection 1.2.2, this thesis uses the Carter et al.'s definition "the extent to which a study comprises real-world use of a system," as this seems to be the accepted definition within the field of information technology (Kieffer et al., 2015; Billis et al., 2015; Stellmann et al., 2015).

Traditional desktop applications are often easy to test in a lab, since a lab can be somewhat similar to an office. However, for mobile applications, body-worn technology, and other systems which are intended to be used outside an office, a clean lab rarely simulates the real world setting for the system. Nielsen et al.'s study on the added values of testing in the field revealed almost twice as many unique critical issues in the field as in a lab, suggesting that more realistic tests are necessary when testing this type of systems (Nielsen et al., 2006). Svanæs et al.'s study on usability testing of a mobile electronic patient record system showed that many of the crucial flaws in the system were detected as a result of the added realism in the environment (Svanæs et al., 2010).

Figure 1.3: Picture of an elderly man's living room. Reprinted from Rozario (2015)

The increased ecological validity can be achieved in multiple ways. Traditionally one would conduct a field test to achieve increased ecological validity (Oates, 2006). However, in some cases, it could be sufficient to create a simulated environment in a lab. This

gives some of the added benefits of testing in a more ecologically valid environment while preserving many benefits of a lab study (Kjeldskov and Skov, 2007).

1.3 Research questions

The two primary goals of this study are to determine how to conduct more ecologically valid tests of exergames for elderly people, and learn more about how exergames can be included in their lives.

The use of exergames in both rehabilitation, as well as regular exercise for elderly, has shown great potential (Flynn et al., 2007; Uzor and Baillie, 2014). Yet very few commercial games exist for this group, and few are focusing their resources on it.

As explained in Section 1.2, knowing the context of use is vital when designing and testing systems. So in order to create more games for elderly people's homes, information about their living environment is required, as the context of use will be their homes. Further determining how to replicate this in a lab to create more ecologically valid tests can help conduct controlled valid user tests.

Many existing games require between $4m^2$ and $9m^2$ available space in front of a TV (Ejupi et al., 2016). It is likely that many elderly people have furnished their homes in such a way that they do not have sufficient space for using exergames. Figure 1.1 from Microsoft's blog shows an example of a suitable living room, which has very few pieces of furniture and only a small side table. However, a quick Google search for "Elderly living room", yields very different pictures. These are smaller rooms, with more furniture, as illustrated in Figure 1.3.

To determine the restrictions for creating exergames for elderly people, it is necessary to find out how much space they have and how their homes are furnished. However, if they are willing to adjust their living environment to incorporate exergames, it is also important to find out what can motivate this, and how much they are willing to adapt. This could have large impacts on how strict the guidelines and restrictions for designing the games need to be.

Seeing as many elderly people have little experience with technology (Ijsselsteijn et al., 2007), it is safe to assume that their experience with exergames is fairly low as well. This makes it interesting to see the effect of exposure to exergames has, especially in regards to motivation.

Therefore, this thesis aims to answer the following research questions:

1. Ecologically valid design and testing
    (a) How do elderly people typically furnish their homes, and how suited are they for playing exergames?
    (b) What is a typical home environment for elderly people that can be simulated in a lab?
    (c) How does game behavior differ between a lab with -, and without a simulated home environment?
2. Willingness to incorporate exergames in their homes, and adapt the living environment
    (a) What are healthy elderly people willing to change about their homes to make room for exergames?
    (b) What factors can motivate elderly people to change their homes to make room for exergames?
    (c) How does being exposed to exergames affect elderly people's attitude towards incorporating it into their homes?

Chapter 2

Theory

Technology acceptance and ecological validity are central parts of this thesis. In order to evaluate a systems technology acceptance, some technology acceptance theories are presented. This chapter also presents a framework for evaluating the ecological validity of a test.

2.1 Technology acceptance

When presented with technology, there is a range of factors which determine how, and even if, it will be used. There has been created many different acceptance theories for technology with different focus. However Venkatesh et al. (2003) did a review of user acceptance literature, and defined a model based on relevant literature, called Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003), and later a second version UTAUT2. This thesis bases the technology acceptance on these two models, as explained in the following subsections.

2.1.1 UTAUT

The Unified Theory of Acceptance and Use of Technology (UTAUT) aims to formulate a unified acceptance model for IT systems, based on eight different theories, including well known and accepted theories like Davis et al. (1989)'s Technology Acceptance Model (TAM). Venkatesh et al. theorizes that performance expectancy, effort expectancy, social influence and facilitating conditions determine users behavior and acceptance in regards to the system. Their relation to behavioral intention and use behavior is showed in Figure 2.1.

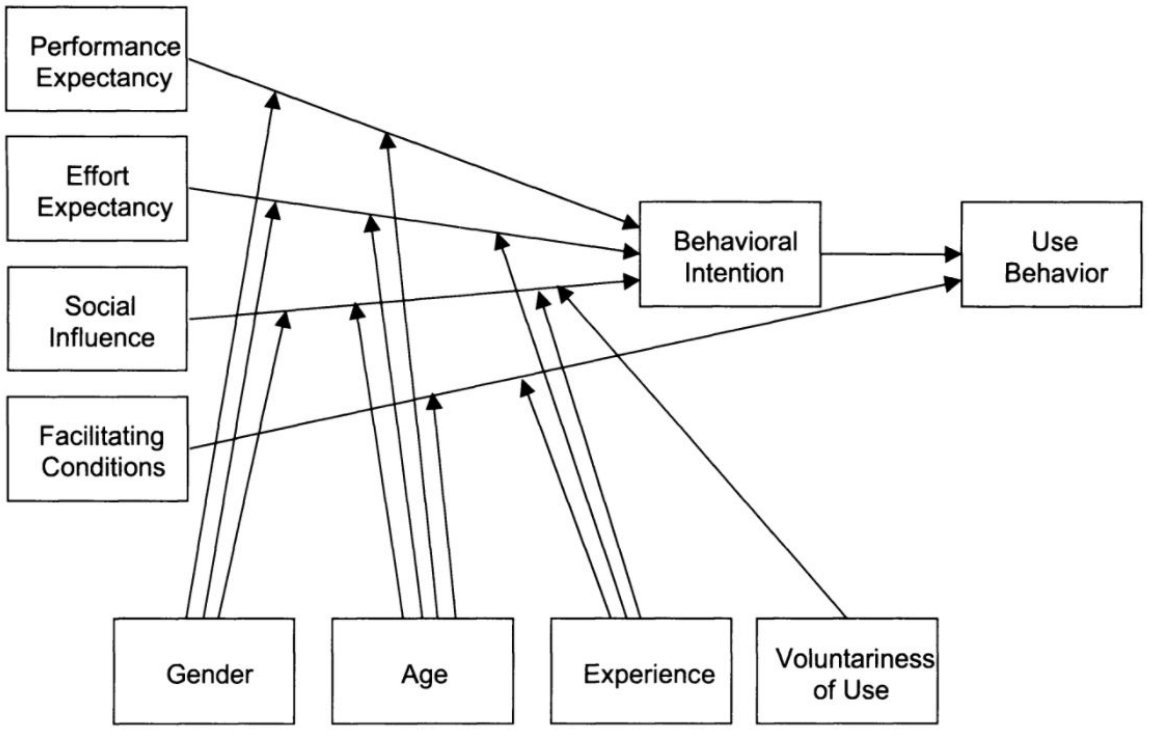

Figure 2.1: UTAUT model. Reprinted from Venkatesh et al. (2003)

Performance expectancy is defined as "the degree to which an individual believes that using the system will help him or her to attain gains in job performance". This is what often is referred to as *utility* or perceived usefulness.

Effort expectancy is defined as "the degree of ease associated with the use of the system". Another term used for this is *usability*, measuring how easy it is to learn how to-, and use the system.

Social influence is defined as "the degree to which an individual perceives that important others believe he or she should use the new system". In other words, the social influence measures to what degree the use of the system is affected by how the user thinks others will view them for using it.

Facilitating conditions are defined as "the degree to which an individual believes that an organizational and technical infrastructure exists to support use of the system". The facilitating conditions could, for example, include physical space, available equipment, internet access and so on.

Age, gender, experience, and voluntariness of use are believed to affect the factors (see Figure 2.1 for relations). Venkatesh et al. specifies that the differences in genders seem to stem from gender roles and socialization processes rather than biological differences (Venkatesh et al., 2003). Therefore, it is possible that there are many other social groups

which could have been included.

2.1.2 UTAUT 2

UTAUT was created with technology acceptance in companies in focus, back in the early 2000s when technology was more focused towards productivity in workplaces (Venkatesh et al., 2003). In 2012 Venkatesh et al. created a new version of the Unified Theory of Acceptance and Use of Technology, namely UTAUT2, which focuses more on technology acceptance for consumers. To better cover the consumer context, UTAUT2 includes hedonic motivation, price, and habit as determining factors. See Figure 2.2 for relations.

UTAUT2 also removes voluntariness of use, as consumers are perceived to have full, or almost full voluntary behavior. However, it is important to note that it can in some cases still be relevant to talk about voluntariness of use in a consumer context as well, if there exist any actors which decide for you.

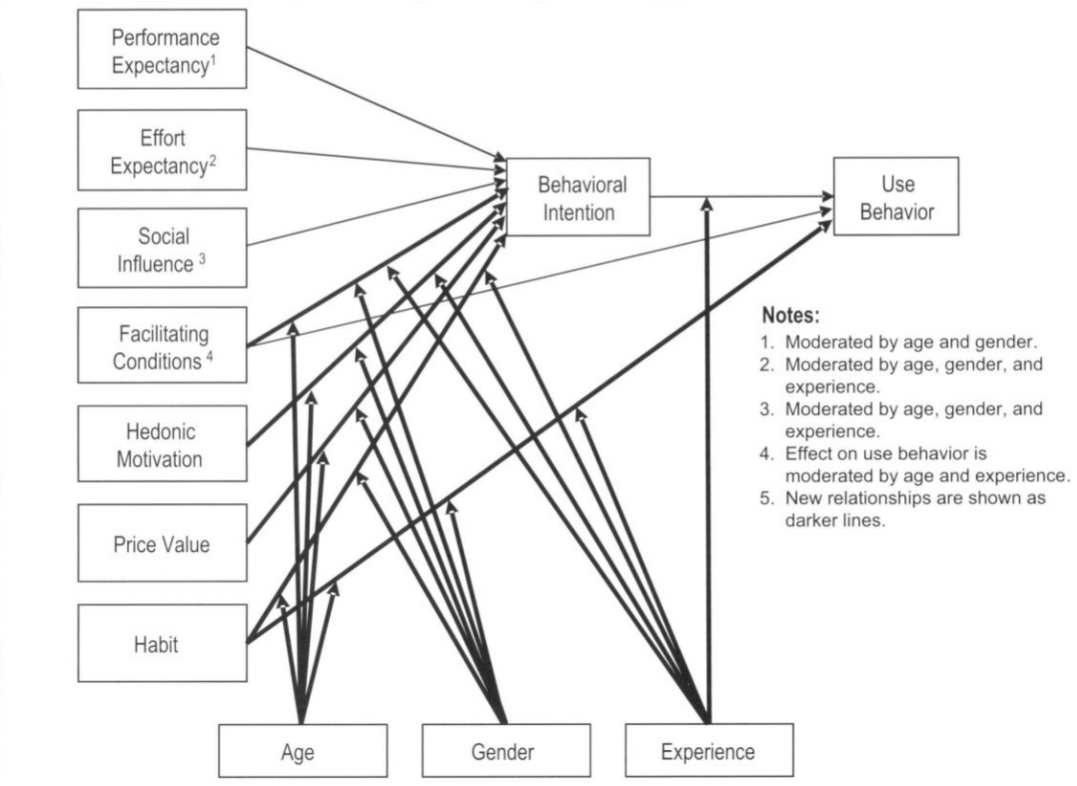

Figure 2.2: UTAUT2 model. Reprinted from Venkatesh et al. (2012)

Hedonic motivation is defined as "the fun or pleasure derived from using a technology". This is especially relevant for games and entertainment technology, as this is their main feature. Although it is also relevant for other types of technology, as users will rarely use a system if it is tedious and unpleasant to use.

Price value is defined as "value as consumers' cognitive tradeoff between the perceived benefits of the applications and the monetary costs of using them". Meaning people are more likely to be using systems where they feel like they are getting more for their money.

Habit is defined as "the extent to which people tend to perform behaviors automatically because of learning". There have been clear connections between using systems and having used it before. As the user continues to use the system, it becomes a habit, which in itself can be a reinforcing factor to continue to use it despite there being better options available.

2.2 ECOVAL

As explained in Subsection 1.2.3, the ecological validity plays a big role in which, and how many, flaws can be detected with a test. However, it is also important to decide how much realism is needed, as added cost is often associated with higher realism. Therefore it is important to consider the trade-offs, and evaluate which can be made, which can often be hard.

Kieffer et al. purposes a framework, ECOVAL, for defining the ecological validity of a test using six dimensions as shown in Figure 2.3. These dimensions are based on the work of Schmuckler (2001) on ecological validity, and Shackel (1991) on usability-context. ECOVAL splits what both Schmuckler and Shackel calls environment into signals and objects, in order to differentiate an environments sensory properties (e.g. sound, smell, colors, lighting, temperature, dust, and pressure), from the physical objects. ECOVAL also splits Shackel's tools, into test medium and user interface, as many tests are conducted with different levels of realism for the medium and the interface (for example wireframe testing on a real device, or the finalized software on a simulated device).

Table 2.1: Examples of Low, Medium, and High values for each dimension of ECOVAL. Based on Kieffer et al. (2015)

	Low	**Medium**	**High**
Signals	No signals	Syntethized signals	Real signals
Objects	No objects	Mock objects	Real objects
Test medium	Paper	Mock device	Intended device
User interface	Sketches	Prototype	Final interface
Task	Only verbalized	Mimicked actions	Real usage
Behavior	Only verbalized	Mimicked actions	Real actions

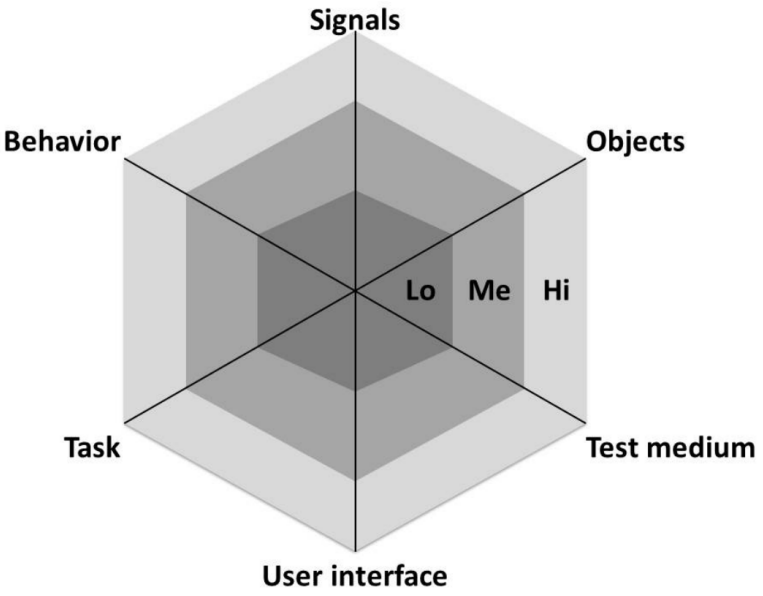

Figure 2.3: The six dimensions of ECOVAL. Reprinted from Kieffer et al. (2015)

By breaking down ecological validity into six dimensions, ECOVAL makes it easier to see how a test differs from real use. It also makes it easier to compare the ecological validity of different types of tests. Table 2.1 shows some examples of what qualifies for each level within the different dimensions.

Chapter 3

Research method

Choosing the right research method(s) for a research is crucial to the quality of the results. Using the wrong methods can in worst case result in insufficient or wrong data (Oates, 2006). The following sections describe methods used in this thesis.

3.1 Research methods

The methods and terminology used in this study is based on Oates' book *Researching Information Systems and Computing*. Figure 3.1 illustrates the different parts of a research and how they are connected.

The research questions for a study usually emerges from a literature review, or experiences and motivation. This study is based on the experiences and motivation of EXACT, which inspired the research questions defined in Section 1.3. A set of strategies, data generation methods and data analysis was defined, as a plan for how to answer each research question. This is further explained in Chapter 4.

For each research question, it is common to use a single research strategy, however it is possible to use multiple, so-called strategy triangulation. Each strategy then uses one or more data generation methods. It is more common to use multiple data generation methods, as many of the strategies makes it easy to generate data in multiple ways. For example, you could both observe an experiment, as well as interview the test subjects, to achieve method triangulation, which could increase the validity of your data.

Once the data is gathered, in order to draw any conclusions it will need to be analyzed. This can be done quantitatively, qualitatively, or both. Quantitative analysis means to work with numbers and statistics, whereas qualitative analysis looks at non-numerical

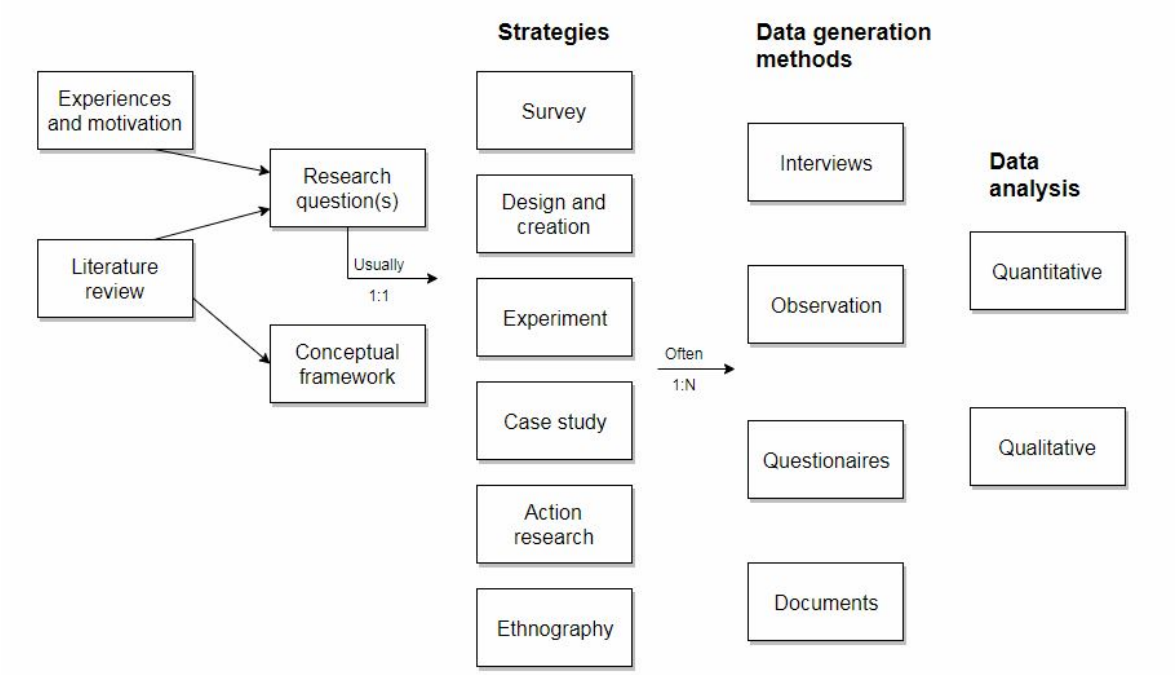

Figure 3.1: Model of the research process. Reprinted from Oates (2006)

values. Qualitative analysis has less defined methods and can vary a lot depending on the data and research questions (Oates, 2006).

