DEGREE PROJECT IN MEDICAL ENGINEERING, SECOND CYCLE, 30 CREDITS

STOCKHOLM, SWEDEN 2018

Improving well-being with virtual reality for frail elderly people

- a mixed method approach letting them into the three-dimensional world

SAFIA TAHAR AISSA

KTH ROYAL INSTITUTE OF TECHNOLOGY

This master thesis project was a collaboration with the municipality of Södertälje, Kultur 365, and Stockholms läns landsting (Film Stockholm)

Improving well-being with virtual reality for frail elderly people

- a mixed method approach letting them into the three-dimensional world

Förbättring av välmående med virtuell verklighet för äldre personer

- En *mixed method approach* som låter dem komma in i den tre-dimensionella världen

SAFIA TAHAR AISSA

Degree Project in Technology and Health
Advanced level (second cycle), 30 credits
Supervisor at KTH: Prof. Britt Östlund
Examiner: Sebastiaan Meijer
TRITA- CBH-GRU-2018:108

Abstract

Introduction:

The Swedish population is ageing – resulting in an increase in the number of elderly people and higher socioeconomic demands that the society needs to support them with. In Sweden, frail elderly people with for example mobility and cognitive problems, have the opportunity to attend a day care center where they can join activities and to socialize.

Purpose:

The purpose of this thesis was to investigate to what extent virtual reality technology could contribute to improved well-being for frail elderly at day care centers.

Method:

This study was conducted via a mixed method consisting of a survey and a semi-structured interview. 19 participants (15 male and 4 female) from three day care centers in Södertälje participated in this study.

Results:

By allowing frail elderly at day care centers to experience virtual reality, quantitative and qualitative data was collected. Both indicating that the experience of using virtual reality was positive and comfortable. 7 themes were identified through a thematic analysis demonstrating what was repeatedly mentioned by the participants. The themes were: (1) immersion & interaction, (2) usage, (3) nature movies, (4) visit places, (5) talking about things that are dear to them, (6) being limited and (7) thinking that VR could affect well-being.

Conclusion:

This study showed that the subjective well-being of frail elderly was arguably partially improved with virtual reality. The participants were overall positive, enjoyed the experience with a sense of immersion and awakening memories.

Sammanfattning

Introduktion:

Den svenska populationen åldras - vilket resulterar i en ökning av äldre personer och högre socioekonomiska krav som samhället måste stödja dem med. I Sverige har äldre personer med till exempel rörlighet och kognitiva problem möjlighet att delta i dagverksamheter där de kan delta i aktiviteter och umgås.

Syfte:

Syftet med detta examensarbete var att undersöka i vilken utsträckning virtuell verklighet skulle kunna bidra till förbättrad välmående hos äldre på dagverksamheter.

Metod:

Detta projekt var genomfört med hjälp av en *mixed method* så som en enkät och en semi-strukturerad intervju. 19 äldre person (15 män och 4 kvinnor) från tre dagverksamheter i Södertälje deltog i denna studie.

Resultat:

Genom att låta äldre personer vid dagverksamheterna uppleva virtuell verklighet, så samlades det in kvantitativ och kvalitativ data. Där båda indikerar att det, till exempel, var en positiv och bekväm erfarenhet. 7 teman identifierades genom en tematisk analys som illustrerade vad som ofta upprepades av deltagarna. Teman var: (1) immission & interaktion, (2) användning (3) naturfilmer, (4) besöka platser, (5) pratar om saker som ligger dem kärt om hjärtat, (6) att vara begränsad och (7) tror att VR kan påverka välmående.

Slutsats:

Denna studie visade att det subjektiva välmåendet hos äldre delvist var förbättrad med virtuell verklighet. Deltagarna var generellt positiva, njöt av upplevelsen av immersion samt minnen som väcktes.

Acknowledgements

First of all, I would like to express my very great appreciation to my supervisor Prof. Britt Östlund for her endless help and support during this master thesis. Her ambition, knowledge and enthusiasm has been a great inspiration to me.

I would like to thank Lars Ahlin and Joel Holm from the municipality of Södertälje for their commitment and excitement for this project, as well as their support and guidance. I would also like to thank all the staff and participants from the day care centers Tallhöjden, Artursberg and Heijkensköldska in Södertälje. You made this thesis possible.

I would also like to thank Maria Olsson from the municipality of Hässleholm for sharing her experience with virtual reality at day care centers.

I would also like to acknowledge the help provided by Peta Sjölander, Maksims Kornevs and Sebastiaan Meijer for supporting and guiding me in the process of writing this master thesis.

Last but not least, I want to give my gratitude to my family who have supported and encouraged me during my time at KTH. A huge thanks to my brother Jamel for proof-reading my thesis.

Safia Tahar Aissa
May, 2018

Table of contents

1. Introduction

The Swedish population is growing as a consequence of an increased life expectancy, low infant mortality and high immigration [1]. According to Swedish Statistics [2], it is estimated that the population will increase between 2015 and 2025, with a prognosis of a 9,9 % and 36,6 % increase in the age groups 65-79 and 80+ respectively. In the United Kingdom, it is also estimated to be an increase from 17,8 percent to 20,2 percent in the age group 65+ between 2015 and 2025 [3]. Overall a growing and aging population is expected worldwide [1], [4].

In Sweden, there are day care centers that offer a variety of activities for frail elderly people where they can socialise with each other. The municipality grants daily activities for frail elderly people based on aid decisions (biståndsbeslut) if they have some sort of health problems. Additionally, Kultur 365 is an occupation in the municipality of Södertälje which offers a variety of activities for frail elderly [5]. They also have a project named PlaymÄkers, established in 2007, where youths visit care homes, day care centers and meeting places in Södertälje. The purpose of PlaymÄkers is to create meetings between the different age generations by using technology and culture to activate senses and awaken memories. One of those technologies that have been used is virtual reality. Overall, Kultur 365 and PlaymÄkers offer great opportunities for frail elderly people to participate and experience a variation of activities that they perhaps would not have done otherwise.