3.2 Research strategy

Oates defines a research strategy as the overall approach to answering the research questions. He also defines six different strategies; survey, design and creation, experiment, case study, action research, and ethnography (Oates, 2006, p.35). In this study, ethnography and experiment were used, and are further explained in the following subsections.

3.2.1 Ethnography

Oates (2006) defines ethnography as "a description of peoples or cultures". This is a natural process when you join a new culture (be that a new work environment or a new country), but can also be used as a research strategy to gain a better understanding of a group of people.

An ethnographer typically spends time in the environment of the group which is being studied. During this time the ethnographer could partake and observe the group, interview them, and create documents (photographs, field notes, etc). Oates defines three

types of ethnographers based on how they partake in the group being studied; holistic-, semiotic- and critical ethnographers. Briefly explained holistic ethnographers identify with the group being studied and live like them for the study. Semiotic ethnographers, on the other hand, do not need to identify with the group, but aims to examine their words, images, and rituals and analyze them in the context of the group. Lastly, critical ethnographers try to find what is hidden and unspoken in the group, like hidden agendas, power centers, and group politics (Oates, 2006).

Although having a specific research question in mind going into the study can be helpful, you need to be open to all kinds of information when researching a group of people. It is hard to go in without any assumptions, and you'll need to be ready to throw them away when contradicting evidence present itself. Information which renders the research question(s) irrelevant could be revealed, and would then be an important result.

3.2.2 Experiment

An experiment often refers to trying something and see what the outcome is. An experiment can be as simple as testing if your plants will survive without water while you are on vacation if you water them a lot before leaving. However, as Oates (2006) mention, simply doing an experiment and look at the result does not mean there is a correlation between the factor you introduced and the result. In the example above, the ambient temperature, amount of sunlight and time of year can all be determining factors for the result, making it hard to determine how much was due to the watering.

It is common to develop a theory, which is refined into a hypothesis, which can be proven or disproved by an experiment. All factors, but the one that is tested, is excluded from the study in order to determine the effect of the factor. This could be done by removing the other factors before doing the experiment, or conduct the experiment under varying conditions to determine the effect of the chosen factor (Oates, 2006).

When conducting experiments, it can either be conducted in its natural environment, the field, or in a controlled environment, the lab. They both present some benefits, as well as limitations.

Conducting research in a lab provides control over numerous factors and often makes it easier to both collect data and replicate the study. It can also in some cases be cost efficient as you do not have to move and set up equipment in multiple locations.

However, sometimes it is impractical or impossible to generate the data needed in a lab. Examples are studies on long-term use, and studies where the context of use is crucial. It can then be necessary to conduct the research in the field. This will yield less control, and

collecting data can sometimes be harder as you might not be able to set up cameras from all angles and avoid distractions.

3.3 Data collection

Data collection methods describe how the qualitative or quantitative data will be gathered. Oates defines four data generation methods; interviews, observation, questionnaires, and documents. In this study, interviews and observation will be used.

3.3.1 Interview

An interview is a particular type of conversation where one or more of the participants aim to gather information from the other(s). The topic of the conversation is usually guided to some extent by the interviewer. Depending on how much the interviewer guides the topic, it could either be a structured-, semi-structured-, or unstructured interview. A structured interview uses a set of predefined and standardized questions for each interview, and does not encourage casual conversation. A semi-structured interview also has predefined questions, but allows you to change the order of the questions to fit the conversation more naturally, and allows for unplanned questions if the interviewee says something the interviewer would like more information about. These two types of interviews are suited for interviews where you aim to answer something specific. An unstructured interview only introduces the topic and lets the interviewee determine the content of the conversation to a much greater degree than the other two. This could, for example, be useful if you do not have a set question you wish to answer, but wish to gather general information about, or someones view on, a given topic (Oates, 2006).

How you are going to analyze the data can also be a deciding factor to which type of interview you are going to conduct. For example, if you are going to do any quantitative analysis, you might not want to use an unstructured interview. As this yields very different data from one interview to another, which can be difficult to analyze quantitatively (Zacharias, 2011).

3.3.2 Observation

To observe means to pay attention to something as it happens. Observation is used in research to determine what happens, and not what people report they do or claim they

will do. There is often a mismatch between what people do and what they believe they do (Oates, 2006).

Observation is often associated with watching something, but the observer can use their other senses as well (Oates, 2006). However, through this study, sight and hearing will mainly be used in the observations.

There are many ways a researcher could conduct observatory research. It could be a short 5minute observation, or it could span over multiple years. The researcher could observe without informing anyone, or make it clear to anyone involved. Oates defines a range of factors, including these, which differentiates types of observation (Oates, 2006, p203).

3.4 Data analysis

Oates defines two types of data analysis; qualitative-, and quantitative analysis. Quantitative analysis focuses on numeric data, which can be analyzed using statistics, average and so on. While qualitative focuses on themes in the words used (Oates, 2006). Although it is possible to do a quantitative analysis of qualitative data, this study only uses qualitative analysis, as this was believed to be a better fit for the data.

3.4.1 Qualitative analysis

Qualitative data comprises of non-numeric data, such as words, pictures, and audio. To analyze this type of data, it is common to also use qualitative analysis methods. Although you could count the occurrences of a word, the number of pictures containing a specific element, and so on to do a quantitative analysis (Oates, 2006).

It can be beneficial to get as much of the data in the same format as possible, making it easier to compare them. Since text is easier to analyze than for example audio, it is almost always necessary to transcribe parts of, or the entire, audio files. When the data is in a format you can work with, it should be sorted into categories based on importance to your study. Oates suggests three categories; relevant to your research question(s), relevant to the context, and irrelevant to the study (Oates, 2006).

A common way to analyze the qualitative data once it is organized properly is to further categorize them by themes. This can be done using post-it notes, or digital tools like Trello[1]. From these themes, one could find patterns and possibly the answers to your

[1]Trello is a free online managing tool, which uses a hierarchy of boards, lists, and cards to organize projects, personal tasks, and similar (Atlassian Corporation Plc, 2018)

research question(s) (Oates, 2006).

Non-textual data is often hard to categorize and analyze the way explained above. In many cases, images are used to substantiate the results from textual data (Oates, 2006). However, images can also be used to look for patterns, similarities, and differences, which can answer the research question(s).

3.5 Research quality

When conducting research, it is important to ensure that the results are of as high quality as possible, for the results to be accepted by the reader. If the appropriate measures are not taken, the data could be compromised, and result in a wrong conclusion.

3.5.1 Research paradigms

Oates (2006) defines multiple research paradigms, and how to judge their quality. He also explains how many research strategies are closely linked to different paradigms. Ethnography and experiments, the strategies used in this study, are respectively associated with interpretivism and positivism. Interpretive research in IT focuses on understanding the social context of the information system. Positivist research is the most common research in natural science, and focuses on finding universal laws, patterns, and regularities (Oates, 2006). In other words, interpretivism allows for the truth to be limited to a social context, while positivism aims to find a single answer.

Since the experiments which will be carried out in this study aims to answer research questions related to social factors, as explained in Chapter 4, they fall closer to interpretivism than positivism. Therefore, this study will be evaluated according to the quality criteria of interpretive research, as explained in Subsection 3.5.2.

3.5.2 Quality criteria

Determining the quality of interpretive research is similar to determining that of positivistic research, but due to their different approach, their criteria are defined a bit different. Table 3.1 shows a which criteria in interpretivism correlates to which criteria in positivism, which are based on the research of Lincoln and Guba (1985).

The following breakdown of each criterion is based on Oates (2006) and Lincoln and Guba

Positivism	Interpretivism
Validity	Trustworthiness
Objectivity	Confirmability
Reliability	Dependability
Internal Validity	Credibility
External Validity	Transferability

Table 3.1: Quality criteria in positivist and interpretivist research. Reprinted from Oates (2006)

(1985).

- **Trustworthiness:** Validity is strongly connected to statistics and used to describe the objectivity, reliability, internal-, and external validity of a research. Since interpretive research does not use these criteria, the research quality is defined as its trustworthiness instead. The trustworthiness of a research describes it confirmability, dependability, credibility, and transferability.

- **Confirmability:** The confirmability of the study says something about whether enough information about the data and processing of them, is presented or not. If insufficient information is presented, it is not possible to confirm the results.

- **Dependability:** A study's dependability defines if it is possible to replicate it, based on the information provided about the study.

- **Credibility:** The credibility of the research refers to if it was carried out in a way which makes ensures that the inquiry was accurately identified. This can be achieved through triangulation, prolonged engagement in the problem situation, and the subject(s) verifying the descriptions and interpretations done by the researcher.

  The credibility of interpretive research is often questioned as it is thought to be biased by nature. However, this can be reduced using the methods specified above.

- **Transferability:** Since the results of interpretive research is not believed to be universal, it is important to provide enough information about the situation for a reader to evaluate if the characteristics of the situation are comparable to a different situation. If the characteristics are sufficiently described, it is possible to determine if the conclusions can be transferred to another situation.

Chapter 4

Research design

The research design defines how research methods were applied to the research questions in order to answer them. The research questions are categorized into two categories; *Ecological valid design and testing,* and *Willingness to incorporate exergames in their homes, and adapt the living environment* .

The first group of research questions focuses on finding out what the real-life environment is like, and how it can be replicated in a lab for more valid tests. While the second group focuses on finding out how static this environment is, and what can motivate for adaption of the environment.

4.1 Ecological valid design and testing

The following research questions aim to map elderly people's current furnishing and how it can be simulated in a lab, in order to generate more ecologically valid tests.

4.1.1 Research question 1A

How do elderly people typically furnish their homes, and how suited are they for playing exergames?

In order to find out how elderly people typically furnish their homes, a series of home visits were planned. The strategy resembles semiotic ethnography, however, it is important to note that the researcher will not live among the elderly people, as many ethnographers do. The home visits are estimated only to take about an hour. See Figure 4.1 below for research process.

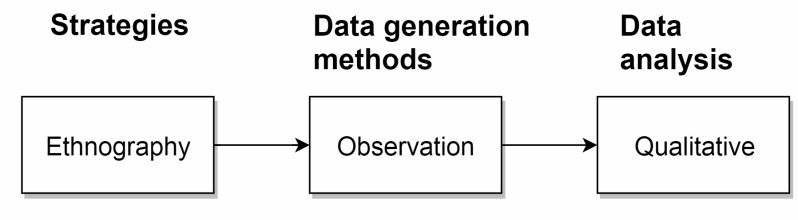

Figure 4.1: Model of research process for RQ1A

Through these home visit, their homes will be observed and documented using pictures and notes. The data collected from the observation will be used to create graphical representations of each home, which then can be compared and analyzed. The goal is to identify common elements, patterns and the size of the different homes. These results will be compared to typical requirements for playing exergames, to determine how easy it is to physically incorporate this technology.

4.1.2 Research question 1B

What is a typical home environment for elderly people that can be simulated in a lab?

By using both ethnography and observation, as well as experiment and interview (see Figure 4.2), the process for RQ1B achieves both strategy- and method triangulation. Which improves the validity of the results given that they generate complementing results.

Based on the results of the home visits and answers to RQ1A, a typical living room for elderly people will be defined. To further confirm or disprove the validity of the living room, it will be created in a lab, and a new group of elderly people invited into the lab, to play exergames and an interview. The interview will gather data on how well the lab environment resembles their living room, and what differentiates it.

As shown in Figure 4.2, the data from the observation and interview come together in a combined analysis. The data from the observations and interviews will be compared, to see if the simulated living room is a valid representation of their living rooms, or if the conclusion from the home visits were wrong.

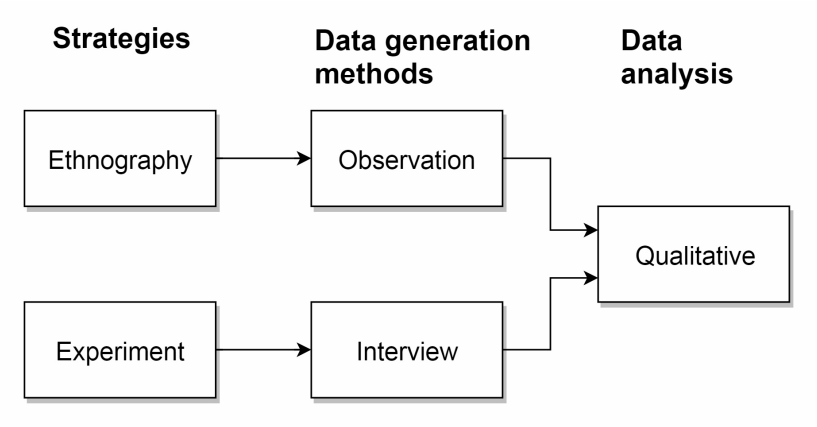

Figure 4.2: Model of research process for RQ1B

4.1.3 Research question 1C

How does game behavior differ between a lab with -, and lab without a simulated home environment?

In order to identify the added value of simulating a living room in the lab, an experiment where conducted. Inviting a group of elderly, one by one, into a lab with a simulated home environment, as well as an open space. The exact process is explained in detail in Chapter 8.

To minimize the effect of other factors, some precautions will be taken through the experiment. The test will be run multiple times with different participants, as well as alternating between which room they start in.

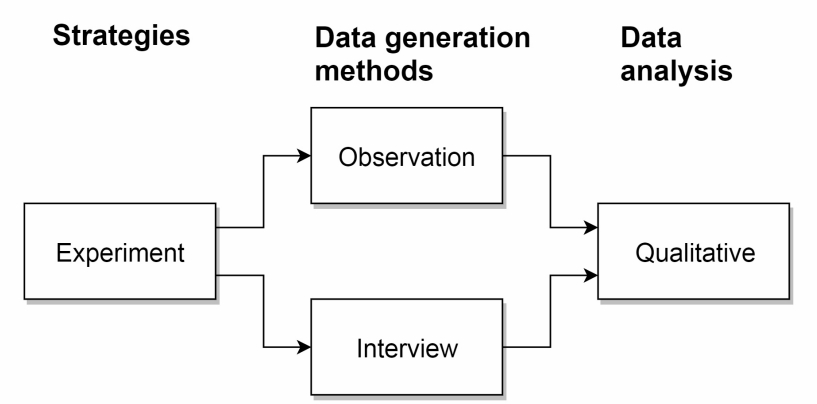

Figure 4.3: Model of research process for RQ1C

As shown in Figure 4.3, the experiment will be used to generate data using both obser-

vation and interviews, achieving method triangulation. The data from both methods will be analyzed qualitatively. The observations will be filmed, and footage played through, looking for differences in movements. The participants will be asked specifically about their perceived differences, which will be analyzed, along with other quotes they might say throughout the interview which related to differences between the two environments to identify any perceived differences.

4.2 Willingness to incorporate exergames in their homes, and adapt the living environment

The second major part of this study is to map elderly people's willingness incorporate exergames in their homes, and adapt their living environment. It is believed that very few of them have sufficient space to play exergames without making any changes to their furnishing. This makes it important to know how much they are willing to adapt their living room, to have a better understanding of the restrictions the games need to follow.

4.2.1 Research question 2A

What are healthy elderly people willing to change about their homes to make room for exergames?

Based on past experiences with how people typically furnish their homes, it is assumed that elderly will have to at least move a table, and possibly a carpet or a couch, in order to play exergames in their living room. It is important to find out how willing they are to move these objects, and how many changes they are willing to make to incorporate exergames into their lives. The results of this will affect the space restrictions these types of games will have to work with.

In order to map this, both the participants in the ethnographic background study and the participants the lab experiment will be asked how much they are willing to adapt and refurnish their home. The data from these two methods will be combined, and analyzed qualitatively, looking for similarities and edge cases.

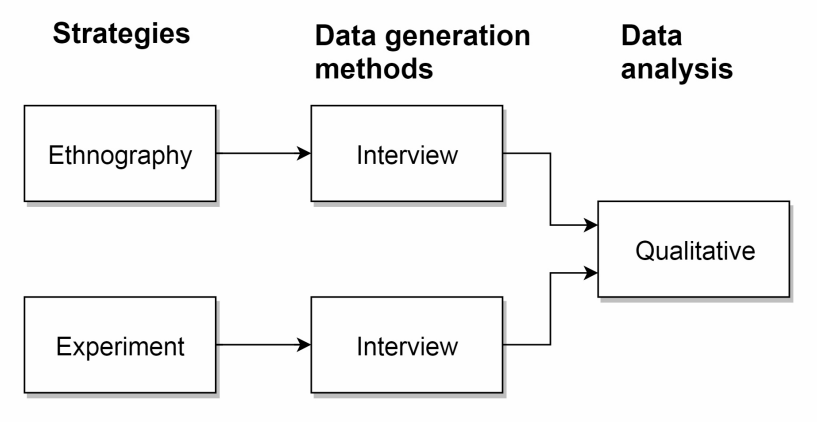

Figure 4.4: Model of research process for RQ2A and RQ2B

4.2.2 Research question 2B

What factors can motivate elderly people to change their homes to make room for exergames?

As explained in Subsection 1.1.5, exergames can be a useful tool for injury prevention. However, if you are not afraid of declining health and fall, this might not be motivation enough in itself. Therefore, it is important to find out what other factors can help motivate elderly people to start, and keep playing exergames.

In order to answer this research question, strategy triangulation of ethnography and experiment will be used. Both of which uses interviews as data generation method, and qualitative analysis, as shown in Figure 4.4.

The ethnography will be a part of the home visits, while the experiment refers to the tests done in a lab. Both groups of elderly people will be asked specific questions on whether they can think of any motivational factors. In addition, the interviews will be analyzed for statements which suggest any motivational factors. This will only give an idea of which factors can be motivational, as people often say one thing, and do another. Therefore, these results should be confirmed using a different strategy. However, this is beyond the scope of this thesis.

4.2.3 Research question 2C

How does being exposed to exergames affect elderly people's attitude towards incorporating it in their homes?

Many elderly people have limited experience with technology, and often no experience with playing video games (Ijsselsteijn et al., 2007). Therefore, it is not unlikely that exposing them to it can affect their attitude towards exergames, by giving them more insight towards how it works and can help them.

This research question will be answered through the experiment, using an interview before, and one after they try the games, as data generation method, before analyzing it qualitatively. Their answers and overall phrasing, use of negative and positive words before versus after trying it, will be compared to see if it made any changes. This process is visualized in Figure 4.5.

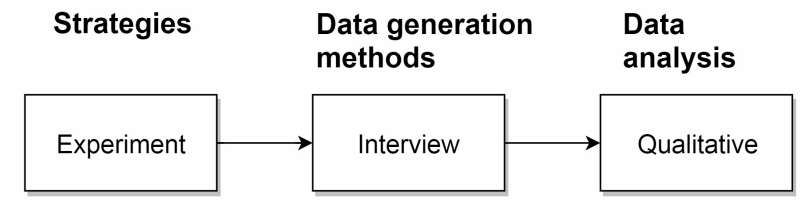

Figure 4.5: Model of research process for RQ2C

4.3 Analysis

The research design described in the previous sections, mainly generate three types of data; voice recordings, images, and video. These will all need to be processed in some way before they can be analyzed. The following paragraphs describe how this will be done for each data type.

The voice recordings will need to be transcribed, in order to efficiently extract quotes. Once they are transcribed, quotes which are relevant to the research questions will be highlighted and categorized based on frequent themes.

The pictures of peoples homes will be used to generate blueprint-like 2D sketches, making it easier to compare them. These sketches will be analyzed, by looking for differences, similarities, and trends which can be generalized.

The videos of people playing will be watched through, to look for special events and patterns. In case of special events, screenshots will be extracted to document them, and potentially compare them to other events.

Chapter 5

Background study

In order to get a better understanding of how elderly people in Norway live, a background study was carried out. Through visiting elderly people in their homes, data was gathered about their homes, as well as attitudes towards technology.

5.1 Purpose

The background study aims to identify similarities and differences between how elderly typically furnish their homes and how suited they are for exergames, answering RQ1A. By analyzing how elderly people live, we can both determine how realistic it is to fit exergames into their housing, as well as create a standardized living room for simulation in labs.

The background study also looks into RQ2A, and RQ2B, by asking them about their willingness to adapt their home environment, and potential motivational factors.

5.2 Procedure

Four elderly people were recruited through Trondheim Municipality and acquaintances for a home visit. The inclusion criterion were people over 65 years, living fully or mostly independently in their own homes. They were all asked to fill out a consent form, found in Appendix B, and the background form, comprising of questions related to age, technology use and physical activity. The form can be found in Appendix C.1, and the results can be found in Table 5.1.

As Table 5.1 shows, all the participants but one are digitally active, regularly using online banking and other services. Most of them are also somewhat active given their age, with an average of just over three workouts per week. The interviews revealed that they all focused on strengthening their legs and maintaining their balance, which as explained in Subsection 1.1.3, is important in order to prevent falls.

Table 5.1: Results from information form in background study

Participant ID	**ID01**	**ID02**	**ID03**	**ID04**
Age	81	87	78	84
Gender	M	M	F	F
How often do you use the following				
Online banking	Never	A bit	A bit	Often
Facebook	Never	Never	Very often	Never
Smart phone	Never	A bit	Very often	Never
Tablet	Never	Never	Very often	Never
Apps	Never	Never	A bit	Never
How often do play on the following platforms				
PC	Never	Rarely	Never	Never
Smart phone	Never	Never	Never	Never
Tablet	Never	Never	Never	Never
Nintendo Wii	Never	Never	Never	Never
Microsoft Kinect	Never	Never	Never	Never
What kind of physical exercise do you do?				
Walking	X	X	X	X
Running/ jogging				
Group classes	X	X	X	X
Outdoor activities				
Swimming				
Other		Balance board and step machine	Gym and PT sessions	Stationary bike and some strength
Workouts per week	1	7	2-3	3
Workout length	30-60min	30-60min	30-60min	16-30min

During these visits, pictures of their housing were obtained as well as information about its size. This was further used to generate sketches for comparison. Figure 5.1 illustrates one of the apartments, and the remaining can be found in Appendix D.2.

In addition, each participant was interviewed, using the interview guide found in Appendix D.1. The interview focused on their home (size, how they use it, etc.), technology use, and attitude towards exergames. A summary of their technology use can be found in Table 5.1.

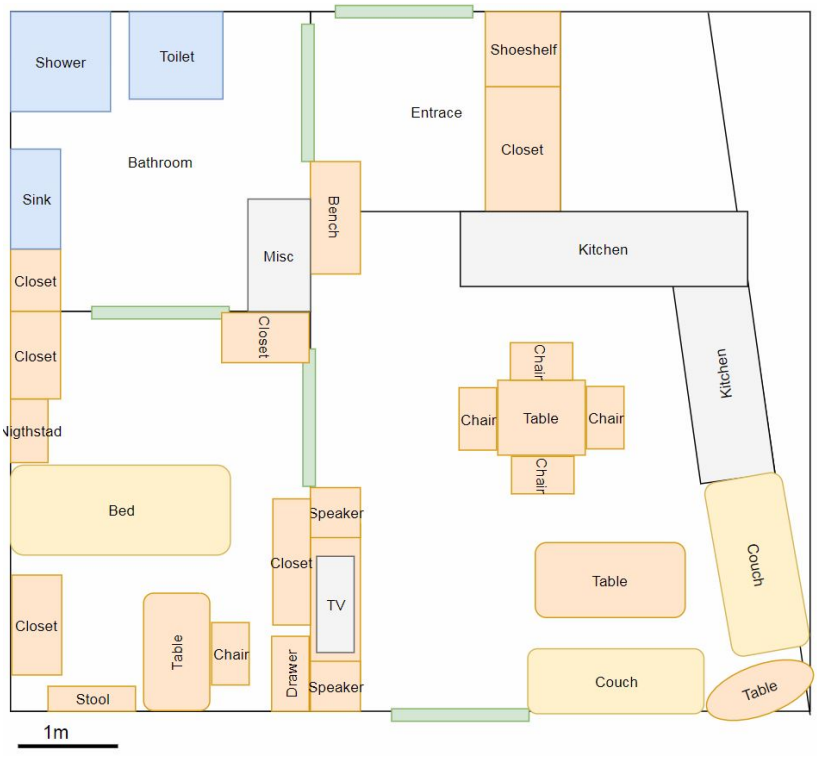

Figure 5.1: Sketch an elderly man's apartment

5.3 Results

Through analyzing the sketches and pictures, a short list of common traits was generated. Since these results are based on a low sample rate (four samples), there may be some inaccuracy. For example, three of the four participants had a walker in their home and therefore furnished in such a way that it was possible to walk around using it. However, based on previous experiences with peoples housing, these common traits are likely to somewhat represent a large portion of elderly people's homes. They are also further confirmed in the usability tests in Chapter 8.

Common traits for living rooms in elderly people's homes.

- It is typically 16-20m2 in size (when it is larger they split it into multiple sitting groups, see Figure D.3 as an example).
- It has seating for 2-6 people (using a combination of chairs and couches).
- The TV is between 27" and 42".
- The majority of the seats are placed such that one can see the TV.

- There are 1-2 meters between the TV and the first furniture. This is typically a table, but could also be a part of a couch, or a footstool.
- It is not furnished to allow for exergames to be played. However, it is possible to get a minimum of 2x2 meters available space in front of the TV by moving light furniture.
- There are 1-4 tables, depending on size (few large, or many small).
- There are 0-2 floor lamps.
- The room has 1-2 other furniture, like shelves and drawers.

Using these common traits and the sketches of peoples homes, a generic living room for elderly was designed. The process and result is further explained in Chapter 6.

The biggest differences in the background study were identified between those who live in a house and those who live in apartments. People tend to move into smaller apartments as they age, due to less need for space and to reduce the need for maintenance. With larger houses, there are often multiple rooms which could potentially be used for exergames.

Ofli et al. (2016) conducted a survey, gathering data about elderly people's homes in 2016 with 30 participants. The study does not seem to have any data on the size of their homes and living rooms, but they collected data on TV-size and available space in front of the TV. Their study found that twelve of the participants had a newer flat screen TV, ranging from 24" to 52" in size. It does not mention what the remaining 18 participants had. They also reported that participants had somewhere between 1 meter and 2.5 meters available space in front of the TV. These data are similar to those observed in the background study, making the data more credible.

In regards to willingness to adapt, the participants in the background study did not seem very eager to get a device right away. However, they did not express any issues with moving some light furniture if they were to get one. They seemed a bit more hesitant towards moving heavy furniture like couches.

Chapter 6

Simulated home environment

Based on the findings in the background study and the common traits defined in Section 5.3, a generic living room was designed. This generic living room is meant to be used as a reference when designing exergames for elderly people, as well as a template for how to furnish a lab to create a more ecologically valid environment for testing.

6.1 Design

Using the common traits and analyzing the sketches of peoples homes, found in Appendix D.2, the living room illustrated in Figure 6.1 was designed. This living room has a bit less furniture and a lot fewer items (plants, pillows, pictures, etc.), than what was observed in the field. This decision was made in order to achieve just enough realism, and don't add more elements than necessary in order to do the tests.

Table 6.1 compares some of the values observed in the field to the designed living room. For some of the values, like distance from TV to obstacles, the chosen value for the simulation is much closer to one end than the other of the spectrum. This was mainly done when one of the edges was believed not to be very common. In regards to distance from the TV, participant ID01 (see Figure D.1 for illustration) had a stool just in front of the TV. This was not observed in any of the other homes, and would not have been an issue to move. Similar decisions were made to the other values.

Table 6.1: Lowest and highest results from the background study compared to chosen values for simulation

Criterion	**Low**	**High**	**Simulation**
Size	$16m^2$	$20m^2$	$19m^2$
Seating for (people)	2	6	4
Distance from TV to obstacles	0m	2m	1.5m
TV-size	27"	42"	42"
Tables	1	4	1
Floor lamps	0	2	1
Other furniture	1	2	2

Figure 6.1 shows the first sketch for a generalized living room. Based on the findings of the background study, this is likely to resemble how elderly people would furnish their living room.

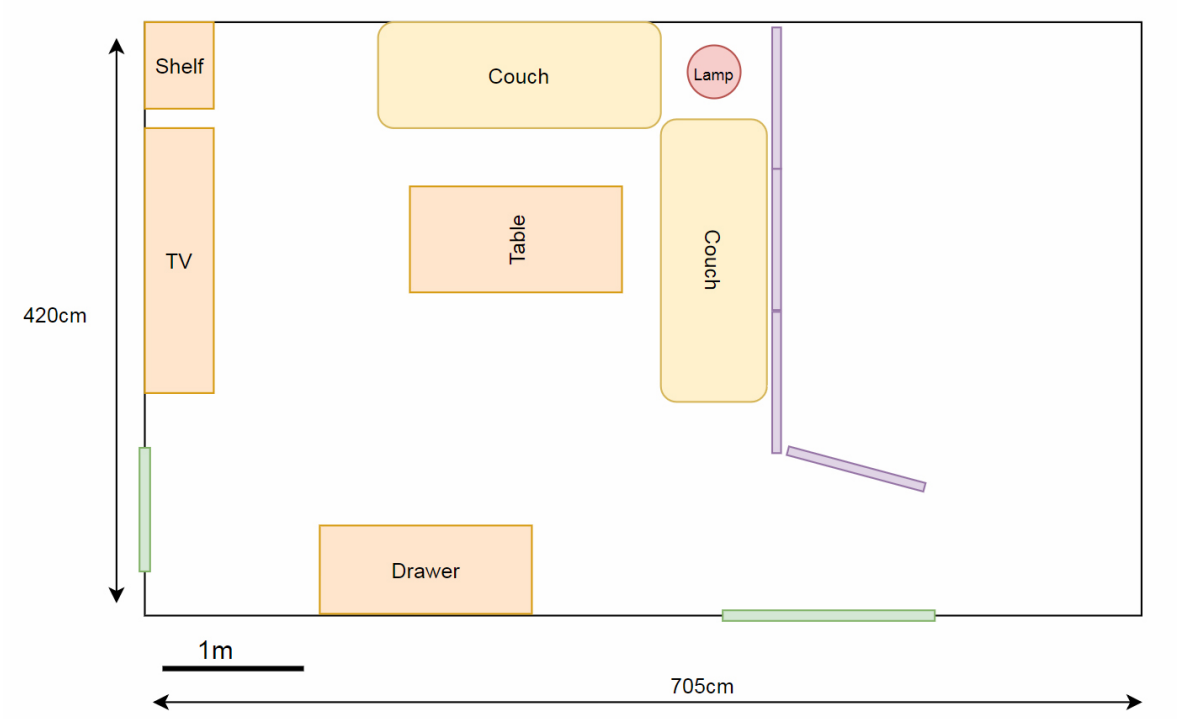

Figure 6.1: Sketch of a potential living room simulation

A more detailed version in 3D was created using IKEA home planner, see Figure 6.2 for the generated 3D model. The version of IKEA home planner which was used did not contain all of IKEA's products. Therefore the 3D-model does not contain the exact furniture used in the implementation. However, it shows the overall feel and space of the room in a better way than the 2D-sketch. This helped confirm that the room actually looked like a living room before buying the items and setting them up the lab. It is also important to

note that the two smallest tables in Figure 6.2 were omitted in the final implementation, as they were not perceived as necessary for the tests.

Figure 6.2: Sketch of the lab setup using IKEA Home planner.

6.2 Implementation in lab

The lab used was about 420x705cm (29.6m^2), ideally for this study, it should have been longer so it could be split into two rooms of about 20m^2. This was solved by moving the screens separating the two rooms as needed.

In order to make the simulated home environment easy to replicate, all the furniture and items were purchased at IKEA (see Appendix G for the complete list of items). Figure 6.3 illustrates the final setup in the lab (see Appendix E for more pictures of the setup).

(a) Living room (b) Open space

Figure 6.3: Lab setup for testing

Chapter 7

Exergame platforms and games

7.1 Exergame technology

Since the launch of the Nintendo Wii in 2006, there has been created many movement-based gaming platforms, using a number of different technologies utilizing the players actions as input. In addition to the well-known platforms, there are many more. For example, Plunder Planet, which uses large buttons spread out in the room, forcing the player's to move around quickly, and NTNU's Pedal Tank project, where the user controls an in-game tank using a stationary bike.

This study focuses on the Nintendo Wii and Microsoft Kinect, due to their market share, price and use in existing research. In recent years different Virtual Reality (VR)-headsets utilizing movement tracking, like the HTC Vive and Oculus Rift has emerged. These were not considered due to their price, and possibly confusing interface for elderly people.

7.1.1 Nintendo Wii

As mentioned in Subsection 1.1.5, the Nintendo Wii brought at-home exergames to the mainstream (Sinclair et al., 2007). The Wii uses a handheld remote with motion detection, allowing you to use it as a racket to play tennis, simulate a bow and arrow to shoot at blinks, and many other ways. All in the comfort of your own living room (Nintendo, 2010).

In addition to the Wii remote, a series of other input methods was released, including the Wii board. The Wii board uses four force sensors, one on each corner of a board, allowing it to measure the user's weight and their center of pressure (Clark et al., 2010). This board can be used to play balance and leg strengthening games without requiring

much space (Van Diest et al., 2013). This limited space requirement can also be seen as a restriction, as you will not always get full movements when standing on or around the board. Another limitation to the Wii board is that it needs to calibrate between each user to track accurately.

A short test at Kattem omsorgssenter (Kattem care center) with a group of elderly people, quickly revealed that the menu of the Wii, as well as its games and the input devices, were a bit hard to grasp. The Wii was therefore not used further in the study.

7.1.2 Microsoft Kinect

Kinect is a line of motion controllers by Microsoft. The first version was introduced in 2010 for the Xbox 360 console. Shortly after its launch, third-party communities created software development kits for the platform, allowing people to develop software for it and use it as a measuring device as well as game device (Pagliari and Pinto, 2015). This allowed for it to be used in multiple research fields (Menna et al., 2011; Mankoff and Russo, 2013; Ejupi et al., 2016).

The original Kinect sensor, further referred to as Kinect V1, consisted of an RGB camera, an IR emitter, and an IR camera, which together tracks color and depth of the scene. However, the data from the Kinect V1 is not very reliable or accurate. It also has a very narrow Field of View (FOV), making it hard to track users which stand too close, resulting in a larger required space for playing. The new version, Kinect V2, has higher resolution camera, a wider Field of View (see Table 7.1 for details) and uses a new method of depth tracking for higher reliability and accuracy. (Pagliari and Pinto, 2015). For casual games where the accuracy doesn't matter that much, the most interesting aspect of the Kinect V2 is the increased Field of View. This allows you to stand closer to the device, and results in significantly less needed available space, making it more suitable for peoples living rooms, which normally are furnished.

Table 7.1: Specification comparison of Kinect V1 and Kinect V2 (Pagliari and Pinto, 2015)

Feature	**Kinect V1**	**Kinect V2**
RGB Camera (pixels)	640x480	1920x1080
Min depth distance (m)	0.8	0.5
Max depth distance (m)	4.0	4.5
Horizontal FOV (degrees)	57	70
Vertical FOV (degrees)	43	60

Typically the Kinect requires more space than controller-based exergames like the Wii, as it does not allow you to sit in a chair and shake the controller to mimic the desired movements. The Kinect tracks your whole body, requiring you to get up and move.

The Microsoft Kinect V2 was chosen to be used in the tests throughout this study, due to its simplicity in use (no buttons, controllers, etc.), and available games for balance and coordination training. The games chosen for the tests are explained further in Section 8.3. Unfortunately, Microsoft discontinued the Kinect platform in the middle of this study (Gartenberg, 2018). Since the focus of the study is on exergames as a whole and how to include it in elderly people's homes, it was decided to use the platform despite it being discontinued.

7.2 Games

When selecting games for the usability tests, both commercial and research projects were considered. Although many more were considered, the following subsections describe the five most relevant of the candidates, and why The Fox and Celestial Shower was chosen.

7.2.1 The Mole

The Mole is a stepping game developed by SilverFit. The Mole uses the Kinect to track your position, and translates this to your position on a board consisting of 3x3 squares, as shown in Figure 7.1. The game is inspired by Whack-a-mole, and you need to step on the square containing a mole and avoid squares containing a ladybug.

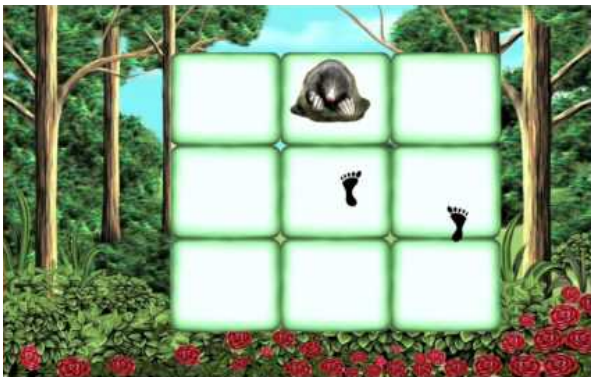

Figure 7.1: Screenshot from The Mole

The Mole is designed explicitly for balance training through weight shifting, and therefore highly relevant for this study. An advantage of The Mole is that it requires the player to walk in all directions, unlike most of the other games considered where the player only walks sideways. However, the game was not made for a living room setting, and when testing it, it required more space than what would be available in the simulation. It was

later discovered that the game has a setting, allowing you to disable some of the squares so that it is possible to have a 3x2 square board instead. Had this feature been known before the tests, this game could have been used in the study.

7.2.2 The Fox

The Fox is another game from SilverFit which also uses the Kinect as input. Here the player controls a fox by walking sideways to move the fox and lifting their arms to make it jump. The goal is to collect grapes and chickens, while avoiding branches. The grapes and branches fall from the sky, while the chickens spawn statically above the fox, requiring it to jump to get them. A screenshot from the game is shown in Figure 8.5.

The Fox was one of the games which was chosen for the usability test. This was due to its low space requirement, and presumably easy to understand mechanics.

7.2.3 Celestial Shower

Celestial Shower is an internal project at IDI, NTNU. In regards to controls, it is very similar to The Fox, as it uses the Kinect to track movement to the sides, as well as arm movements. The main difference is that the arm movements are mapped to the arm movement of the avatar, instead of jumping. Meaning when you raise your left arm, the character in the game replicates this movement. The goal of the game is to avoid meteors which are coming in the middle of the screen, and catch stars as they hit a snowflake. The avatar and the other game elements are shown in Figure 8.5.

Celestial Shower was the second selected game for the usability test. This game was selected partly due to its simplicity, but also to allow for data collection about the game.

7.2.4 Plunder Planet

Plunder Planet is also a research project, created by Koboldgames. The game can be played using either a Kinect, or a custom setup with large buttons distributed in the room. When using the Kinect with the game, the player performs a series of gestures and movements to control a ship, sailing through sand dunes, and dodging obstacles (Martin-Niedecken and Götz, 2016).

This game mainly targets a much younger audience and was assumed to be too abstract and fast for elderly players. Therefore it was not used in the tests.

7.2.5 Just dance 2018

Just dance is a well-known exergame franchise and is available on a range of platforms, including the Kinect. The game uses different tracking techniques based on which platform you play on. The goal is to follow the dance instructions presented on the screen as best as you can, and you are awarded points on how well you replicate them.