Well-being is a term that is common in research, especially related to old people [6-8]. Subjective well-being is associated with an individual's subjective experience with for example how happy or sad one is and thoughts related to life satisfaction. Well-being is also related to health, and according to the World Health organization, health is defined as: "*Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity*" [9]. Many elderly people live good healthy lives, but a significant portion are troubled by different kinds of ill health and overall decline making them frail and vulnerable. Frailty leads to limitations, such as mobility and cognition [10]. Well-being also appears differently in various parts of the world especially when it comes to the general older generation [11].

Virtual reality (VR) is a virtual environment generated by a computer allowing the user to immerse themselves in a three-dimensional virtual world. The sense of immersion is achieved as the user places a device in front of the eyes and activates multiple senses, such as vision, hearing and touch [12]. Virtual reality has been existing for many decades but has just recently become available for anyone to buy. This type of technological device can be used in various fields, such as entertainment, gaming industry and medicine.

1.1. Purpose

Kultur 365 in collaboration with Film Stockholm funded by Stockholm County Council, have with the project PlaymÄkers tried virtual reality amongst frail elderly at their day care centers. Their preliminary observation was that the participants appreciated and enjoyed the experience, and it was felt that the benefits and comments amongst users using the technology needed to be investigated further leading to the creation of this project. This has also been tried elsewhere, such as in the municipality of Hässleholm where the same observation was made [13-15].

The purpose of this thesis is to investigate to what extent virtual reality technology can contribute to improved well-being for frail elderly at day care centers. In this thesis, elderly people with some sort of frailty will be referred to as frail elderly and virtual reality is signifying the use of VR goggles.

1.2. Research questions:

The following research questions were developed for this project:

- **To what extent are VR goggles usable for frail elderly people to use i.e. comfortable to use?**
- **To what extent do their use of VR goggles with two short movies contribute to well-being?**

1.3. Selection criteria

The thesis had a time limit of 20 weeks and, therefore, the following limitations were made:

- Frail elderly people from day care centers in the municipality of Södertälje (Tallhöjden, Artursberg and Heijensköldska)
- Participants had not used virtual reality before
- Two short movies were shown (Skansen and Torekällberget)
- Only subjective well-being was considered

1.4. Structure of degree project thesis

The thesis is structured in a logical order beginning with an introduction and finished with a discussion and conclusion. The first chapter is an introduction of the topics and includes the purpose and limitations of this thesis. The second chapter is the literature study which will provide the reader with in-depth knowledge in the various topics. The third chapter is the methodology which explains in details how this study was conducted. The forth chapter is the results which consist of both qualitative and quantitative data. The final chapters are the discussion and conclusion which contains the analysis and discussion of the results as well as a conclusion. There are two additional sections at the end of this thesis- the references and appendices.

2. Literature study

2.1. Population

In Sweden and many other countries world-wide (see Figure 1), the population in the older age group is growing and consequently the population is getting older [1], [4], [16]. In 2004, Sweden had a population that was oldest after Italy, Greece and Japan [17, 18]. One of the contributing factors to this growing population is the increased life expectancy [1]. Interestingly, it is estimated that in year 2045 Sweden will have more than one million elderly people that are 80 years and older compared to 499 000 in 2014 [19]. Within the older population there are groups of frail elderly people such as those diagnosed with dementia disease and stroke. Hence, our growing and aging population needs to be taken care of to maintain a good quality of life in the older years of life.

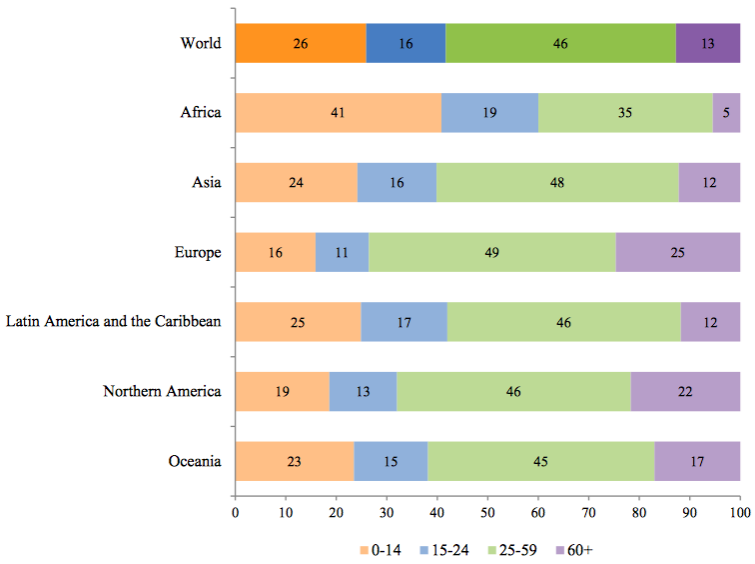

Figure 1. Population distribution in different parts of the world with notable differences in the proportion of different age groups (illustrated in percent) [1]. Europe has the largest percentage (25%) of its population being in the 60 years and over age category.

2.1.1. Frail elderly people

Not all elderly people are in good optimal health, many suffer from limitations in their physical, cognitive and emotional health. With limitations such as immobility, balance problems, reduced muscle strength and activity and a declining cognitive state, they can be referred to as frail [10]. Frailty poses significant risks to these individuals making them vulnerable [20]. The combination of an increasing number of elderly and especially frail

elderly makes development of the care for these important from both the individuals, families, and society's point of view. Optimising the health and care of this group is of socioeconomic interest [21].

In the last decades, the number of people suffering from dementia has increased and in 2012 around 160 000 people were diagnosed with dementia in Sweden [22]. In 2017, World Health Organization, WHO, described dementia as following: "*dementia is a syndrome in which there is deterioration in memory, thinking, behavior and the ability to perform everyday activities*" [23]. Further, there are various types of dementia and where Alzheimer's is the most common type with approximately 60-70% of cases. Common symptoms are forgetfulness, behavior changes and difficulties communicating [23]. This affects both the person in question, their families, and society as a whole.

Another big group of frail elderly are those affected by stroke, which is brain damage caused by blood clots or bleedings. Several of the symptoms are numbness in the face, legs and arms, severe headache and difficulties smiling and talking. Common damages after suffering from a stroke could be paralysis and sensory deficits on one side of the body and difficulties talking and expressing oneself [24].