This game was also made for a much younger target group, and as shown in Figure 7.2, there are very many graphical elements, and a lot happening at the same time. This combined with the fact that the game is very fast and sometimes uses very complex movements, resulted in this game being excluded from the study as well.

Figure 7.2: Screenshot from Just Dance 2018. Reprinted from Microsoft (2018)

Chapter 8

Usability tests

In order to find out how a home environment affects the way elderly people play exergames, as well as verify the simulated home environment, six elderly people ranging from 65 to 87 years were invited into the lab. The lab was split in half so one half was an open space, while the other was a simulated living room.

8.1 Open space

The half of the room used for the open space was approximately 420x400cm (17m^2) and contained only a TV, standing on a TV bench. This room is supposed to represent traditional test labs, rehabilitation centers and other locations where one would have a dedicated room for playing exergames. Figure 8.1 shows how the screens and furniture were arranged while using the open space (the right half of the room). As shown in Figure 8.2, this setup scores high ecological validity on the dimensions related to the system and behavior, as this is a finished product and the tasks are carried out fully. The score on user interface is lowered a bit from full score, as one of the games used was still in beta. Whereas it scores low on both dimensions related to the environment as this setting differs a lot from the real setting. The value for signals is set between low and medium, as some adjustments like temperature and light were done to the living room, and carried over to the open space as they are in the same room.

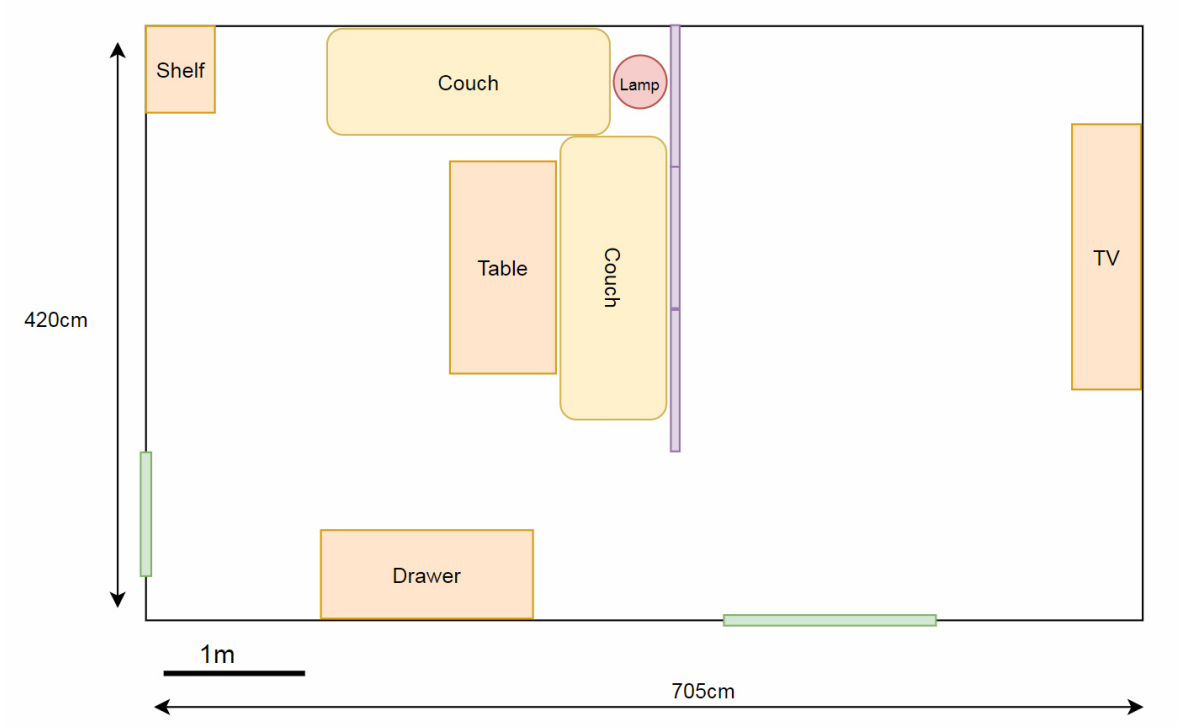

Figure 8.1: Sketch of the lab setup when playing in the open space

8.2 Simulated home environment

The half of room used for the simulated home was approximately 420x450cm (19m^2). The fact that the open space was a bit smaller than the simulated home environment is not likely to have affected the results, as the test subjects generally tended to walk more towards the screen rather than use the space behind them. Figure 8.3 shows how the screens and furniture were arranged while using the simulated home environment (the left half of the room).

This room is, as described in Chapter 6, a based on the homes of elderly people, and aims to have higher ecological validity than the open space. As shown in Figure 8.4, this setup has the same ecological validity as the open space for most dimensions. However, it has higher ecological validity for objects. The objects were estimated to be between medium and high, as there is a bit less furniture than in a real setting, a lot less small objects (like plants, books, etc), and it is not their personal objects. As mentioned in Section 8.1, the signals are the same as both environments are a part of the same room. They both score low-medium due to increased temperature and decreased light brightness to avoid the cold, almost sterile, feeling a lab can have.

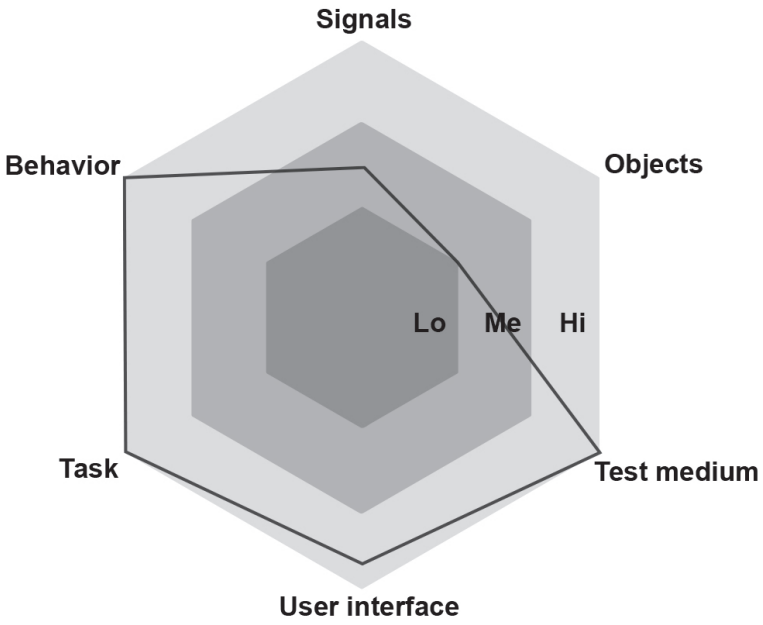

Figure 8.2: The ecological validity of the open space, based on ECOVAL

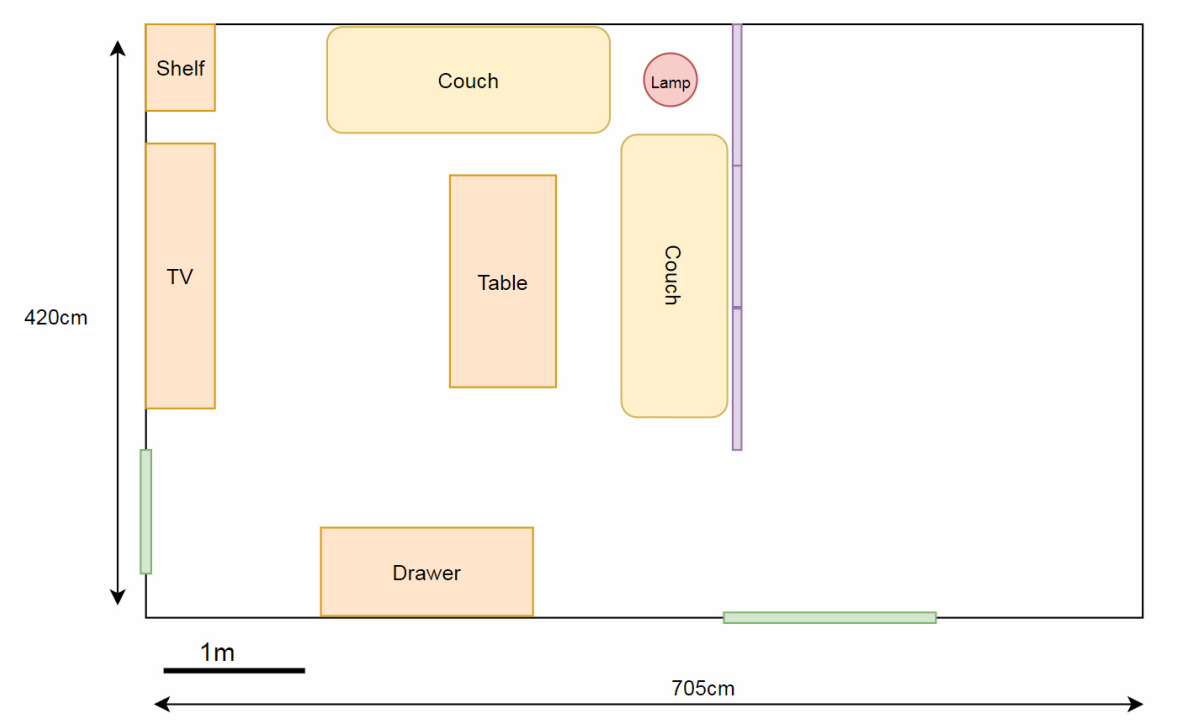

Figure 8.3: Sketch of the lab setup when playing in the simulated home environment

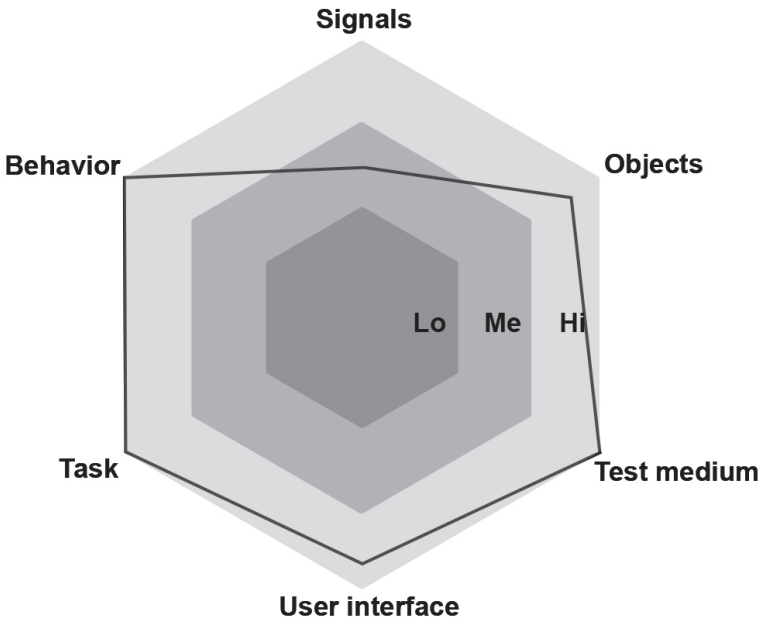

Figure 8.4: The ecological validity of the simulated home evnironment, based on ECOVAL

8.3 Games used

The test subjects were asked to play two different games, namely The Fox by Silver Fit, and Celestial Shower, an internal project at IDI NTNU. In both games, you control an avatar which tries to catch and avoid objects by moving sideways and moving your arms. In The Fox your arms are used to jump by raising them, whereas in Celestial Shower your arms control your avatar's arms, in order to catch stars. See Figure 8.5 for screenshots of the games.

(a) Celestial Shower (b) The Fox

Figure 8.5: Screenshots from the games played

8.4 Procedure

A group of six participants was recruited based on the same criteria as in the background study; people over 65 years, living fully or mostly independently in their own homes.

The tests were conducted over the span of a week in the UX-Lab at IDI. Participants were invited to the lab, where they were they got a brief introduction to what was going to happen and asked if they had any questions. The timetable is shown below, in Table 8.1. Despite the estimate of 70 min, 90 min were set aside for each test in order to provide some room for breaks, longer interviews and such as needed. An additional 30 minutes for a break and preparing for the next test was put in between tests when multiple were scheduled in a row.

Table 8.1: Timetable for user tests in lab

Activity	**Time estimate**
Introduction	5 min
Background information	10 min
Game 1 round 1	5 min
Game 2 round 1	5 min
Room change	5 min
Game 1 round 2	5 min
Game 2 round 2	5 min
Interview	30 min
Sum	**70 min**

Each participant was asked to fill out a consent form, which can be found in Appendix B, before being asked a series of background questions. The questions can be found in Appendix C.1, and the results in Appendix C.2. The conversation was carried out in the couches in the simulated home environment for practical reasons, as well as to prime them and let them get comfortable in the setting.

The participants then got to try the first game. Every other participant started in the open space and the simulated home environment, as they are likely to perform better on the second round, which would affect the results if everyone started in the same room. Which game they started with was also alternated in such a way that all combinations of the first room and the first game was covered.

After each game, the participants were asked if they needed a break to prevent fatigue and risk of falls. When they had tried both games once, there was a 5-minute break. During this break, the lab was rearranged to prepare for the next test as described in Section 6.1.

After the break they got to try both games in the other setup, before sitting down in the simulated home environment for the interview.

The interview guide used can be found in Appendix F.1. These questions cover the different factors defined in UTAUT2, differences between the lab and their home, and general attitude towards exergames.

8.5 Results

The tests and interviews generated large amounts of data. Some of the most interesting quotes are structured in Appendix F. An interesting observation during the tests was how the participants did not seem to care about the furniture and did not seem to gain any benefits from the open space, as explained in the following sections.

8.5.1 Playing with obstacles present is not an issue

It was assumed before carrying out the study that the furniture would be a distraction and be in the way. There was also a theory that even if the furniture were not in the way, they would be perceived as so, forcing them to look around to ensure that they don't hit anything. However, no such behavior was observed.

When looking at the videos of the participants playing the games, it was not possible to detect any difference in the way they play in the open space and simulated home environment. Nina S. Maroni, a physiotherapist and postdoctoral fellow in movement science at NTNU helped analyze the videos and was not able to detect any differences.

Figure 8.6: Two of the participants playing very close to obstacles

Some of the participants were standing only centimeters away from the couches, as shown in Figure 8.6, without it affecting them in any noticeable way. They did not need to look around themselves to identify where the obstacles were, and seemed to have good control over the situation.

8.5.2 Game scores

As expected, the participants got better scores the second round of each game compared to the first, as they had a better understanding of the goal and interface. Their game scores for each round can be found in Table C.2 in Appendix C.2.1. However, the data did not show any differences between playing in the simulated home and the open space. Although the small sample makes it impossible to draw any conclusion, the data suggest that they can play just as well in a living room as an open space.

Chapter 9

Results and analysis

9.1 Simulated home environment

The simulated home environment is, as explained in detail in Chapter 6, based on the data collected from the home visits. During the interviews after the lab tests, the participants were asked how this living room reflected their living room, to confirm the realism, and identify differences.

Some of the participants commented on the simulated living room having a cold feeling and not being very personal. They pointed out that they have more bookshelves, pictures, and other personal items. This is partially due to the attempt at achieving just enough realism, and not including objects which are not necessary to the test. The simulated living room is also supposed to cover a large group and can therefore not be too personal.

Overall it seems to be very similar to their homes. Although, especially those who live in a house mention that their living room is larger. However, in most cases, the room is then split into two separate spaces. Leaving the TV-area about the size of the simulated living room.

Some of those who had a house also pointed out that they might want to use a guest room or similar instead of the living room. In those cases, the extra room was estimated to be about $20m^2$ as well, but potentially with a different furnishing.

9.2 Technology acceptance

To get a better understanding of elderly people's willingness to adapt, motivational factors and overall attitude towards exergames, it is important to map the technology acceptance of exergames. If exergames scores high on a range of technology acceptance factors, they are more likely to be willing to adapt, regardless of what they say when being asked in a hypothetical scenario.

As described in Section 8.4, parts of the interview in the lab was based on UTAUT 2. They were asked questions which ties directly into the different factors in UTAUT 2, which are summarized below. Each of the factors in UTAUT2 are defined in Section 2.1.

9.2.1 Performance expectancy

The participants were asked whether they thought this could help them be more active, to which the participants replied everything from definitely, to probably not. However, those who were skeptical highlighted that the main reason was that they were already on a satisfying activity level, or would prefer to increase the amount of existing activities. Although should the need for activity increase, or their mobility decrease, they could see themselves looking into this type of alternatives.

> *ID07: "Based on my current situation, the answer is no. However, in a different setting, I won't exclude it. The greater the need had been for that type of activity, working out with moderate intensity etc., pretty simple movement."*
> Translated quote from the interview.

The participants were also asked if they thought computer games could help them become more active before trying the games. Then almost all of them said they were not sure, expressing a bit of confusion towards how this could be achieved.

Participant ID08 was the only one who gave a clear no when asked this before trying. The quotes below are from the interview after trying the games. This ties in with RQ2C; How does being exposed to exergames affect elderly people's attitude towards incorporating it into their homes? Trying the games had a positive effect on all the participants' attitude towards this types of games. Participant ID06 was the only one saying he was not personally interested, as he would rather play more tennis instead, and suggested this type of technology might be better suited for those with a lower activity level. It is also worth mentioning that all the participants had a much more clear answer after trying, suggesting that this is an unknown topic which is hard to evaluate abstract.

ID08: "I have never thought about the possibility of combining games and staying active. [...] I thought you sat in a chair and used a keyboard right."
"I'm more positive now that I know what it is, than if someone would have asked me before e started if I wanted some game in my living room I would have said no, that's not interesting. But this is something different from what I think of as gaming"
Translated quotes from the interview.

9.2.2 Effort expectancy

The participants did in no way express any concern with the effort exergames would require from them. It was both observed and stated that the controls for the game were a bit confusing for some of them, as well as the goal of the games. However, this significantly improved in most cases during the second round of each game, suggesting that they would master it within few rounds.

Some did point out that they did not want to install more devices in their homes, and that adding more cables around their TV was not very attractive. Although this concern seems to be much lower, or nonexistent, when considering exergames for rehabilitation instead of general activity.

9.2.3 Social influence

Overall the participants seem to think playing exergames at home would be socially acceptable, and not any stranger than using a workout DVD or similar.

A couple of the participants said they had some conservative acquaintances with little experience with technology, which they assumed would think exergames was just a waste. It is worth mentioning that both of them had received a reply on the invitation from a colleague who was very much against games. This statement is likely to have colored their view of what others might think of exergames. It did not seem like the view of their conservative acquaintances bothered them, or colored their personal view in a significant way.

ID08: "[...] And if someone came over to visit, I would not try to hide it. I would rather say 'come see the fun game I'm playing'. "
Translated quote from the interview.

9.2.4 Facilitating conditions

Playing exergames requires a screen (for example a TV), a platform to run the games, and sufficient space, and internet access is preferred. All the participants in the study had a TV which could have been used as the screen. Based on this and previous experiences, it is safe to assume that most elderly have a screen at home which could be used.

Some of the participants had a computer, but the specifications of these were not investigated. Ofli et al. (2016)'s study found that most of the elderly people in their study who had a computer, had one with an old operative system, incompatible with Kinect and similar systems. Therefore, it is probably more reasonable to bundle a device with the sensors and games when targeting elderly people.

Nine out of the ten participants total used a combination of online services like online banking, e-mail, and Facebook. Suggesting that they have internet access which could be used to update the games remotely, or for health personnel to track progress or change the difficulty.

In general, people don't tend to have enough available space for playing exergames. Among the participants of this study, no one had enough available space without moving any furniture. Merely moving a table would typically yield sufficient space, and none of the participants expressed any problems with doing so.

> *ID05: "One simply has to find space. Move some furniture downstairs for example."*
> *ID07: The easy [solution] is to move the table a bit. The way it is furnished now, we just have to move the table. And that would not be an issue.*
> Translated quotes from the interviews.

9.2.5 Hedonic motivation

Seeing as this was the first time the participants tried any form of exergames, some were having some trouble grasping how to play the games. Venkatesh et al. connects experience to hedonic motivation, as more experience would give them a better feeling of whether they think it is fun or not once they have mastered it.

Especially Celestial Shower caused some frustration, as the participants did not always understand the controls and goal of the game. However, all of them thought it was fun to some degree. One participant pointed out that it was fun to try just as a curiosity, while others would want this in their homes for the entertainment value alone.

Interviewer: "Was it fun to play?"
ID08: Yeah, it was, but a bit stressing as well. Especially when you feel like you are not mastering it properly, it becomes a bit stressful
Translated quote from the interview.

9.2.6 Price value

When the study was conducted, a gaming console with appropriate sensors, for example, an Xbox one with a Kinect sensor, was priced at around 3000NOK. The participants were asked if this was a price they would be willing to pay to have exergames at homes. For elderly in Norway, the price did not seem to be an issue. Those who were a bit hesitant was asked whether halving the price would make it more attractive, but replied that the price was not the issue, with some pointing out they don't want more cables and boxes around the TV, and others pointing out that they feel like that the lifespan of this type of equipment is too short for them to want to invest in it.

ID07: It may be that, if you are a bit skeptic, you'd like to lease it in the beginning.
ID09: It's not the price that is the issue. But one has so many things [...] If I knew I could buy new games to it in 10 years, but you can't.
Translated quotes from the interview.

Generally, the price issue seems to be even less of a concern when focusing on rehabilitation, and not just the fun and exercise aspect. The value becomes much clearer when health personnel recommends it, and they see a need for this type of activity.

ID05: I wouldn't use that much on it as of today, but if I needed it, I'd maybe save up a bit.
If it could not be used to anything but rehab, I'd probably buy a used one.
ID10: How much is it worth to be rehabilitated? Way more than 3000NOK.
Translated quote from the interview.

9.2.7 Habit

Seeing as this was the first encounter with exergames for most of the participants, it is hard to say anything specific in regards to what habits would emerge from the use of exergames over time. The interviews did not reveal any existing habits which would have a clear impact on their use of exergames.

One of the participants used a workout DVD from time to time. However, if this habit reinforces the use of exergames because they are already used to something similar, or if it prevents it as they already have a solution which serves that purpose, is impossible to determine without more data.

9.3 Elderly people's attitude towards games

None of the participants seemed to have any negative attitudes towards games when entering the study, nor did they have any prominent positive attitude. They were overall curious and open-minded, but did not have any experience with exergames.

Based on the background study most elderly people's homes will only have to move a table in order to be able to play exergames in their living room. No one seemed to have any problems with moving a table, either occasionally or permanently, for rehabilitation. They seem a bit more skeptical doing so for general exercise. Problems might arise with games requiring more space, or if larger furniture like a couch is in the way.

9.3.1 Effect of exposure

As mentioned in Section 9.2.1, the participants were able to give much clearer, and mostly positive, answer on whether or not they thought exergames could help them be more active after trying the games. All of the participants, even the most skeptical ones said they were more positive to exergames after trying it out.

> *Interviewer: "Are you more or less positive to exergames after playing?"*
> *ID08: I'm probably a bit more positive, because I've never thought of games like this. [...] This is entirely new to me and I've never thought that one could do it like this.*

> *Interviewer: Do you want something like this at home?*
> *ID08: I'm not exactly eager to get one, but not against it either. More positive now that I know what it is, if someone had asked before we started if I wanted some game in my living room, I'd say no that's not interesting. But this is not what I associate with games.*
> Translated quotes from the interview.

9.4 Other observations

Associations to grandchildren
A reoccurring theme was the mention of grandchildren or great-grandchildren. Suggesting that even though they find it fun to play, they feel like it is for children.

> *Interviewer: What was it like to play?*
> *ID06: Yes, that was fun. The great-grandchildren would think something like this was great.*

> *Interviewer: The setup for playing this costs around 3000NOK, is that a reasonable price for personal use?*
> *ID07: [...] But if you invest in this, then you have it. And maybe the grandchildren would find it very entertaining for a period.*
> Translated quotes from the interviews.

Hard to imagine possibilities
Many of the participants seemed to have problems grasping the possibilities for exercises and movements exergames can provide. This is likely to be partly due to their little experience with it, and partly because the two games they tried used very similar movement.

> *ID06: Well, this isnt very physically active, compared to what an exercise would need.*
> *ID10: I cant answer that abstract*
> Translated quotes from the interviews.

They also had problems evaluating some of the questions abstract. In some of these situations, the simulated living room helped them, by giving them a point of reference. Most of the participants used the participants used the simulated living room as a reference at some point, and several of them started looking around the room, thinking and analyzing it, when asked questions they had trouble answering.

Perceived safety
None of the participants felt at any point that they were afraid of falling or injuring themselves in any other way. Some expressed that they would have wanted a break after playing a couple more minutes than they did during the test.

Chapter 10

Discussion

Throughout the study, recruiting was proven to be a difficult task, which resulted in quite few participants (four for the home visits, and six for the tests in the lab). These low sample sizes became a problem when answering all of the research questions. Another problem in regards to recruiting was that the people who agree to join a study on exercise games are likely to be on the liberal end of the spectrum, with less fear of technology. Therefore, it is possible that there are groups of elderly people who are more skeptical to the concept, which were not represented in the study. This makes it hard to determine the exact stigma and attitude elderly people in general have towards the concept.

Despite efforts to prevent it, through triangulation and confirming observations with the participants, it is possible that some bias from the researcher has affected the results. Through both interviews and observations, the researcher may put assumptions or personal beliefs into the data and analysis.

10.1 Method discussion

Overall, the research design used, which was defined in Chapter 4, seem to have been a good fit for the research questions. However, with more time and resources, some of the methods could have been changed to give more valid results, as explained in the following subsections.

10.1.1 Research question 1A

How do elderly people typically furnish their homes, and how suited are they for playing exergames?

The ethnographic home visits resulted in a list of common traits between the homes through the observations. The main issue with the results, is the low sample size, of only four participants, recruited from a geographically limited area (all within Trondheim municipality in Norway). Ideally, the sample size should be much larger and distributed wider in order to be able to generalize the results more.

Another problem with the data is that three out of the four participants had a walker in their homes, which could have affected their furnishing. Gell et al. (2015)'s study on the use of mobility devices in America showed that about 11.6% of elderly use a walker. Although this number might be different in Norway, it is likely that it is not 75%, as in this study. However, as explained in Section 5.3, it did not seem to have a significant impact on the data, though it is still desirable to acquire more data to confirm this.

In regards to determining how suited their homes and current furnishing are for playing exergames, it is likely that simply comparing them to the theoretical requirements was sufficient. Also, given that the simulated living room reflects their home sufficiently, letting them play exergames in the simulated living room also validates the the results. However, testing the games in peoples homes and observing how many objects needed to be moved would yield a more definite answer.

10.1.2 Research question 1B

What is a typical home environment for elderly people that can be simulated in a lab?

As mentioned in Subsection 10.1.1, there are some limitations to the data about elderly people's homes. These limitations carry on to RQ1B, as it builds on the same data. However, the issue with a low sample size was reduced to some degree, by confirming the data against a new group of elderly, of six participants. The sample size is still a bit small, and the new group of elderly people were also from the same geographical area.

Another limitation of the simulated living room is that the simulation will always feel like someone else's living room at best. Peoples living room is personal (Nyholt, 2007), and this personal aspect is not feasible to replicate in a lab.

10.1.3 Research question 1C

How does game behavior differ between a lab with -, and without a simulated home environment?

Since the study did not reveal any differences in game behavior between the two scenarios, it is possible that the method used was not sufficient. It is also possible that there were differences present, which simply were not detected or looked for. There could also be greater differences in a subgroup of elderly people which were not represented in this study.

It would have been interesting to compare the results in the two lab settings, with peoples actual homes to determine if there are any differences to be found there. This would also have gathered more data for RQ1B, by seeing how the simulation compares to the real environment. Given more time and resources, this should have been prioritized.

10.1.4 Research question 2A

What are healthy elderly people willing to change about their homes to make room for exergames?

For many of the participants, this became a very abstract scenario, which they had not taken into consideration before. This made their answers highly speculative, and there is a great chance they would act in a different way than what they describe in the interviews. Ideally, a group of elderly people should be given an exergame device for an extended period, and observe how they adapt the living environment to incorporate it. However, this would take more time and resources than available for this thesis.

10.1.5 Research question 2B

What factors can motivate elderly people to change their homes to make room for exergames?

Like with RQ2A, this was very abstract for the participants and hard to come up with on the spot during the interviews. It is also hard to know what factors are motivating until you become motivated. However, some factors emerged so naturally in the conversations and gave such a strong indication of being motivational factors, making it possible to draw some conclusions.

10.1.6 Research question 2C

How does being exposed to exergames affect elderly people's attitude towards incorporating it into their homes?

Gathering data about the participants' attitude towards exergames at the beginning of the experiment yielded a good baseline for what they think about it in general. Asking them again after trying the games, gave a good indication of how exposure changed their attitude. Seeing as very few other factors had changed in between, it is safe to assume that the results are credible for the test group.

10.2 Research quality

As explained in Section 3.5, the overall quality of a research within the interpretivism paradigm is defined by its confirmability, dependability, credibility, and transferability. The credibility of the study is covered through the method discussion in Section 10.1, while the remaining are covered in the following sections.

10.2.1 Confirmability

In order to ensure confirmability, as much data as possible from each step in the process should be presented. Some data, like raw notes and full transcripts have been omitted from this thesis, as they are lengthy and is not believed to carry much useful information. The pictures of people's homes, which the living room sketches found in Appendix D.2 are based on, are not included either, as the participants did not grant permission to publish them. All other data which is perceived as relevant is included, and all the raw data is available to parts of the EXACT research team. Which makes the research fairly confirmable.

10.2.2 Dependability

The procedure of the background study is described in detail in Section 5.2, and the usability test in Section 8.4. Every step from the recruiting to the execution is described, and the information form and interview guides are provided. Based on this, it is believed that it is possible to replicate the study for either the same or a different target group.

10.2.3 Transferability

It is hard to determine what characteristics of the situation is necessary, in order to say something about whether the results of a study can be transferred to a different situation or not. The core of the situation observed in this study is the living room, and general home, of elderly people living partially or fully independently in their own homes in Trondheim municipality. This means that the research can not be transferred to elderly people living in a care facility, as their housing differs significantly from those in this study. However, it is believed that enough information is provided for a reader to determine if the results can be transferred to their setting of interest.

10.3 Surprising results

The most surprising results were the results to RQ1C, on how the game behavior differs between a simulated living room and an open space. It was assumed that especially the couches would be in the way for the players and that they would need to look to the sides, and possibly behind themselves, every so often to make sure they don't hit anything. However, no such behavior was observed. Suggesting that people have more control of where they are in regards to the obstacles around them than assumed.

Chapter 11

Conclusion

As explained in Section 1.3, this thesis aims to answer how to conduct more ecologically valid tests of exergames for elderly people's homes and learn more about how exergames can be included in their lives. Through both a field study and a lab experiment, this thesis has gathered useful information in regards to these topics.

11.1 Research questions

Despite the limitations to the data gathered about elderly people's homes, as described in Subsection 10.1.1 and 10.1.2, the guidelines based on them can still be used as long as their limitations are kept in mind. The study did not reveal any differences in game behavior between the open space and the simulated home environment, but that does not mean that using a more ecologically valid environment did not have any added value. Given that the participants had trouble putting themselves into hypothetical scenarios, having a more realistic setting seemed to help them better grasp the scenario. The participants used the simulation as a reference and looked around the room, analyzing and comparing it to their own when asked questions. This proves some of the added benefits of the living room, regardless of how generalizable it is.

In regards to elderly people's attitude towards exergames, the elderly people who partook the study were generally positive to the concept. Although most of them were not eager to get one just for general exercise and health benefits. Injury and rehabilitation seemed to be the most motivating factors for acquiring an exergame platform, followed by loss of mobility in other ways, and entertainment with grandchildren or similar. If they were to get one, moving a table when playing would not be an issue. Also, some participants said they were willing to move heavy objects like couches for rehabilitation purposes. Al-

though, as stated in Chapter 10, the results may be different with a more diverse group of elderly, especially in regards to technology use.

It was evident that being exposed to exergames had a considerable impact on their attitude towards it. As stated, exergames was a very abstract concept to them, making it hard to have a definite opinion about it. Some of them said they had such strong associations of games being played using a keyboard, that even imagining how to use a game for exercising was impossible before partaking in this study. In addition to being able to make up a somewhat educated opinion on exergames, being exposed to it seemed to generally make them more positive to the concept.

A short summary of the conclusion of each research question:

- **RQ1A - How do elderly people typically furnish their homes, and how suited are they for playing exergames?** The living room of elderly people seems to be a 16-20m^2 room, with seating for 2-6 people, whom all can see the 27-42" TV (more details in Section 5.3). Their homes are fairly suited for playing exergames, given that they move some light furniture, like a table, to get more available space.

- **RQ1B - What is a typical home environment for elderly people that can be simulated in a lab?** Based on the common traits of elderly people's homes, a simulated home environment should be about 18m^2, have seating for four people, have a 36" TV which most seats can see, and some other furniture.

- **RQ1C - How does game behavior differ between a lab with -, and without a simulated home environment?** There does not seem to be any difference in game behavior between these two situations.

- **RQ2A - What are healthy elderly people willing to change about their homes to make room for exergames?** In general, people seem willing to at least move a table out of the way, and possibly other light furniture. Although, they are a bit hesitant towards moving heavy objects.

- **RQ2B - What factors can motivate elderly people to change their homes to make room for exergames?** Injury and rehabilitation seem to be the most prominent motivational factor. However reduced mobility, and as a way of engaging with their grandchildren was also brought up as motivational factors.

- **RQ2C - How does being exposed to exergames affect elderly people's attitude towards incorporating it into their homes?** Overall the participants had a clearer, and somewhat more positive attitude towards the concept after having tried it. None of the participants become more negative towards it.

11.2 Further work

Through the study, some recommendations for further work emerged. Some due to limitations of this study, and others outside its scope.

11.2.1 Increase the validity of the home simulation

As explained in detail throughout Section 10.1, there are some limitations to the home simulation and the data it is based on. A bigger, and nationally distributed study should be conducted in order to create a more generalizable result.

Participant ID10 has been living in England as well as Norway and pointed out that both the layout of the home, as well as the furnishing, differs between these two countries. This indicates that even a sample from a greater portion of Norway, will not be generalizable to an international level. It is hard to say if each country or region will need their own set of guidelines, or if it is possible to make generalized global guidelines based on an international distributed samples, without further knowledge of how significant the differences are.

11.2.2 Determine motivational factors

The study found some indicators towards motivating factors, however, the results are only speculative, and not conclusive. Investigating households of elderly people which has exergames or similar already, and identifying their motivational factors could be a step towards establishing the major motivational factors.

11.2.3 Game behavior comparison between home simulation and home

Despite the tests not revealing any differences in game behavior between the open space and the simulated home environment, it is yet to be determined if the same stands when comparing the simulation to real homes. This would contribute to determining the validity of the lab simulation. It could also investigate differences between playing in someone else's living room, which the lab simulation essentially is, versus playing in your own home.

A test in people's homes could also be conducted over the span of weeks, looking into the long term effects. As mentioned in Subsection 10.1.4, an at home test over a longer period

of time could further determine exactly how people adjust their homes to incorporate this type of technology.

11.3 Summary

From the two studies conducted, it is clear that there are some limitations when working with exergames for elderly people. Although, they are not as restrictive as initially thought. Even though there is not enough space to play exergames given elderly people's current furnishing, moving a table or other light furniture usually granted a minimum of 2x2 meters of available space. Therefore, games for this target group should aim to be playable given this restriction.

Depending on what is being tested, using a simulated home environment might not be necessary. As the lab experiment showed, there was no difference in how they played the games in the simulated living room and the open space. If the test looks at social factors and at-home use, a simulated home environment seems to be necessary for them to put it into perspective and better compare it to their own homes. However, it does not seem to be necessary when testing a game. This study does not verify if this goes for field tests as well, as no games were tested properly in the field.

It also seems like a rehabilitation and mobility regaining is the most relevant setting for them to use exergames. Therefore focusing resources on making games for rehabilitation is likely to be more beneficial given the current attitudes towards games. Although, as exposure to exergames was proven to have a positive effect on attitude, this could change over time if it becomes more common and they get more exposure to it.

Acronyms

DDA dynamic difficulty adjustment. 5

DDR Dance Dance Revolution. 4

FOV Field of View. 40

IDI Department of Computer Science. i, 1, 5, 6, 42, 48, 49

INB Department of Neuromedicine and Movement Science. i, 1, 5

IR infrared radiation. 40

ISO International Organization for Standardization. 6

IT Information Technology. 11, 22

N/A Not applicable. 100

NTNU Norwegian University of Science and Technology. i, 1, 5, 39, 42, 48, 50

RGB red, green, and blue. 40

RQ research question. 26, 31, 61–63, 65

TAM Technology Acceptance Model. 11

UTAUT Unified Theory of Acceptance and Use of Technology. 11–13

UTAUT2 Unified Theory of Acceptance and Use of Technology 2. 11, 13, 50, 54

VR Virtual Reality. 39

Appendix A

Data collection application

An application for collecting data about elderly people was sendt to NSD, and approved. The application can be found on the following pages.

Dag Svanæs
Sem Sælandsvei 7-9
7491 TRONDHEIM

Vår dato: 13.11.2017 Vår ref: 56220 /3 /PEG Deres dato: Deres ref:

Vurdering fra NSD Personvernombudet for forskning § 31

Personvernombudet for forskning viser til meldeskjema mottatt 27.09.2017 for prosjektet:

56220	*Bruk av dataspill for trening: Hvordan gjenskape de fysiske omgivelser i eldres hjem i en labsituasjon*
Behandlingsansvarlig	*NTNU, ved institusjonens øverste leder*
Daglig ansvarlig	*Dag Svanæs*
Student	*Ole Knurvik*

Vurdering

Etter gjennomgang av opplysningene i meldeskjemaet og øvrig dokumentasjon finner vi at prosjektet er meldepliktig og at personopplysningene som blir samlet inn i dette prosjektet er regulert av personopplysningsloven § 31. På den neste siden er vår vurdering av prosjektopplegget slik det er meldt til oss. Du kan nå gå i gang med å behandle personopplysninger.

Vilkår for vår anbefaling

Vår anbefaling forutsetter at du gjennomfører prosjektet i tråd med:

- opplysningene gitt i meldeskjemaet og øvrig dokumentasjon
- vår prosjektvurdering, se side 2
- eventuell korrespondanse med oss

Vi forutsetter at du ikke innhenter sensitive personopplysninger.

Meld fra hvis du gjør vesentlige endringer i prosjektet

Dersom prosjektet endrer seg, kan det være nødvendig å sende inn endringsmelding. På våre nettsider finner du svar på hvilke endringer du må melde, samt endringsskjema.

Opplysninger om prosjektet blir lagt ut på våre nettsider og i Meldingsarkivet

Vi har lagt ut opplysninger om prosjektet på nettsidene våre. Alle våre institusjoner har også tilgang til egne prosjekter i Meldingsarkivet.

Vi tar kontakt om status for behandling av personopplysninger ved prosjektslutt

Ved prosjektslutt 03.09.2018 vil vi ta kontakt for å avklare status for behandlingen av personopplysninger.