2.2. Day care centers

In Sweden, there is a selection of day care centers in each municipalities. A day care center is a place that frail elderly people can attend during the day and where various staff-lead activities are held in some cases tailored to the individual's need [16]. The Health and Medical Service Act (Hälso- och sjukvårdslagen) states that all individuals should have equal access to the appropriate care [25] and where the Municipal health and medical care offers care for patients such as special housing and daily activities [26]. Additionally, there are for instance day care centers for people suffering from dementia where they have activities such as music and song, and where other day care centers focus on rehabilitation for people who have for example suffered from stroke [25]. Certainly, this is a great opportunity for frail elderly people to have activities during the day and to meet other people to socialise.

2.3. Well-being

In the recent decades, well-being has become a popular research topics, as well as topics related to quality of life and happiness [6]. There are various types of well-beings such as mental, psychological- and subjective well-being. However, only subjective well-being is considered in this thesis as the other types of well-beings are not in the scope of this project. Since life expectancy is increasing, there is an interest and importance that an individual's well-being is maintained as one ages, especially as there is an increased risk for chronic illnesses at older age [27].

2.3.1. Subjective well-being

Subjective well-being, SWB, originates from one of the classical philosophical traditions known as the hedonistic tradition- based on the philosophy of philosophers such as Epicurus [6]. The hedonistic tradition is based on that our desire is to maximise our pleasure and to minimise our pain. SWB consists of three variables: life satisfaction and positive- and negative experiences related to emotions [28, 29]. The meaning/ purpose of life is another potential variable that may relate to SWB, but mainly to psychological well-being [27], [30]. Essentially, SWB is related to that individuals, on their own, are in the best position to assess their own life.

Further, L. Siedlecki et al [28], conducted a study where they wanted to investigate whether there was a relationship between SWB and social support across age. This was conducted with over 1000 adults between the ages 18 to 95 and where they got to answer questionnaires. They found that perceived support, satisfaction of exchanged- and expected support, was a predictor for negative effect and satisfaction of life, and that family embeddedness, frequency of contact with family, was related to positive effect. Additionally, Ann Bowling [31] conducted a national survey in Britain regarding if older and younger people differ regarding their well-being. It was found that people over the age 65 defined well-being as them still being able to do activities they used to do and this was less likely defined by younger people. In general, doing research in SWB could help to find vulnerable age groups that may suffer from poor health [11]. Hence, there is an interest in investigating SWB [6].

Furthermore, there are large scaled surveys that have been conducted to assess well-being. An example is the immensely large dataset with surveys on well-being known as The Gallup-Sharecare Wellbeing Index- previously known as The Gallup-Healthways Wellbeing Index Poll. It consists of over 2.5 million surveys and conducts 500 interviews daily with US adults [32]. According to figure 2 [27], the life satisfaction varies depending on age as well as region. This was assessed with the Cantril ladder with a scale from 1 (worst possible life) to 10 (best possible life)- see section 2.3.2 regarding the Cantril ladder. On the upper left graph, High-income English-speaking countries has a U-shaped pattern with the dip at the ages mid 50's. However, this pattern is not observed on the remaining three graphs. The sub-Saharan graph shows a relatively low score across the age groups and the upper and lower graphs, to the right, show how the score drops at advanced age.

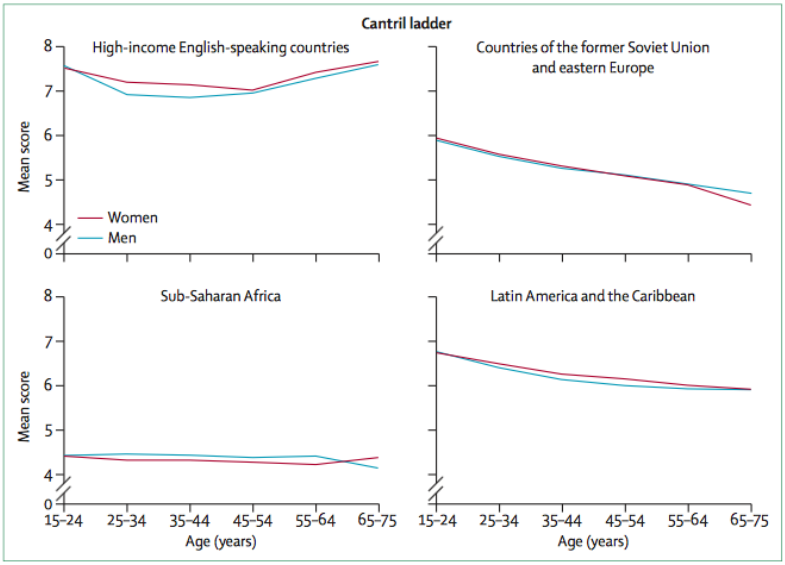

Figure 2. The following figure illustrates four graphs from different regions in the world related to satisfaction of life measured with Cantril ladder, as well as a relation between male and female [27].

2.3.2. Measure subjective well-being

To measure SWB there are various types of measures available. Larsen et al. [33] mentioned in their article numerous different SWB measures that are mainly from the 1960's and 1970's. One of the measures is the Cantril Self-Anchoring Striving Scale, also known as Cantril Ladder [27], [34] which can be used to measure life evaluation. This measure can be seen as a ladder with sometimes a 9-11-step ladder where one of the ends is labelled *worst possible life* and the other end *best possible life*. The participants will be asked to place themselves on the ladder to a variety of questions, such as " where on the ladder do you stand

at the present time?" or "All things considered, how satisfied are you with your life as a whole these days?". Additionally, more examples of measures and typical questions that are used for SWB can be found in a book published by Organisation for Economic Co-operation and Development, OECD, called *OECD Guidelines on Measuring Subjective Well-being* [34]. In the chapter *Annex A*, there are several examples of SWB measures, such as the Cantril ladder and Scale of Positive and Negative Experience, SPANE. There is, as well, thorough guidance on how to proceed to measure SWB. Overall, there are several measures that can be used and where each one of them measures a specific variable related to SWB.

There are two types of designs mentioned in various literature that can be used when measuring SWB [35]. The first one is Ecological Momentary Assessment, EMA, and the second is Day Reconstruction Method, DRM. EMA is used when participants are asked to provide information from specific intervals and events regarding factors such as activities and mood. In DRM, a survey is used where participants are asked about events throughout their entire day, such as activities and location, and their mood during the events. A difference between EMA and DRM is that EMA only covers some events during the day and whereas DRM covers moments during the entire day. Nevertheless, these two designs can be used, when possible, to measure SWB.

There are cases when measuring SWB, as a global measure, can be a challenge. The main two cases are [6]: the participant's current mood and the participant's cognitive function. The participants current mood could have a great impact when responding to a survey related to SWB. It could impact in the sense that it would change how the person assesses their SWB depending on whether they are happy or sad at that particular moment. For example, being immensely happy could cause a person to assess his or her SWB as perfect and whereas being sad and depressed could cause the person to assess his or her SWB as very bad. Further, a person's cognitive function could as well affect the way the participant responds and assess their SWB. For example it could be the case that the participant suffers from some kind of memory failure which then could affect the measure. Overall, these two factors should be considered when measuring SWB as they can affect the end result and thus be a challenge.

2.4. Virtual reality

2.4.1. What is Virtual Reality?

Virtual reality, VR, is a three- dimensional, 3D, computer generated virtual world that allows a user to experience immersion in a virtual environment [36, 37]. The sensation of immersion enables the user to feel present in the virtual environment [38, 39] - a sense of being there. It is, therefore, an important feature when it comes to the experience and sense of presence in the virtual world. Further, VR can be non-immersive, semi-immersive and fully immersive [36], [40] and where various types of VR devices can be used to experience this- see table 1. Two examples of different VR technologies are the Cave automatic virtual environment, CAVE, and Head-mounted device, HMD [40].

	NON-IMMERSIVE	**SEMI-IMMERSIVE**	**FULLY IMMERSIVE**
VIEWING MEDIUMS	Computer monitor, TV screen	Panoramic TV	HMD, CAVE
COST	Low	Medium	From low (HMD) to high (CAVE)
SENSE OF IMMERSION	Low	Medium-high	High

Table 1. The following table illustrates three general categories of immersion and what types of viewing mediums, cost and what type of sense of immersion they have [36].

2.4.2. Head-mounted device

HMD is a head worn device that is placed in front of the eyes and that allows the user to watch whatever is shown from the device. There is usually a position-and rotation tracking system in the devices which enables the display to update the images according to the users' movements [41, 42]. As the device is placed in front of the eyes, all contact with the real surrounding is lost and is replaced with the computer-generated images [12]. This will trick the brain into believing that whatever is shown from the device is actually in the real surrounding. This enables immersion and the user feels present in the virtual world.

The first HMD, also known as the *Sword of Damocles*, is considered to be developed by Ivan Sutherland [43]. Nowadays, there are a variety of HMD devices on the market with different

price ranges and possibilities to feel immersion. Meaning that some are more simply constructed and others more complex. For example, there are HMD goggles that can be used with a joystick to interact with objects in the virtual world and whereas other HMD goggles use nothing apart from the googles themselves. Some examples of these developed HMD's are: Oculus Rift, HTC Vive, Sony PlayStation VR, Google Cardboard and Samsung Gear [43]. Overall, there is a wide range of HMD's that can be used to immerse into virtual worlds.

Figure 3. An example of a VR device- HMD Samsung Gear VR. Images taken from two different angles. Image printed with permission from Kultur 365.

2.4.3. Cave automatic virtual environment

CAVE is a VR technology that is shaped as a large cube where a user can stand inside and be surrounded with image-projected walls [12]. The user wears goggles that track the position and orientation of the head in order to update the images that are projected on the walls. A joystick or a wand can also be used to navigate in the virtual world. This enables the user to fell fully immersed inside the CAVE [41].

2.4.4. The experience with virtual reality

There are several elements that makes the VR experience, such as 1) virtual world, 2) immersion, 3) feedback, 4) interactivity [44] and 5) participants [45].

1) Virtual world is an imaginary and an unreal world/ space that can be experienced via the VR devices. However, such imaginary space can also exist without VR systems as it can be experiences through a play or imaginary thoughts [44].

2) Immersion can be experienced in different ways depending on the activity that a participant is performing. There is, for example, immersions such as mental- and physical immersion [45]. First, mental immersion can be experienced when someone is reading a novel which allows them to feels as if they are there in the scene. However, this type of media only allows one person at the time to immerse [44]. Second, physical immersion is, for instance, when pilots practice flying a plane in a flight simulator. The images in front of them gets updated with time and the pilots get the chance to practice and experience various virtual flight situations [45].

3) Sensory feedback is the feedback that the user receives when interacting with a VR system. The VR device usually consists of a sensor that can obtain information about the users movements and position.

4) Interactivity is an important element for the experience with VR. A VR system should be able to respond to what the user does, such as a movement with the head or moving a hand. It can also be moving in the virtual environment and picking up objects [44]. An example of a VR systems that can be used to interact with the virtual environment is CAVE [45].

5) Not everyone has tested VR, which means that some are new to the system and others not. Different VR systems are needed for beginners, compared to others that have used it and are experts in this field. Further, a minimum of one person (participant) should interact with the VR device [45].

2.4.5. Previous studies

Research related to VR is very broad and there are numerous articles. For example, there are articles related to how VR could be used to improve balance in elderly [46, 47] in medicine [48, 49], dementia [50, 51] and Alzheimer [52]. According to Motomatsu. H [49], VR technology could be used to help patients that experience pain and a reduction of medical intakes and, thus, improve the healthcare. W. de Vries et al. [46] conducted a test with 60 participants (30 young adults and 30 old adults) where they performed two skiing games, Wii ski and Kinski, where they were skiing down a slalom track. The study showed that the kinski game cause larger centre of mass, COM, displacements than the Wii ski game. Additionally,

Park et al. [47] conducted an experiment with 30 elderly participants where they were divided into two groups. One group tested a virtual reality game (Wii Fit) and the other group a ball exercise game. This study showed that the group that performed the virtual reality game had a difference in the before and after compared to the other group. Moreover, in a review conducted by K. Iglesia Molina et al. [53] they found that it is still questionable whether VR could improve physical function in older adults. Additionally, J. Miller et al [54] investigated, in a review, fourteen studies as their objective was " *to summarise evidence for the effectiveness and feasibility of VR/gaming system utilisation by older adults at home for enabling physical activity to improve impairments, activity limitations or participation*". They identified various things in the studies such as:

- Some of the studies did not mention what their sampling strategy was
- The description on feasibility and methodology had insufficient details
- One of the studies mentioned the cost of VR technology

In general, there is no doubts that VR is common in research and has a great potential in several fields.