Se våre nettsider eller ta kontakt dersom du har spørsmål. Vi ønsker lykke til med prosjektet!

Katrine Utaaker Segadal

Pernille Ekornrud Grøndal

Kontaktperson: Pernille Ekornrud Grøndal tlf: 55 58 36 41 /pernille.grondal@ nsd.no

Vedlegg: Prosjektvurdering
Kopi: Ole Knurvik, olemkn@ stud.ntnu.no

Personvernombudet for forskning

Prosjektvurdering - Kommentar

Prosjektnr: 56220

Utvalget består av eldre personer som vil rekrutteres via boligstiftelser og gjennom NTNUs seniornettverk. Personvernombudet forutsetter at rekrutteringen skjer på en måte som ivaretar konfidensialitet og frivillighet.

Utvalget informeres skriftlig om prosjektet og samtykker til deltakelse. Informasjonsskrivet er hovedsakelig godt utformet. Vi har imidlertid følgende kommentarer:

I skrivet indikeres det at videopptakene vil lagres i etterkant av prosjektslutt. Personvernombudet anbefaler at det opplyses om videopptakene lagres i personidentifiserbar eller anonymisert form. Dersom opptakene som skal lagres identifiserer enkeltpersoner, ber vi dere opplyse om formålet med lagringen, å angi en tidsramme for lagringen, samt opplyse om hvordan dataene vil bli lagret (på fysisk isolert PC tilhørende virksomheten). Dersom opptakene lagres i anonymisert form, ber vi dere tydeliggjøre dette i skrivet.

Videre ber vi dere opplyse om at dere ønsker å dra på hjemmebesøk, slik at utvalget er forberedt på dette. Vi ber vi dere også om å omformulere avsnittet om at det er frivillig å delta slik at det fremstår som en opplysning til utvalget. Vi bemerker at også kontaktinformasjonen til studenten skal oppgis i skrivet. I tillegg ber vi dere om å informere om at datamaterialet vil gjøres tilgjengelig for to PhD-kandidater tilknyttet prosjektet.

Personvernombudet legger til grunn at forsker etterfølger NTNU sine interne rutiner for datasikkerhet.

Forventet prosjektslutt er 03.09.2018. Ifølge prosjektmeldingen skal innsamlede opplysninger da anonymiseres. Anonymisering innebærer å bearbeide datamaterialet slik at ingen enkeltpersoner kan gjenkjennes. Det gjøres ved å:
- slette direkte personopplysninger (som navn/koblingsnøkkel)
- slette/omskrive indirekte personopplysninger (identifiserende sammenstilling av bakgrunnsopplysninger som f.eks. bosted/arbeidssted, alder og kjønn)
- slette/redigere digitale lyd-/bilde- og videoopptak

Appendix B

Consent form

Each participant in the study were asked to sign a consent form, allowing for data collection. The form can be found of the next page.

Deltakelse i forskningsprosjekt.

Samtykkeerklæring

Dataspill har stort potensiale som hjelpemiddel i fysisk rehabilitering. I dette prosjektet skal vi utvikle dataspill for eldre brukere, og vi behøver derfor å være i en konstruktiv dialog med potensielle brukere.

Institutt for Datateknikk og Informatikk ved NTNU er ansvarlig for prosjektet, i samarbeid med Fakultet for Medisin og Helsevitenskap ved NTNU. Oppgaven befinner seg innen fagområdet Menneske-Maskin Interaksjon.

Formålet med dette konkrete prosjektet er å finne ut i hvilken grad eldres private hjem er tilpasset bruk av kroppsstyrte dataspill, samt hvordan laboratorier kan utformes for å gjenskape disse fysiske omgivelsene. Vi vil samle data gjennom observasjon og uttesting i lab. De data som samles er bilder, video og lyd. Datamaterialet planlegges anonymiseres ved prosjektslutt 01.09.2018.

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

Det vil bli tatt video- og lydopptak. Dette gjøres for at vi skal kunne analysere opptakene i etterkant og sikre at vi har forstått deres 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.

Dette innbærer at informasjon som blir formidlet til offentligheten ikke vil kunne settes i sammenheng med den enkelte. Enkeltpersoner vil ikke kunne gjenkjennes i de endelige publikasjoner. Det er kun de involverte i prosjektet som vil kunne se opptakene i ettertid.

Jeg samtykker i å delta.

Trondheim, _____ (dato)

_____

Underskrift

Kontaktperson:
Professor Dag Svanæs
Institutt for Datateknologi og Informatikk
NTNU - Trondheim
e-mail: dags@idi.ntnu.no

Appendix C

Background information

All participants filled out a form with background information, focusing on personals, technology use, and physical activity. The form used is found in appendix C.1, the results from the background study in table 5.1, and the results from the usability test in appendix C.2.

C.1 Form

This form was used for all participants. However the field for email was added after the background test, therefore there is no data on use of email among the participants in the background study.

Bakgrunnsinformasjon om deltakere

Personinformasjon

Navn: _____

Telefon: _____

Alder: _____

Kjønn: __ Mann __ Kvinne

Teknologibruk

Hvor ofte bruker du følgende?

	Aldri	Sjeldent	En del	Ofte	Veldig ofte
Nettbank:	__	__	__	__	__
Facebook:	__	__	__	__	__
Smarttelefon:	__	__	__	__	__
Nettbrett:	__	__	__	__	__
Apper:	__	__	__	__	__
E-post:	__	__	__	__	__

Hvor mye har du spilt dataspill på disse plattformene?:

	Aldri	Sjeldent	En del	Ofte	Veldig ofte
PC:	__	__	__	__	__
Smarttelefon:	__	__	__	__	__
Nettbrett:	__	__	__	__	__
Nintendo Wii:	__	__	__	__	__
Microsoft Kinect:	__	__	__	__	__

Andre plattformer: _____

Trening

Hvilken type trening driver du med?
( ) Går tur
( ) Løping/jogging
( ) Gruppetimer (yoga, seniortrim, spinning)
( ) Utendørs aktivitet (ski, sykkel, annen idrett)
( ) Svømming
( ) Annen aktivitet: ……..

Hvor ofte trener du?
( ) Aldri
( ) Sjeldnere enn en gang i uken
( ) En gang i uken
( ) 2-3 ganger i uken
( ) Omtrent hver dag

Dersom du trener, hvor hardt trener du?
( ) Tar det rolig uten å bli andpusten eller svett
( ) Tar det så hardt at jeg blir andpusten eller svett
( ) Tar meg nesten helt ut

Hvor lenge varer en typisk treningsøkt?
( ) Mindre enn 15 minutter
( ) 16 - 30 minutter
( ) 30 minutter - 1 time
( ) Mer enn 1 time

Ønsker du at du kunne være mer aktiv?
( ) Ja
( ) Nei

Hva må til for at du skal være mer aktiv?

……

Tror du dataspill kan få deg til å være mer aktiv?
( ) Ja
( ) Usikker
( ) Nei

C.2 Results from lab study

Table C.1: Results from information form in lab study

Participant ID	**ID05**	**ID06**	**ID07**	**ID08**	**ID09**	**ID10**
Age	65	86	71	81	69	77
Gender	F	M	M	M	F	M
How often do you use the following						
Online banking	Rarely	A bit	A bit	Very often	Often	A bit
Facebook	Rarely	Never	Rarely	Never	Very often	Never
Smart phone	Often	A bit	Often	A bit	Often	Rarely
Tablet	Rarely	A bit	Rarely	Never	Very often	Often
Apps	Rarely	Often	Often	A bit	Very often	A bit
E-mail	Rarely	Often	Often	A bit	Very often	Very often
How often do play on the following platforms						
PC	Rarely	Never	Never	Never	Never	Never
Smart phone	Never	Never	Never	Never	Often	Never
Tablet	Never	Never	Never	Never	Very often	Never
Nintendo Wii	Never	Never	Never	Never	Never	Never
Microsoft Kinect	Never	Never	Never	Never	Never	Never
What kind of physical exercise do you do?						
Walking	X	X	X	X	X	X
Running/ jogging						
Group classes	X	X	X	X		
Outdoor activities			X		X	
Swimming						
Other	Gym	Tennis			Yoga	Gardening and simple exercises
Weekly workouts	2-3	2-3	2-3	2-3	None, but active daily	None, but active daily
Workout length	>60 min	30-60 min	30-60 min	>60 min	20 min	16-30 min

C.2.1 Game scores from usability test

Table C.2 shows in detail how each participant performed playing The Fox (TF) and Celestial shower (CS). When playing The Fox, you get points for catching grapes and chickens

(more for chickens than grapes), and lose points for hitting branches. When playing Celestial shower you get points for catching stars, as well as remaining health.

Table C.2: Individuals scores from lab test

Participant ID	**ID05**	**ID06**	**ID07**	**ID08**	**ID09**	**ID10**
First room	Living room	Lab	Living room	Lab	Living room	Lab
First game	CS	TF	TF	CS	CS	TF
The Fox (TF) first round						
Score	141	131	41	111	120	103
Grapes	66	71	32	62	85	71
Chicken	12	15	6	18	14	10
Branches	2	5	4	3	2	1
The Fox (TF) second round						
Score	189	178	87	144	171	142
Grapes	83	87	53	90	90	101
Chicken	18	18	13	20	17	16
Branches	1	8	2	5	1	0
Celestial shower (CS) first round						
Score	73	29	96	6	83	88
Stars	23	29	16	6	13	18
Health	50	0	80	0	70	70
Celestial shower (CS) second round round						
Score	97	55	93	13	115	134
Stars	37	35	23	13	25	34
Health	60	20	70	0	90	100

Appendix D

Background study

D.1 Interview guide

Intervjuguide - Eldres hjemmemiljø og treningsspill

Løs prat
- Skape en avslappet setting
- Trygghet

Informasjon
- Tema for samtalen, bakgrund, formål
- Hva skal intervjuet brukes til (infoskrivet)
- Har intervjuobjektet noen spørsmål?
- Samtykke til opptak
- Start opptak

Personinformasjon, teknologibruk og trening
Se eget skjema, fyll ut sammen med informanten

Hjemmemiljø
- Hvor stor er leiligheten? (Evt. mulighet for bilde av plantegning)
- Hvor mange bor i husstanden?
- Får du ofte besøk? Av familie eller bekjente.
    - Brukes da leiligheten eller fellesområdet? (Hvis relevant)
- Spørre om å få lov til å ta bilder (uten personer).
- Hvilke rom bruker du mest?
    - Hva brukes de enkelte rommene til?
        - Hverdag
        - Besøk
- Hvordan ser en typisk dag ut i forhold til inne/ute og de forskjellige rommene?
- Hva brukes TVen til? NRK, Netflix… Hvor mye…

Bevegelsesstyrte dataspill i leiligheten
- Trener du noen gang i leiligheten?
- Kunne du tenke deg å ha aktivitetsspill i leiligheten? (koblet til TV)
    - Mange av disse spillene krever i dag ca 2x2-3x3 meter, er det aktuelt å flytte bordet for å spille, eller generelt ommøblere?
- Dersom du skulle bli syk eller trenge en operasjon, for eksempel lårhalsbrudd, og denne typen spill kunne bidra til å raskere komme tilbake på beina, ville du da vært villig til å ommøblere i perioden med opptrening?

Fellesområdet (hvis relevant)
- Hvordan bruker du fellesområdet?
- Hva føler du i forhold til bruk av fellesområdet til treningsspill?

Oppsummering
- Kjapp oppsummering
- Dobbelsjekk at man har forstått riktig
- Noe du ønsker å legge til?

D.2 Results

Sketches based on the homes of the participants in the background study was created. They are to some extent color coded. Yellow meaning soft objects (couches, beds, etc), orange meaning hard objects (tables, shelves, etc), gray meaning fixed objects like kitchen counter, fire place, etc). Blue was used for objects using water, like sinks and showers. While green was used for both doors and larger plants.

These are rough sketches meant for looking for similarities and trends, and are not perfectly to scale with the real apartments and can not be used for work where precision is needed.

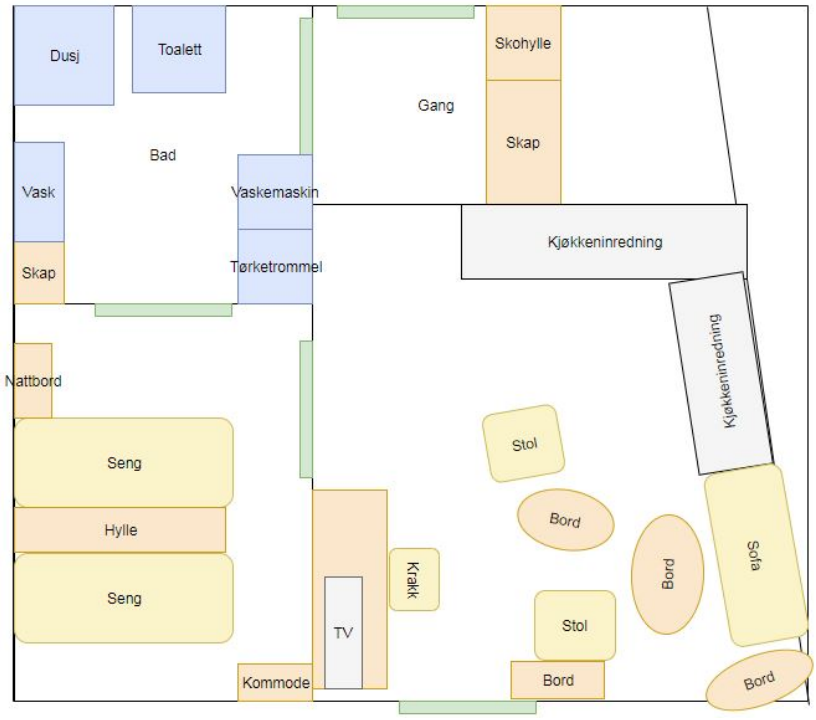

Figure D.1: Sketch of participant ID01's home

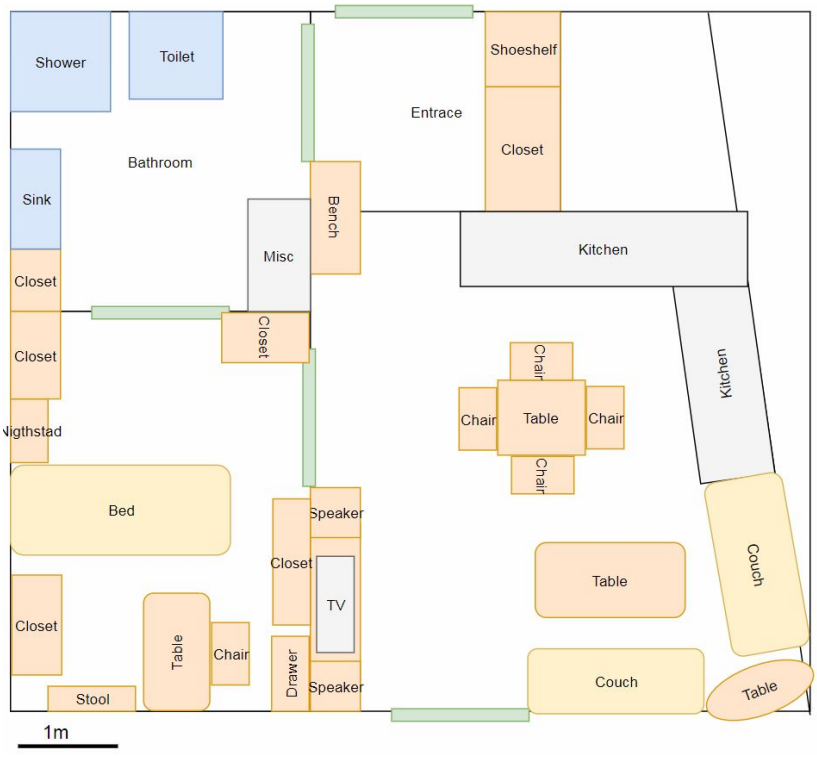

Figure D.2: Sketch of participant ID02's home

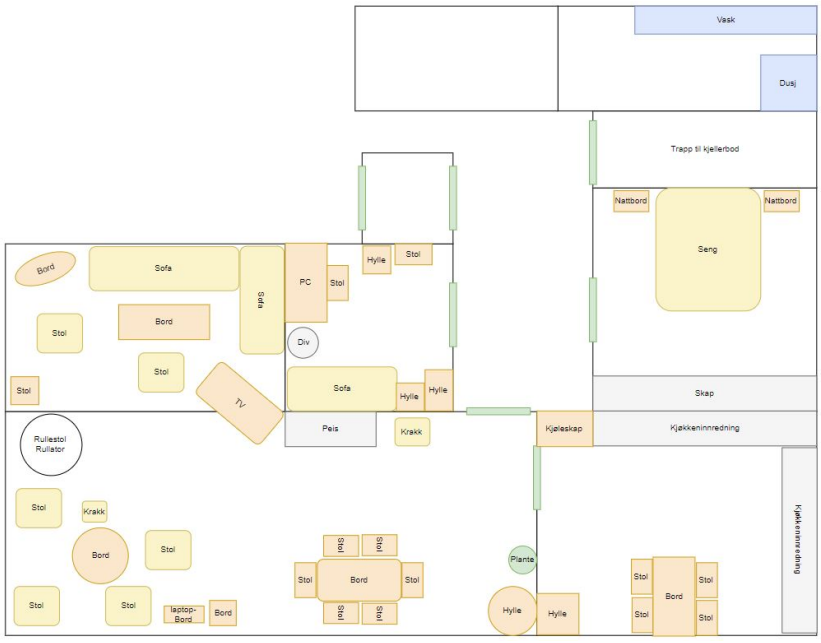

Figure D.3: Sketch of participant ID03's home

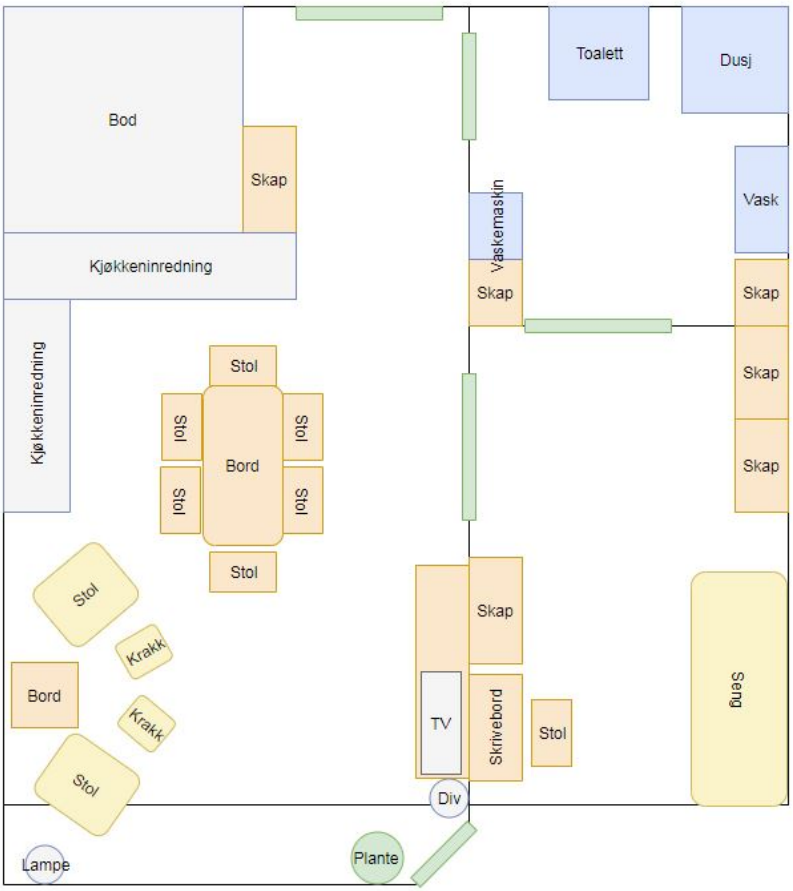

Figure D.4: Sketch of participant ID04's home

Appendix E

Lab setup

Figure E.1: Lab setup - Open space

Figure E.2: Lab setup - Living room, view of entrance

Figure E.3: Lab setup - Living room, view from couches

Appendix F

User test interviews

F.1 Interview Guide

Intervjuguide

Intervju etter brukertest (45 min)

Løs prat

Debriefing om spillopplevelsen:

- Var det gøy å spille? Morsomt-underholdende vs. kjedelig (fun)
- Fysisk anstrengende - enkelt rent fysisk (dual flow)
- Følte du deg trygg da du spilte (mot mulig fall etc.)
- Hva var forskjellig mellom å bruke det i “leiligheten” og “på gulvet”?