Despite that there are several advantages with VR that has been shown through research, there are also some disadvantages with it. Some of the disadvantages that have been seen using VR in rehabilitation are the expensive VR tools [42] and the potential for dizziness and headache [55]. There is a variety of devices that could be bought for VR rehabilitation and the price varies. An example of an expensive system is the Cave, whereas a cheaper alternative is a Nintendo Wii.

3. Methodology

This thesis was initiated with a thorough literature search on the topics of virtual reality, well-being, old/ elderly/ frail elderly people. Articles on research methodology and data collection was also covered (see Figure 4). Majority of the selected articles are up-to-date and more recent than year 2000.

A mixed method was selected for this project where both quantitative and qualitative data were collected [56], this was done in the form of a survey and semi-structured interview. A mixed method could result in a more complete understanding of the topic, as one method could compensate for the others weakness. In this project a survey was used which consists of statements and both open-ended and closed-ended questions. Hence, a mixed method could improve the conclusion by using data both from qualitative and quantitative methods [57].

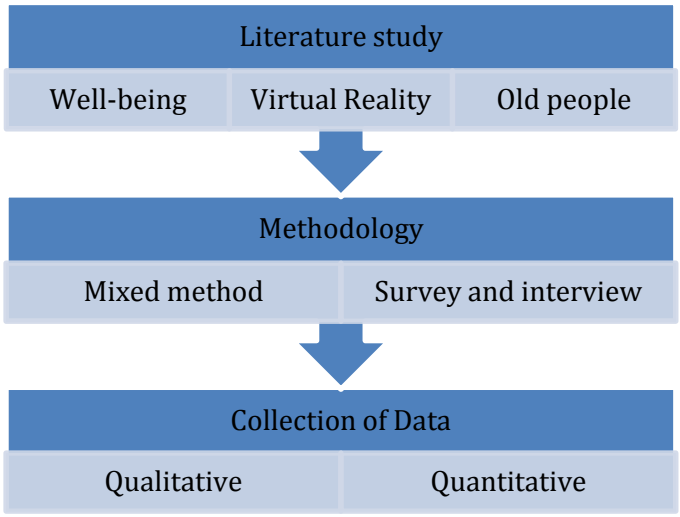

Figure 4. A flowchart of topics covered in the literature search for this thesis.

.

3.1. Initial survey

A preliminary survey was designed with numerous questions and statements that are common during SWB measure. This was tested on two male subjects at a day care center in Södertälje to detect misunderstandings and need for clarifications in the survey. Following this some questions/statements were felt to be too sensitive with regards to life satisfaction and values. Following discussion with the project supervisor, it was felt these could be excluded in the final survey.

3.2. Final survey

The survey (see Appendix A & B) consists of 22 questions and 7 statements, as well as several general questions related to for example gender and age. The survey begins with background questions, followed by two questions represented as a Cantril ladder. The scale is from 1 to 10 and where 1 represents *worst possible life* and 10 represents *best possible life*. On the second page, there are 2 questions and 7 statements with a 1-10 Likert scale. Finally on the last page, there are 10 open-ended questions.

3.3. Selection of participants

In this study, 19 frail elderly participants were selected from three day care centers in Södertälje (*Heijkensköldska, Tallhöjden* and *Artursberg).* There were 15 men and 4 women with an age range from 70-95 and with a median age of 79,6.

3.4. Selection of short movies

Kultur 365 provided four short movies filmed in Stockholm and Södertälje:

1) Skansen (monkeys) – 7 minutes
2) Torekällberget (goats, sheep and cows) – 5 minutes
3) The butterfly house (butterflies and fishes and sharks)
4) The butterfly house (fishes and sharks)

Two of these movies were selected (first and second) as these were felt to be more stimulating and therefore more likely for the subjects to interact with the events in the movies. The first movie (1), showed monkeys playing and interacting with each other. In the second movie (2), cows, sheep and goats were seen eating and interacting with the person filming.

3.5. Selection of VR-device

In this thesis, a HMD Samsung Gear VR (Oculus) with its respective mobile phone was used.

3.6. Conducting the interviews

Prior to starting the survey a short introduction on the project was given and consent was obtained to be part of the study. The interviews were documented as voice recordings. Help was offered in case the subject needed help with reading or writing their replies to the survey. The first page of the survey (see Appendix A-B) was then completed followed by showing the subject both movies through the VR goggles in the *180x180 hemispheres* setting. The rest of the survey was then completed (see Figure 5). After each survey, the recordings were stored anonymously on a computer and the survey sheets were collected.

Figure 5. A flowchart of the structure of the survey.

3.7. Analysis of the data

The interview voice recordings were translated into a text transcript to enable further analysis.

The quantitative data was analyzed using data from the closed-ended questions and statements and presented as graphs and statistics. The open-ended questions were qualitatively analyzed, identifying potential theme categories from the interview transcripts and where citations were used to illustrate what was mentioned. This type of method is known as thematic analysis and can be conducted as following [58]:

(1) *Get to know the data* – The method initiates with that the reader should read the data repeatedly to become familiar with its contents. The data in this case is referred to the text transcripts from the recorded interviews.

(2) *Coding* – The data is organized into smaller sections using coding. This reduces the amount of data as well as organizing it, transcript by transcript. The reader can add codes at the side of the transcripts.

(3) *Themes* –The codes are evaluated and examined to determine the themes that can be created. These themes signify patterns of something interesting from the entire data.

(4) *Go through the themes* – All themes that are identified in step 3 are now reviewed and modified. There may be themes that are similar and can be combined to form one theme, some themes may not make sense, and new themes can be identified.

(4) *Define the themes* – The themes are checked a last time to identify what they are about as well as the meaning of them.
(5) *Begin with the writing* – The last step is to start writing the report using the results from the thematic analysis. The themes are stated and explained with enough data. Common quotes from the transcripts can be used as support and evidence.

3.8. Ethical Considerations

Prior to the interviews, day care center staff were asked to give the potential participants at their center an information letter and a consent form- see appendix C & D. Before each interview, the author repeated what was written in the consent letter regarding who she was, where she studied, the purpose and steps of the study. All interviews and data would be stored and analyzed anonymously. Participants were also informed they participation was voluntary and that they could stop taking part in the study at any time.

Prior to the interviews:
On the consent letter, it was stated that the participants were supposed to watch four movies. However, this was changed to two movies after that the letters had been distributed to the day care centers. And as some of the participants had already signed the consent letter, it was kept as it was and instead the author informed them about the change. No one complained.

4. Results

A total of 19 participants (see Table 2) from three day care centers were enrolled in the study. Five participants did not conduct the entire, but varying amounts of the survey, which resulted in an internal loss. One participant watched one rather than two movies. Two participants were not native Swedish (one requiring an interpreter). Two participants had some kind of difficulty expressing themselves during the open-ended questions. Saturation was achieved around the 12th interview.

Characteristics of participants	
Background variables	**No of participants**
Gender (n = 19)	
Male	15
Female	4
Age (n = 19)	
70-75	4
76-80	8
81-85	5
86-90	1
91-95	1
Living arrangement (n = 19)	
Alone	10
With someone	9
If anyone in their social circle is IT/ technical knowledgeable (n = 19)	
Yes	10
No	7
Yes & No	2
Number of children (n = 19)	
0	4
1 – 2	10
3 – 4	4
5	1
Wears glasses? (n= 19)	
Yes	15
No	3
Other: occasionally	1
Have heard of VR? (n = 19)	
Yes	10
No	9

Table 2. The following table illustrates the characteristics of the participants from this study. Background information regarding for example gender, age and living arrangements are mentioned. A total of 79% men and 21% women participated and none of them had previously tried VR goggles.

How do you think it will be to be part of	**Are there any activities you used to do**

this study? What are you expecting?	before that you no longer can participate in? Such as?
“ I do not know” *“ I do not expect anything”* *“ That it will be interesting”*	*“ Nothing”* *“ Taking long walks”* *“ Various sports”*

Table 3. Several examples of answers from the following questions.

Additional comments:

It was observed during the interviews that there was a variation in levels of stimulus and interaction among the participants while watching the movies (such as laughing, talking, and grabbing out towards objects in the movies).

4.1. Quantitative Data

Below, the quantitative data from the survey is presented along with several citations expressed by the subjects while replying.

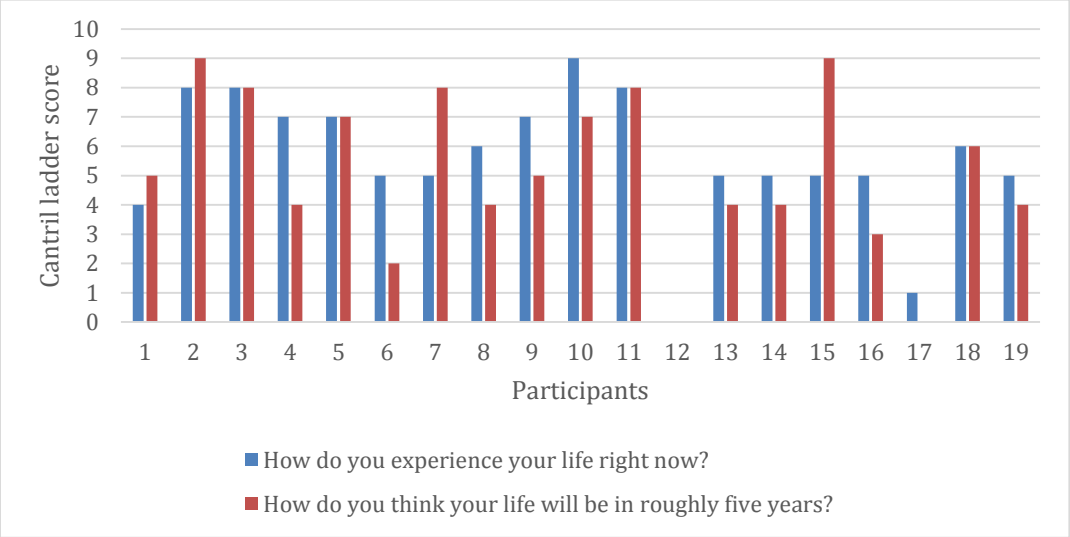

Figure 6. The blue colour represents the replies by the participants regarding their current life satisfaction with the majority scoring five and above. The red colour represents the replies by participants regarding their expectations on life in five years; where 47 % (n=9) think that their life will be worse than what it is today, 21 % (n=4) that it will be the same and 21 % (n=4) that it will improve. Scores are given along the Cantril ladder where 1 is worse and 10 is the best possible life.

“ That is very bad. I have been diagnosed with cancer”.

“ …One should be optimistic”.

” That was difficult. Well, I am not getting better…”.

The following results were obtained after the experience with experience of VR.