(Legger frem 2 x A5 utskrift av skjermbilde fra spillene)

Celestial Shower (vis fram A5 med C.S.)

- Lett/vanskelig å bruke (usability interaksjon)
- Lett/vanskelig å forstå (tekst, spillets logikk,,)
- Var spillet gøy?
- Hva likte du med spillet?
- Hva likte du ikke med spillet?
- Fikk du med deg hvor mange poeng du hadde?
- Er dette et spill du ville spilt igjen? Hvorfor, hvorfor ikke?

The Fox (vis fram A5 med Fox)

- Lett/vanskelig å bruke (usability interaksjon)
- Lett/vanskelig å forstå (tekst, spillets logikk,,)
- Var spillet gøy?
- Hva likte du med spillet?
- Hva likte du ikke med spillet?
- Fikk du med deg hvor mange poeng du hadde?
- Er dette et spill du ville spilt igjen? Hvorfor, hvorfor ikke?

Sammenligning (legg fram begge):

- Hvis du skulle velge ett av spillene, hvilket ville du velge.
- Hva gjør evt. det ene spillet bedre enn det andre?

Motivasjon:

- Motiverende: Er dette noe du ville gjøre mer av frivillig hvis du hadde muligheten?
- Er dette noe du kunne tenkte deg å gjøre hjemme?
- Dersom du fikk valget mellom et treningsprogram som benytter denne typen spill, og et som ikke gjør det. Hvilket tror du at du ville valgt?

Hjemmemiljø mot lab

- Hvor mange bor i hustanden med deg?

- Hva slags boligtype har du? Hvor stor?
    - Hvis hus: Har du et annet rom der du ville ha satt et slikt spill?
- Er det nok plass til å ha noe slikt hjemme hos deg?
    - Hvilket rom?
- Hvor stort er dette rommet målt mot din stue (eller annet rom)?
- Ville du selv innredet det slik hjemme hos deg?
- Hva skiller dette rommet fra din stue (eller annet rom)?

Bevegelsesstyrte dataspill i leiligheten

- Trener du noen gang i egen bolig?
- Tror du at noe slik kunne hjulpet deg å være mer aktiv?
- Er du mer positiv eller mer negativ nå etter å ha prøvd slike spill enn du var før testen?
- Kunne du tenke deg å ha aktivitetsspill i egen bolig? (koblet til TV)
    - Mange av disse spillene krever i dag ca 2x2-3x3 meter, er det aktuelt å flytte bordet for å spille, eller generelt ommøblere?
- Dersom du skulle bli syk eller trenge en operasjon, for eksempel lårhalsbrudd, og denne typen spill kunne bidra til å raskere komme tilbake på beina, ville du da vært villig til å ommøblere i perioden med opptrening?
- Andre faktorer? (Andre scenario hvor dette kunne vært aktuelt?
- Hvilke holdninger tror du folk rundt deg har til at man spiller denne type spill hjemme?

Pris:

- Den del av disse systemene koster per i dag 3000,-. Er det noe du kunne vært villig til å betale for noe slik?
- Dersom prisen synker til 1500,- er det da aktuelt?
- Om man får låne av fysioterapaut, lege eller lignende?

F.2 UTAUT

F.2.1 Performance expectancy

The participants were asked about their performance expectancy both before and after testing the games. The fist question below is before, while the second is after.

Tror du dataspill kan få deg til å være mer aktiv?
Do you think computer games can make you more active?

ID05: *Usikker. Kanskje*
ID06: *Usikker. Gjennstår å se*
ID07: *Usikker. Kanskje*
ID08: *Nei*
ID09: *Ja, kanskje*
ID10: *Usikker*

Tror du noe slikt(exergames) kunne hjulpet deg å være mer aktiv?
Do you think something like this(exergames) could help you be more active?

ID05: *Hjem ja? Jaja*
ID06: *Nei. Det tror jeg ikke. Skal jeg aktivisere meg mer så e det tennis. Et par timer i uka ekstra*
ID07: *Ut fra dagens situasjon, så er svaret nei. Men altså i en annen setting, skal du ikke se bort fra det. Jo større behovet hadde vært for den type bevegelse, trening med moderat intensitet osv, ganske enkle bevegelser. Skjønt det å få armene over hodet kan være vanskelig.*
ID09: *Ja det tror jeg.*
ID10: *Jeg ser mulighet for... jeg vil ikke lukke den ut.*

F.2.2 Effort expectancy

Var det lett å bruke og forstå?
Was it easy to use and understand?

ID05: *Jeg synes det var lett å bruke, og greit å forstå.*
ID06: *The Fox: Nei jeg var ikke klar over hvordan jeg skulle bruke armane [...] Jeg motte jo erfare hvordan man skulle unngå de pinnane.*
Celestial shower: Ja det var jo artig det. Når jeg skjønte åssen de skulle gjøres.Var poenget at en skulle være der [peker på snøfnugg] med hånda for å få poeng? Det var jeg ikke klar over. Jeg trodde det var nok å treffe den.
ID07: *The Fox: Sidesveis var veldig enkelt. Og hopp gikk fint. Det sa du vel også, at man motte hoppe for å få fuglen, mens druene kom rett i munnen. Så er det strategi. Fuglen fader jo bort, så et par ganger kom jeg for seint. Så kommer greinene i mellom. Skal en stå i ro og få to jafser med druer eller skal en prøve å ta fuglen i steden. [...] Det virker jo på mange måter intutivt. Greinene var spesilt i starten større enn antatt og gikk litt for nære.*
Celestial Shower: Meteorspillet, det, litt mentalt litt fjernere. [...] Ja så sant jeg har forstått det jeg burde forstå. Og det var jo det å fange stjernene og holde seg unna meteoren. Og når det ville være mulig å løpe gjennom en meteor vet jeg ikke enda. Hvor god tid jeg har til å gå fra en side til den andre.
ID08: *The fox: Jeg synes det her var lettere å forstå enn det første. [...] Det var greiere det- for meg i hvert fall.*
Celestial shower: Ja det var litt vanskeligere å komme inn i det. Hva som var poenget og hva en skulle gjøre. Det var det som var litt kinki.
Intervjuer: Gikk det bedre andre gang?
Ja litt synes jeg jo. Men fremdeles sitter jeg med en følelse av at jeg ikke gjorde det jeg burde gjøre.
ID09: *The fox: Missing data*
Celestial shower: Jeg synes det var litt vanskelig og forstå når du skal treffe stjernene. Hvor rask skal du være, hvor nærme skal de.
ID10: *Jeg vet ikke om målet spillet hadde var det samme som jeg hadde. Fordi jeg vil ikke, jeg kunne ikke identifisere med reven fordi jeg var ikke sulten for så mange druer og kyllinger. Etterhvert motte jeg vekke opp en motivering på en abstrakt måte ikke sant. Hva kan jeg si. Du må vekk- hvis du skal score høyst mulig må du ha et mål som er at jeg skal score mer enn ham for eksempel, eller mer enn forrige gang. Men spesielt første gang hadde jeg ikke et slik mål. Hvis jeg kunne ha flyttet meg fort over, men jeg må vurdere underveis om jeg når det eller ikke. Da ville jeg heller la være. Det er kompromi mellom sjangsen og anstrengelse.*

F.2.3 Social Influence

Hvilke holdninger tror du folk har til at man spiller denne type spill hjemme?
What attitudes do you think people have in regards to playing this type of games at home?

ID05: *Det må verr greit det? Trur it folk har noe negative tankar. [...] Jeg synes det er veldig greit og artig, hvorfor skal ikke andre synes det?*
ID06: *Jeg ser jo på disse, mine eldre kollegaer, det e mange der som tydlig e lite aktive. Om de ville da tro at dette ville hjelpe dem er jeg ikke så sikker på. [...] Dette er veldig individuelt. Det er sikkert noen som ville synes det er artig.*
ID07: *Jeg vil jo tro at det i utgangspunktet er positivt altså. Og om folk skulle se gjennom vinduet at en står og vifter forran tven tror jeg det er et stykke igjen til de ringer til psykiatrisk avdeling.*
ID08: *De fleste er litt gammeldags, men er et par stk som er litt mer vant til og jobber mer med data. [...] Kommer på et par stk som ville synes dette var artig, og noen andre som mener det bare er tøys.*
ID09: *Ungane ville synes det var veldig greit. [...] Ingen som ville være negative utenom han i pensjonistforeningen. Jeg ville ikke synes det var noe flaut.*
ID10: *De vil more seg over det. Fordi det er så ut av karakter.*

F.2.4 Facilitating conditions

Har har du plass til dette hos deg?
Do you have enough space for this at home?

ID05: *Missing data*
ID06: *Det kreve jo litt plass da. Får flytte litt på sofaen.*
ID07: *Det er det minste rommet vi har tven i (15m2), men vi har et ganske lite bord, og slanke sofaer. Så det er alltid plass til å reise seg for såpass beskjedne bevegelser som dette krever.*
ID08: *Akkuratt det tror jeg ikke ville vært noe problem. Mulig en må flytte på et bord eller en stol men ikke noe være enn det*
ID09: *Ja, vi må snu på bordet bare. Det er ikke noe problem.*
ID10: *Eneste rommet som er stort nok er stuen. Men stuen er også møbelert.*

F.2.5 Headonic motivation

Var det gøy å spille?
Was it fun to play?

ID05: *Ja*
ID06: *Jo, det var jo egentlig artig det. I hvert fall oldebarna ville syntes det var strålende med noe sånt*
ID07: *Jo en lar seg rive med litt. En kommer vel etterhver til et punkt der off vekk med det, og blir lei av det. Det blir jo litt ensformig. Men ikke på så korte ting som detta*
ID08: *Jo, det er forsåvidt det, men det er litt stressende og. I hvert fall når du føle at du ikke mestre det ordentlig, så blir det litt stress.*
ID09: *Ja det var gøy og jeg kan bli svett. Ikke veldig svett*
ID10: *Det var ikke værst. Kunne ikke funnet på å gjøre hver dag. Men som en nysjerrighet var det greit.*

F.2.6 Price value

En del av disse systemene koster per i dag 3000,-. Er det noe du kunne vært villig til å betale for noe slik?
Some systems similar to this costs per today 3000 NOK. Would you would be willing to pay that for something like this?

ID05: *Ja, det vil jeg nå tru. Det kjem jo ann på inntektå og prioriteringar. Men jeg tror eldre ville synes dette var artig. [...] Jeg ville nok ikke brukt så mye penger per i dag, men hadde jeg hatt bruk for det så kanskje jeg hadde spart opp litt.*
ID06: *Ja det kunne jeg godt ha tenkt meg. Hvis kona synes det var artig. Jeg tror nok vi ville betale kontigenten i tennisklubben i steden.*
ID07: *Jeg trodde ikke du kunne få den trackeren så billig. 3000,- er en del penger, jeg trodde bare den slags utstyr var mye dyrere. [...] Jeg snakket jo varmt om gruppetimer. Og det gir jo mer. Men har du invister i dette for 3000,- så har du det jo. Det kan jo godt hende at barnebarn synes det var fryktelig gøy i en periode.*

ID08: *Hvis jeg var tent på å ha det, ville prisen vært akseptabel. Jeg og kona må begge synes det har noe for seg. Er en sterk motstander så er det ikke aktuelt, men bare en kilde til krangel*
ID09: *Det er ikke prisen som er problemet. Men vi har jo så mye dingsebomser. Og det blir så mye.*
ID10: *Hvis den ikke kunne brukes til noe annet, og den kun skulle brukes til rehab. Så ville jeg heller kjøpt brukt*

Dersom prisen synker til 1500,- er det da aktuelt?
If the price were to be reduced to 1500 NOK, would it then be interesting?

ID05: *Ja*
ID06: *N/A*
ID07: *N/A*
ID08: *N/A*
ID09: *Nei. Det er ikke prisen. Har jeg lyst på det så kjøper jeg det.*
ID10: *N/A*

Om man får låne av fysioterapaut, lege eller lignende?
What if you were to borrow one from a physiotherapist, doctor, or similar?

ID05: *Ja*
ID06: *Ja absolutt. Hvis det kom det som alternativ til andre øvelsar så*
ID07: *Ja, hvis du tenker på sjangsen for at du kjøper det og det blir stående og støve ned. I mot å ha det en periode hvor det er vanskelig å komme seg ut da.*
ID08: *Lite forbehold om konas innstilling. Men for egen del ikke helt fjernt.*
ID09: *Ja. Det ville vært veldig fint. Fordi da vet du at det blir brukt og det blir byttet ut naturlig, ikke hjemme hos meg.*
ID10: *Ja. Men det avhenger av behov. Hvor mye er det verdt å bli rehabilitert. Langt mer enn 3000.*

F.3 Other topics

When analyzing common themes in the interviews, a couple of themes unrelated to technology acceptance emerged. These themes with quotes are listed in the following subsections.

F.3.1 Exergames associated with children

ID06: *Jo, det var jo egentlig artig det. I hvert fall oldebarna ville syntes det var strålende med noe sånt.*
ID07: *Det kan jo godt hende at barnebarn synes det var fryktelig gøy i en periode.*
ID10: *Kanskje med barnebarn eller for å vise frem til nysgjerrige.*

F.3.2 Hard to imagine possibilities

ID06: *altså det er ikke veldig fysisk aktivt det her da i forhold til for eksempel et treningsprogram motte inneholde vil jeg tro. Bevege seg sidelengs og armer. [...] Ja... Hvorfor ikke. Dette burde jo være veldig bra for beinbevegelse i hvert fall. Kanskje litt ensidig frem og tilbake.*
ID07: *Jeg har aldri tatt den problemstillingen ordentlig inn over meg.*
ID08: *Nei det er jeg ikke så sikker på, for jeg tror, for jeg har et sånn, på grunn av den tilstanden jeg har, så har jeg et behov for et opplegg som skal ta vare på, hva skal jeg si, muskelgrupper og ting med kroppen som skal holdes vedlike og trenes opp. Og da er jo det lagt opp etter det, så å sløyfe noe sånt det tror jeg ikke. Det måtte bli i tillegg det da*
ID10: *Jeg kan ikke vurdere det abstrakt*

Appendix G

IKEA shopping list

Min huskeliste

Ta den med til varehuset

Prisene var gyldige på utskriftstidspunktet hos IKEA Leangen 2018-02-01 10:05 CET

Produkt	Antall	Sum inkl. mva.	Vekt	Detaljer Lagerplassering
FEJKA Kunstig potteplante, Bregne inne/ute inne/ute Bregne 69,- Blomsterpottens diameter: 10 cm Plantens høyde: 34 cm Artikkelnr.: 003.495.33	1	69,-	1x0.2kg	*Dette produktet er antageligvis tilgjengelig på ditt varehus : I dag 1 feb, fr 2 feb, lø 3 feb, sø 4 feb* FEJKA Kunstig potteplante Artikkelnr.: 003.495.33 *Finnes i Soverom avdelingen*
LEDARE LED-pære E14 400 lumen, dimbar, mignon klar 39,- Forhåndsinnstilt lysfluks: 400 lm Forhåndsinnstilt fargetemperatur: 2700 K Fluks: 400 lm Artikkelnr.: 703.587.03	1	39,-	1x0.1kg	*Dette produktet er antageligvis tilgjengelig på ditt varehus : I dag 1 feb, fr 2 feb, lø 3 feb, sø 4 feb* LEDARE LED-pære E14 400 lumen Artikkelnr.: 703.587.03 *Finnes i Belysning avdelingen*
MUSKOT Blomsterpotte, hvit 12,- Høyde: 11 cm Ytterdiameter: 12 cm Maks diameter blomsterpotte: 9 cm Artikkelnr.: 303.082.01	2	24,-	2x0.4kg	*Dette produktet er antageligvis tilgjengelig på ditt varehus : I dag 1 feb, fr 2 feb, lø 3 feb, sø 4 feb* MUSKOT Blomsterpotte Artikkelnr.: 303.082.01 *Finnes i Planter og dekor avdelingen*
FEJKA Kunstig potteplante, timian 39,- Blomsterpottens diameter: 9 cm Plantens høyde: 22 cm Artikkelnr.: 903.751.55	1	39,-	1x0.2kg	*Dette produktet er antageligvis tilgjengelig på ditt varehus : I dag 1 feb, fr 2 feb, lø 3 feb, sø 4 feb* FEJKA Kunstig potteplante Artikkelnr.: 903.751.55 *Finnes i møbelavdelingen*
 FEJKA Kunstig potteplante, Bambusgress 39,- Høyde: 28 cm Blomsterpottens diameter: 10 cm Artikkelnr.: 900.550.93	1	39,-	1x0.2kg	*Dette produktet er antageligvis tilgjengelig på ditt varehus : I dag 1 feb, fr 2 feb, lø 3 feb, sø 4 feb* FEJKA Kunstig potteplante Artikkelnr.: 900.550.93 *Finnes i Planter og dekor avdelingen*

IKEA Leangen

Adresse Landbruksvegen 2, 7048 Trondheim
Telefon 02340
Åpningstider Mandag-fredag: 10-22 Lørdag: 10-20 | Restauranten: 09.30-21.15 (19.15)