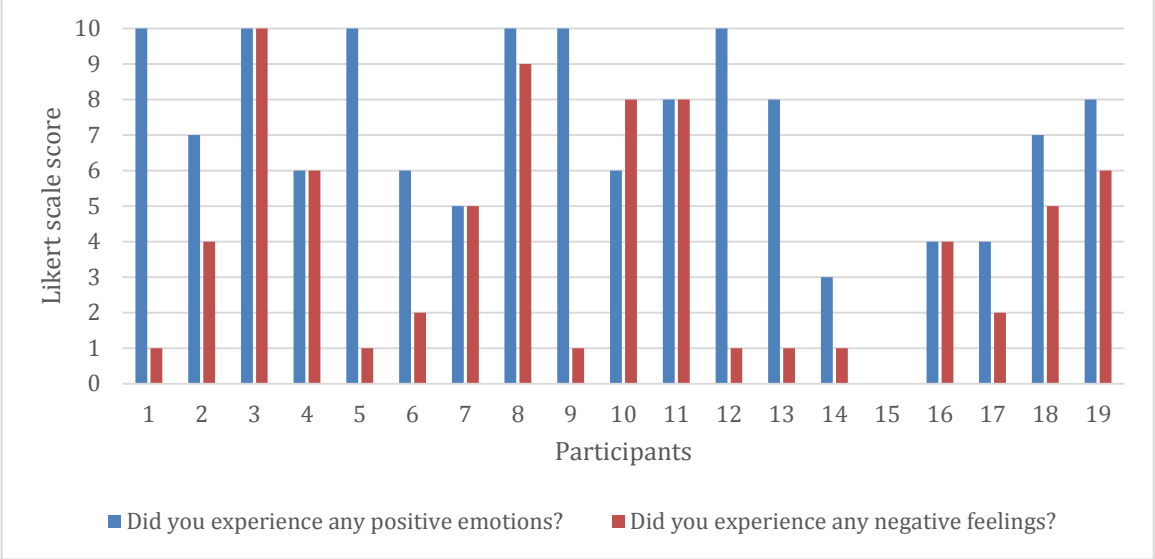

Figure 7. Replies to the subjects emotions directly following the VR experience. 74 % (n=14) experienced some kind of positive emotions (score>=6). 32 % (n=6) experienced some kind of negative experience (score>=6). One participant did not answer the two questions. Scores represented as Likert scale where 1 is absolutely disagree and 10 is absolutely agree.

"... It was probability very good this, you know. I was so glad there were no spiders".

"No, nothing negative".

Subjects replied the following to the below questions:

- What positive feelings did you experience?

  7 participants felt interested, 6 felt inspired, 3 felt calm, 1 felt excited, 1 felt and 1 felt nothing. Where other signified that they did not feel any positive feelings. Example of citation: *"Inspired, it was something new"* and *"Calm to see the animals. And to know that they did not eat me up".*

- What negative feelings did you experience?

  10 participants selected other, 3 felt stressed, 2 felt tired, 1 felt worried, 1 felt upset and 1 felt angry. Where other signified that they did not feel any negative feelings. Example of citation: *"No, negative feelings"* and *"It is enough with worried. But I now know that the animals do not come in here".*

Subjects replied the following to the below statements:

- The movie brought memories to me

  63 % felt that memories were awoken by the movies. One person did not answer the following statement. Example of citation: *"Yes, it did absolutely… It awoke memories"* and *"Well, I do not know".*

- It was comfortable to use (VR) goggles

  79 % felt that the VR goggles were comfortable. Two participants did not answer the following statement. Example of citation: *"Yes, it was".*

- I want to visit places I have not seen for several years using the (VR) goggles.

68 % felt that they wanted to visit places, that they have not seen for a long time, by using VR goggles. Two participants did not answer the statement. Example of citation: *"Yes, that would be interesting"*.

- I think that my friends at the day care center would feel the same as me

  37 % think that their friends at the day care center will feel the same as them. Three participants did not answer the statement. Example of citation: *"Yes, I think so. Because the age is 70 and up"* and *"I do not know. I do not know them so well".*

- The experience was as I expected

  74 % felt that the experience was as they expected. Two participants did not answer the statement. Example of citation: *"... I expected more"* and *"Yes, it was as I expected"*

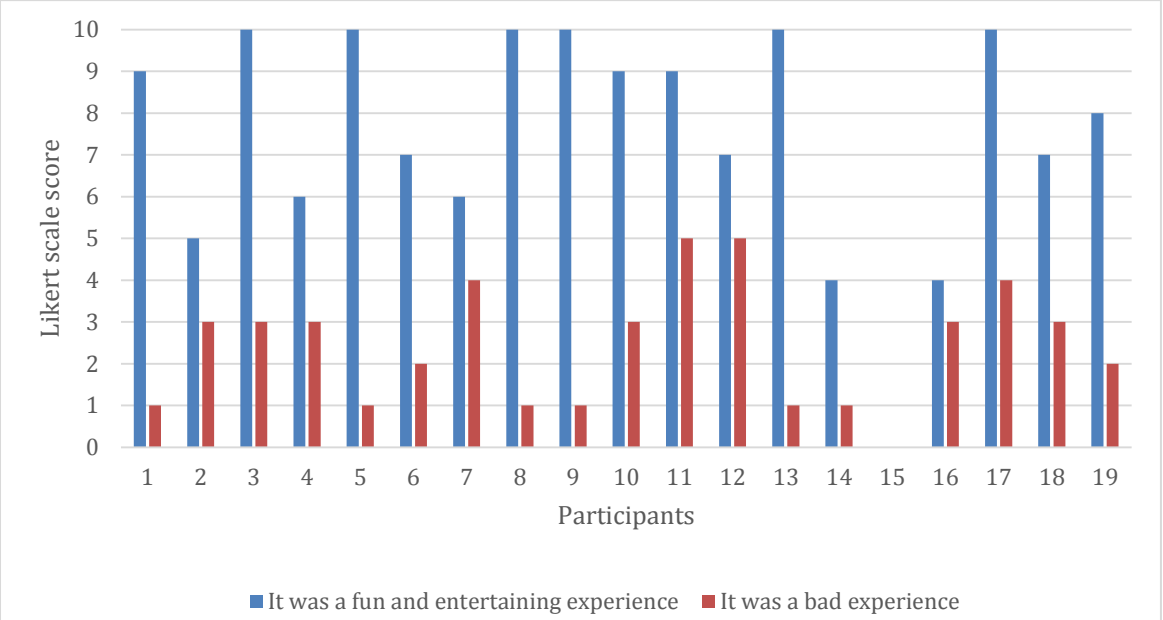

Figure 8. The blue color represents replies by the subjects regarding if they felt that the experience was fun and entertaining. 79 % (n=15) felt that the experience was fun and entertaining (score>=6). The red color represents replies by the subjects regarding if they felt that it was a bad experience. 95 % (n=18) experienced that the experience was not bad (score<6). One participant did not answer both statement. Scores represented as Likert scale where 1 is absolutely disagree and 10 is absolutely agree.