	BESTÅ TV-benk, hvitbeiset eikemønster IKEA FAMILY-pris 415,- Ordinær pris 595,- Bredde: 120 cm Dybde: 40 cm Høyde: 38 cm Artikkelnr.: 702.945.13	1	IKEA FAMILY-pris 415,- Ordinær pris 595,-	1x16.8kg	*Dette produktet er antageligvis tilgjengelig på ditt varehus : I dag 1 feb, fr 2 feb, lø 3 feb, sø 4 feb* BESTÅ TV-benk Artikkelnr.: 702.945.13	*Reol* 08	*Plass* 17
	BESTÅ Hylleplate, hvitbeiset eikemønster 60,- Bredde: 56 cm Dybde: 36 cm Maks belastning: 20 kg Artikkelnr.: 002.955.49	2	120,-	2x1.2kg	*Dette produktet er antageligvis tilgjengelig på ditt varehus : I dag 1 feb, fr 2 feb, lø 3 feb, sø 4 feb* BESTÅ Hylleplate Artikkelnr.: 002.955.49	*Reol* 10	*Plass* 17
	ÅRSTID Gulvlampe, forniklet, hvit 398,- Maks: 100 W Høyde: 155 cm Lampefotens diameter: 28 cm Artikkelnr.: 601.638.62	1	398,-	1x4.5kg	*Dette produktet er antageligvis tilgjengelig på ditt varehus : I dag 1 feb, fr 2 feb, lø 3 feb, sø 4 feb* ÅRSTID Gulvlampe Artikkelnr.: 601.638.62	*Finnes i Belysning avdelingen*	
	RYET LED-pære E27 400 lumen, globeformet opalhvit 9,- Fluks: 400 lm Styrke: 5 W Artikkelnr.: 103.712.03	1	9,-	1x0.1kg	*Dette produktet er antageligvis tilgjengelig på ditt varehus : I dag 1 feb, fr 2 feb, lø 3 feb, sø 4 feb* RYET LED-pære E27 400 lumen Artikkelnr.: 103.712.03	*Finnes i Belysning avdelingen*	
	LACK Bord, bjørkemønstret 369,- Lengde: 118 cm Bredde: 78 cm Høyde: 45 cm Artikkelnr.: 201.042.90	1	369,-	1x18.7kg	*Dette produktet er antageligvis tilgjengelig på ditt varehus : I dag 1 feb* LACK Bord Artikkelnr.: 201.042.90	*Ta kontakt med personalet for informasjon og kjøp*	
	JÄRA Lampeskjerm, grå 45,- Høyde: 19 cm Diameter: 25 cm Artikkelnr.: 703.283.58	1	45,-	1x0.2kg	*Dette produktet er antageligvis tilgjengelig på ditt varehus : I dag 1 feb, fr 2 feb, lø 3 feb, sø 4 feb* JÄRA Lampeskjerm Artikkelnr.: 703.283.58	*Finnes i Belysning avdelingen*	
	RODD Bordlampefot, forniklet 90,- Maks: 40 W Høyde: 35 cm Lampefotens diameter: 14 cm Artikkelnr.: 401.924.03	1	90,-	1x0.8kg	*Dette produktet er antageligvis tilgjengelig på ditt varehus : I dag 1 feb, fr 2 feb, lø 3 feb, sø 4 feb* RODD Bordlampefot Artikkelnr.: 401.924.03	*Finnes i Belysning avdelingen*	

GERSBY
Bokhylle, hvit

198,-

Bredde: 60 cm
Dybde: 24 cm
Høyde: 180 cm

Artikkelnr.: 702.611.31

1

198,-

1x19.8kg

Dette produktet er antageligvis tilgjengelig på ditt varehus : I dag 1 feb, fr 2 feb, lø 3 feb, sø 4 feb

GERSBY
Bokhylle
Artikkelnr.: 702.611.31

Reol	*Plass*
17	23

BESTÅ
Støtteben, grå

70,-

Høyde: 10 cm
Min. høyde: 10 cm
Maks høyde: 11 cm

Artikkelnr.: 502.936.04

2

140,-

2x0.2kg

Dette produktet er antageligvis tilgjengelig på ditt varehus : I dag 1 feb, fr 2 feb, lø 3 feb, sø 4 feb

BESTÅ
Støtteben
Artikkelnr.: 502.936.04

Reol	*Plass*
10	14

BESTÅ
Stamme, hvit

IKEA FAMILY-pris

350,-

Ordinær pris

500,-

Bredde: 120 cm
Dybde: 40 cm
Høyde: 64 cm

Artikkelnr.: 102.458.46

1

IKEA FAMILY-pris
350,-

Ordinær pris
500,-

1x18.5kg

Dette produktet er antageligvis tilgjengelig på ditt varehus : I dag 1 feb, fr 2 feb, lø 3 feb, sø 4 feb

BESTÅ
Stamme
Artikkelnr.: 102.458.46

Reol	*Plass*
08	03

BESTÅ
Hengsel, myktlukkende/trykk-åpne

100,-

Antall i pakken: 2 stk.

Artikkelnr.: 802.612.58

2

200,-

2x0.3kg

Dette produktet er antageligvis tilgjengelig på ditt varehus : I dag 1 feb, fr 2 feb, lø 3 feb, sø 4 feb

BESTÅ
Hengsel, myktlukkende/trykk-åpne
Artikkelnr.: 802.612.58

Reol	*Plass*
10	19

STUBBARP
Ben, hvit

50,-

Bredde: 44 mm
Dybde: 44 mm
Høyde: 100 mm

Artikkelnr.: 102.935.64

2

100,-

2x0.4kg

Dette produktet er antageligvis tilgjengelig på ditt varehus : I dag 1 feb, fr 2 feb, lø 3 feb, sø 4 feb

STUBBARP
Ben
Artikkelnr.: 102.935.64

Reol	*Plass*
08	19

LAPPVIKEN
Dør-/skuffefront, hvit

100,-

Bredde: 60 cm
Høyde: 38 cm

Artikkelnr.: 002.916.74

2

200,-

2x2.6kg

Dette produktet er antageligvis tilgjengelig på ditt varehus : I dag 1 feb, fr 2 feb, lø 3 feb, sø 4 feb

LAPPVIKEN
Dør-/skuffefront
Artikkelnr.: 002.916.74

Reol	*Plass*
10	09

BESTÅ
Hylleplate, hvit

60,-

Bredde: 56 cm
Dybde: 36 cm
Maks belastning: 20 kg

Artikkelnr.: 002.955.54

2

120,-

2x1.6kg

Dette produktet er antageligvis tilgjengelig på ditt varehus : I dag 1 feb, fr 2 feb, lø 3 feb, sø 4 feb

BESTÅ
Hylleplate
Artikkelnr.: 002.955.54

Reol	*Plass*
10	15

KIVIK
2-seters sofa, Orrsta lys grå

2.595,-

Bredde: 190 cm
Dybde: 95 cm
Høyde: 83 cm

Artikkelnr.: 490.114.17

2

5.190,-

Dette produktet består av flere deler. Alle deler er antageligvis tilgjengelig på ditt varehus : I dag 1 feb, fr 2 feb, lø 3 feb, sø 4 feb

2x63.8kg

2xKIVIK
2-seters sofastamme

Artikkelnr.: 201.801.18

Ta kontakt med personalet for informasjon og kjøp

2x5.0kg

2xKIVIK
trekk 2-seters sofa

Artikkelnr.: 502.786.65

Ta kontakt med personalet for informasjon og kjøp

6 pakke(r) totalt

Sum IKEA FAMILY-pris inkl. mva.	8.154,-	(6.523,- Sum IKEA FAMILY-pris ekskl. mva.)
Sum inkl. mva.	8.484,-	(6.787,- Sum ekskl. mva.)
Samlet vekt / totalt antall artikler:	231.4kg/30 pakker	

Bibliography

Abbate, S., Avvenuti, M., Bonatesta, F., Cola, G., Corsini, P., and Vecchio, A. (2012). A smartphone-based fall detection system. *Pervasive and Mobile Computing*, 8(6):883–899.

Agmon, M., Perry, C. K., Phelan, E., Demiris, G., and Nguyen, H. Q. (2011). A pilot study of wii fit exergames to improve balance in older adults. *Journal of geriatric physical therapy*, 34(4):161–167.

Alankus, G., Lazar, A., May, M., and Kelleher, C. (2010). Towards customizable games for stroke rehabilitation. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 2113–2122. ACM.

Atlassian Corporation Plc (2018). About trello. https://trello.com/about. [Retrieved 11-05-2018].

Billis, A., Kartsidis, P., Garyfallos, D.-K., Tsatali, M. S., Karagianni, M., and Bamidis, P. D. (2015). Ecologically valid trials of elderly unobtrusive monitoring: analysis and first results. In *AI-AM/NetMed@ AIME*, pages 32–41.

Blanchard, C. M., Stein, K. D., Baker, F., Dent, M. F., Denniston, M. M., Courneya, K. S., and Nehl, E. (2004). Association between current lifestyle behaviors and health-related quality of life in breast, colorectal, and prostate cancer survivors. *Psychology & Health*, 19(1):1–13.

Brox, E., Konstantinidis, S. T., and Evertsen, G. (2017). User-centered design of serious games for older adults following 3 years of experience with exergames for seniors: A study design. *JMIR serious games*, 5(1).

Burns, E. R., Stevens, J. A., and Lee, R. (2016). The direct costs of fatal and non-fatal falls among older adults—united states. *Journal of safety research*, 58:99–103.

Carter, S., Mankoff, J., Klemmer, S. R., and Matthews, T. (2008). Exiting the cleanroom: On ecological validity and ubiquitous computing. *Human–Computer Interaction*, 23(1):47–99.

Chen, J. (2007). Flow in games (and everything else). *Communications of the ACM*, 50(4):31–34.

Chodzko-Zajko, W. J., Proctor, D. N., Singh, M. A. F., Minson, C. T., Nigg, C. R., Salem, G. J., and Skinner, J. S. (2009). Exercise and physical activity for older adults. *Medicine & science in sports & exercise*, 41(7):1510–1530.

Clark, R. A., Bryant, A. L., Pua, Y., McCrory, P., Bennell, K., and Hunt, M. (2010). Validity and reliability of the nintendo wii balance board for assessment of standing balance. *Gait & posture*, 31(3):307–310.

Daatland, S. O. (1999). *Framtidens boformer for eldre: Perspektiver og eksempler fra de nordiske lande*. Nordic Council of Ministers.

Daly, J., Sindone, A. P., Thompson, D. R., Hancock, K., Chang, E., and Davidson, P. (2002). Barriers to participation in and adherence to cardiac rehabilitation programs: a critical literature review. *Progress in cardiovascular nursing*, 17(1):8–17.

Davis, F. D., Bagozzi, R. P., and Warshaw, P. R. (1989). User acceptance of computer technology: a comparison of two theoretical models. *Management science*, 35(8):982–1003.

Ejupi, A., Gschwind, Y. J., Valenzuela, T., Lord, S. R., and Delbaere, K. (2016). A kinect and inertial sensor-based system for the self-assessment of fall risk: A home-based study in older people. *Human–Computer Interaction*, 31(3-4):261–293.

Finco, M. D. and Maass, R. W. (2014). The history of exergames: promotion of exercise and active living through body interaction. In *Serious Games and Applications for Health (SeGAH), 2014 IEEE 3rd International Conference on*, pages 1–6. IEEE.

Flynn, S., Palma, P., and Bender, A. (2007). Feasibility of using the sony playstation 2 gaming platform for an individual poststroke: a case report. *Journal of neurologic physical therapy*, 31(4):180–189.

Gartenberg, C. (2018). Microsoft has discontinued the kinect adapter for newer xbox one consoles. https://www.theverge.com/circuitbreaker/2018/1/2/16842738/microsoft-kinect-adapter-xbox-one-x-s-discontinued. [Retrieved 07-05-2018].

Gell, N. M., Wallace, R. B., Lacroix, A. Z., Mroz, T. M., and Patel, K. V. (2015). Mobility device use in older adults and incidence of falls and worry about falling: Findings from the 2011–2012 national health and aging trends study. *Journal of the American Geriatrics Society*, 63(5):853–859.

Gelperin, D. and Hetzel, B. (1988). The growth of software testing. *Communications of the ACM*, 31(6):687–695.

Gerling, K. M., Schild, J., and Masuch, M. (2010). Exergame design for elderly users: the case study of silverbalance. In *Proceedings of the 7th International Conference on Advances in Computer Entertainment Technology*, pages 66–69. ACM.

He, X. Z. and Baker, D. W. (2004). Body mass index, physical activity, and the risk of decline in overall health and physical functioning in late middle age. *American Journal of Public Health*, 94(9):1567–1573.

Headley, J. A., Ownby, K. K., and John, L. D. (2004). The effect of seated exercise on fatigue and quality of life in women with advanced breast cancer. In *Oncology nursing forum*, volume 31.

Hershkovitz, A., Kalandariov, Z., Hermush, V., Weiss, R., and Brill, S. (2007). Factors affecting short-term rehabilitation outcomes of disabled elderly patients with proximal hip fracture. *Archives of physical medicine and rehabilitation*, 88(7):916–921.

Ijsselsteijn, W., Nap, H. H., de Kort, Y., and Poels, K. (2007). Digital game design for elderly users. In *Proceedings of the 2007 conference on Future Play*, pages 17–22. ACM.

ISO9241-11:1998(E) (1998). Ergonomic requirements for office work with visual display terminals (VDTs) — Part 11: Guidance on usability. Standard, International Organization for Standardization, Geneva, CH.

ISO9241-210:2010(E) (2010). Ergonomics of human-system interaction — Part 210: Human-centred design for interactive systems. Standard, International Organization for Standardization, Geneva, CH.

Jurkiewicz, M. T., Marzolini, S., and Oh, P. (2011). Adherence to a home-based exercise program for individuals after stroke. *Topics in stroke rehabilitation*, 18(3):277–284.

Kieffer, S., Sangiorgi, U. B., and Vanderdonckt, J. (2015). Ecoval: A framework for increasing the ecological validity in usability testing. In *System Sciences (HICSS), 2015 48th Hawaii International Conference on*, pages 452–461. IEEE.

Kjeldskov, J. and Skov, M. B. (2007). Studying usability in sitro: Simulating real world phenomena in controlled environments. *International Journal of Human-Computer Interaction*, 22(1-2):7–36.

Lester, J., Hartung, C., Pina, L., Libby, R., Borriello, G., and Duncan, G. (2009). Validated caloric expenditure estimation using a single body-worn sensor. In *Proceedings of the 11th international conference on Ubiquitous computing*, pages 225–234. ACM.

Lincoln, Y. S. and Guba, E. G. (1985). *Naturalistic inquiry*, volume 75. Sage.

Mankoff, K. D. and Russo, T. A. (2013). The kinect: A low-cost, high-resolution, short-range 3d camera. *Earth Surface Processes and Landforms*, 38(9):926–936.

Maroni, N. S. (2017). Physical rehabilitation and exergames. Personal interview.

Martin-Niedecken, A. L. and Götz, U. (2016). Design and evaluation of a dynamically adaptive fitness game environment for children and young adolescents. In *Proceedings of the 2016 Annual Symposium on Computer-Human Interaction in Play Companion Extended Abstracts*, pages 205–212. ACM.

Menna, F., Remondino, F., Battisti, R., and Nocerino, E. (2011). Geometric investigation of a gaming active device. In *Videometrics, Range Imaging, and Applications XI*, volume 8085, page 80850G. International Society for Optics and Photonics.

Microsoft (2018). Just dance 2018 for xbox one. https://www.microsoft.com/en-us/store/d/just-dance-2018-for-xbox-one/91rr6csg2xsn?activetab=pivot:reviewstab. [Retrieved 16-05-2018].

Myers, J., Kaykha, A., George, S., Abella, J., Zaheer, N., Lear, S., Yamazaki, T., and Froelicher, V. (2004). Fitness versus physical activity patterns in predicting mortality in men. *The American journal of medicine*, 117(12):912–918.

Nielsen, C. M., Overgaard, M., Pedersen, M. B., Stage, J., and Stenild, S. (2006). It's worth the hassle!: the added value of evaluating the usability of mobile systems in the field. In *Proceedings of the 4th Nordic conference on Human-computer interaction: changing roles*, pages 272–280. ACM.

Nielsen, J. (1993). Iterative user-interface design. *Computer*, 26(11):32–41.

Nintendo (2010). Wii: spillkonsollen som endret verdens syn på tv-spill. https://www.nintendo.no/support/146-om-wii. [Retrieved 07-05-2018].

Nyholt, I. K. (2007). Hjem kan ikke kjøpes. *Kvinners strategier og forståelser av hjeminnredning*.

Oates, B. J. (2006). *Researching Information Systems and Computing*. Sage Publications Ltd.

Oeppen, J. and Vaupel, J. W. (2002). Broken limits to life expectancy.

Ofli, F., Kurillo, G., Obdržálek, Š., Bajcsy, R., Jimison, H. B., and Pavel, M. (2016). Design and evaluation of an interactive exercise coaching system for older adults: lessons learned. *IEEE journal of biomedical and health informatics*, 20(1):201–212.

Pagliari, D. and Pinto, L. (2015). Calibration of kinect for xbox one and comparison between the two generations of microsoft sensors. *Sensors*, 15(11):27569–27589.

Pate, R. R., Pratt, M., Blair, S. N., Haskell, W. L., Macera, C. A., Bouchard, C., Buchner, D., Ettinger, W., Heath, G. W., King, A. C., et al. (1995). Physical activity and public health: a recommendation from the centers for disease control and prevention and the american college of sports medicine. *Jama*, 273(5):402–407.

Peel, N. M. (2011). Epidemiology of falls in older age. *Canadian Journal on Aging/La Revue canadienne du vieillissement*, 30(1):7–19.

Penedo, F. J. and Dahn, J. R. (2005). Exercise and well-being: a review of mental and physical health benefits associated with physical activity. *Current opinion in psychiatry*, 18(2):189–193.

Prudham, D. and Grimley Evans, J. (1981). Factors associated with falls in the elderly: A community study. *Age and ageing*, 10:141–6.

Rapp, K., Freiberger, E., Todd, C., Klenk, J., Becker, C., Denkinger, M., Scheidt-Nave, C., and Fuchs, J. (2014). Fall incidence in germany: results of two population-based studies, and comparison of retrospective and prospective falls data collection methods. *BMC Geriatrics*, 105(14).

Rozario, B. (2015). Is it safe for the elderly to live independently? http://www.3age.com.my/is-it-safe-for-the-elderly-to-live-independently/. [Retrieved 15-05-2018].

Sahel, J.-J. (2013). Convergence and the future of media: neutrality and 'digital fitness' the best way to promote content creation and dissemination and protect fundamental values. https://blogs.microsoft.com/eupolicy/2013/09/16/convergence-and-the-future-of-media-neutrality-and-digital-fitness-the-best-way-to-promote-content-creation-and-dissemination-and-protect-fundamental-values/. [Retrieved 15-05-2018].

Schmuckler, M. A. (2001). What is ecological validity? a dimensional analysis. *Infancy*, 2(4):419–436.

Shackel, B. (1991). Usability-context, framework, definition, design and evaluation. *Human factors for informatics usability*, pages 21–37.

Sinclair, J., Hingston, P., and Masek, M. (2007). Considerations for the design of exergames. In *Proceedings of the 5th international conference on Computer graphics and interactive techniques in Australia and Southeast Asia*, pages 289–295. ACM.

Stellmann, J., Neuhaus, A., Götze, N., Briken, S., Lederer, C., Schimpl, M., Heesen, C., and Daumer, M. (2015). Ecological validity of walking capacity tests in multiple sclerosis. *PloS one*, 10(4):e0123822.

Svanæs, D., Alsos, O. A., and Dahl, Y. (2010). Usability testing of mobile ict for clinical settings: Methodological and practical challenges. *International journal of medical informatics*, 79(4):e24–e34.

Svanæs, D. (2018). Lecture notes on introduction to interaction design (ixd) and human-computer interaction (hci).

Tassey, G. (2002). The economic impacts of inadequate infrastructure for software testing. *National Institute of Standards and Technology, RTI Project*, 7007(011).

Tinetti, M. E., Speechley, M., and Ginter, S. F. (1988). Risk factors for falls among elderly persons living in the community. *New England journal of medicine*, 319(26):1701–1707.

Uzor, S. and Baillie, L. (2014). Investigating the long-term use of exergames in the home with elderly fallers. In *Proceedings of the 32nd annual ACM conference on Human factors in computing systems*, pages 2813–2822. ACM.

Van Diest, M., Lamoth, C. J., Stegenga, J., Verkerke, G. J., and Postema, K. (2013). Exergaming for balance training of elderly: state of the art and future developments. *Journal of neuroengineering and rehabilitation*, 10(1):101.

Venkatesh, V., Morris, M. G., Davis, G. B., and Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. *MIS quarterly*, pages 425–478.

Venkatesh, V., Thong, J. Y., and Xu, X. (2012). Consumer acceptance and use of information technology: extending the unified theory of acceptance and use of technology. *MIS quarterly*, pages 157–178.

World Health Organization et al. (2010). Global recommendations on physical activity for health.

Zacharias, N. T. (2011). *Qualitative research methods for second language education: A coursebook*. Cambridge Scholars Publishing.