4.2. Qualitative Data

The following themes were obtained from the open-ended questions:

Theme 1: Immersion & Interaction
Several participants mentioned the feeling of being present in the movies, as well as making various attempts to interact with the animals such as patting them. Observing the participants:

" Can they bite me if I want to pat them?... Now I do not know where I have my fingers. Where do I have them? …. This was really fun. But I cannot really find out when I am going to pat them. Are we not supposed to?".

"This gives you more of an impression of that you are present…".

"…. You think you are sitting there…at Skansen…".

" It feels as if I would want to touch them (laughter)…. One would almost want to stretch out the hand and pat".

Theme 2: Usage
Several participants experienced an issue with the adjustment of the sharpness of the image.

"It is a bit blurry".

"… There was probably a bit of handling error…".

" Yes, I think it is okay. But now it is blurry…. It is better with glasses on….".

Theme 3: Nature movies
Numerous participants mentioned that they were interested in watching nature movies with the VR goggles.

"Yes, it is nature movies in that case".

" Animals".

" Yes, nature movies".

" Yes, it would be with animals or so".

Theme 4: Visit places
Some of the participants mentioned various places they would want to visit using the VR goggles.

"… We could go to Norway. I have been there a couple of times…".

" The Naturhistoriska riksmuseet would actually be fun to see. Because it was a long time ago…. I would love to dive and see exotic fish species".

Theme 5: Talking about things that are dear to them
Several participants enjoyed talking about various things such as their family, trips, hobbies and their previous job. It was very noticeable during the interviews that they were keen on speak about these subjects.

" Everything (previous hobbies) is associated with a kind of sorrow since I can no longer continue with it….".

"… it is nice to have contact. And then one can send video messages between as well…".

"I have travelled a lot with the job… my wife and I have done a lot of summer trips…".

" Yes, it actually brought up memories when I was there with my children and grandchildren….".

Theme 6: Being limited
Several participants mentioned that they were limited from doing things that they used to.

"I do not do that anymore (going to the cinema) because I use a walker and it is tough to walk as well".

" …. I do not get out as much…"

" It makes one to be very limited (having a walker)".

Theme 7: Thinking that VR could affect well-being
Numerous participants felt that VR could be able to affect their well-being in the long term.

"Well, it would be very relaxing and fun"

"I might think that it would be nice…. One can watch something different than just the apartment"

"That it can affect it well"

4.3. Patterns

Patterns were observed from the qualitative and quantitative data, such as:

- All four female participants selected scores indicating an overall positive experience with the use of the VR goggles. Their age range was 75-89 years old.

- Participants, that live alone, initially selected a high score on the first Cantril ladder question “How do you experience your life right now?” and then selected a lower score on the second Cantril ladder question “How do you think your life will be in roughly five years?”.

- The participants that had some kind of vision impairment experienced and commented much more regarding the blurriness compared to the remaining participants. Participants typically informed the interviewer regarding their visual impairments prior to using the VR goggles.

- The majority of the participants preferred to watch programs regarding nature and animals. This was independent on their gender.

5. Discussion

The world's population is ageing and the proportion of elderly in society living with complex health and social needs puts socioeconomic burden on the society. Technology is advancing and its use in day-to-day life and in medicine is increasing. The purpose of this study was to investigate to what extent VR technology could contribute to improved well-being for frail elderly at day care centers in Södertälje. Improving the well-being of this growing group of frail and elderly should be prioritized as this category of people are often forgotten about by society as a whole but deserve to live as a fruitful and vital life for as long as possible.

The results of this study indicate an overall positive and unexpected experience with the film clips shown via the VR goggles. The experience was for many positively surprising as they expressed they did not expect to be that immersed into the experience of the movies and seems to bring back memories. Participants reported the experience as fun, entertaining, and interesting. Similar previous studies have had similar positive reactions to the use of VR, previous studies mainly looked at the use of VR in people with dementia with regards to improving mobility and balance [46, 47], [59], navigation [60] and detecting potential disease progression [61]. Interestingly, no studies looking at SWB have been identified in the literature search.

The goggles were perceived as comfortable to use. The majority did not feel any negative emotions, but some perceived the movies as too close and too real. As discussed in Section 2.3.1, subjective well-being has multiple contributing factors, such as life satisfaction, positive- and negative experiences related to emotions [28, 29]. Looking at the results, one could argue that the VR experience only partially affected the subjects' SWB despite the overall positive response. This may be of no surprise as SWB is a complex feeling as there are so many contributing factors (e.g. economic status, family, physical, emotional state and mental illness). However, one may argue that by stimulating positive emotions, triggering memories and discussions this may still lead to an overall improved SWB.

Patterns were identified from both the qualitative and quantitative data. First, all four female subjects indicated that the experience was positive. Unfortunately the number of female subjects were too low to draw a robust conclusion to why this could be the case. Second, participants that selected a lower score on the second Cantril ladder question compared to the

first question indicated that the participant believed that their life would be worse within five years compared to present. This can have been impacted by the fact that they live alone, as well as that they might have a diagnoses. Third, the issue regarding blurriness was reported much more by participants that had some sort of vision impairment. Forth, the preference of watching programs with nature and animals was shown independent on age. A possibility could be that elderly preferer to watch such programs as they are informative as well as interesting.

5.1. Discussion of Method

In this study, a mixed method was used as it uses both qualitative- and quantitative methods to strengthen the research as well as obtaining enough data to be able to answer the research question [58]. Both closed- and open-ended questions were used to extract sufficient facts. The advantage is that the best type of method for a researcher to tackle the research question as personal preferable methods can be used and in this way gain more information [62]. Its disadvantage is that it generates a lot of information which can be difficult to organize and analyze making it time consuming [57]. Nevertheless, it was still felt to be the best method and was used in this study despite it being laborious as it is give a complete picture of the studied question.

The scale and layout of the survey can be discussed. Likert scale is typically used to measure the subjects' opinions towards various questions and statements [63]. Options such as "Strongly agree" to "strongly disagree" are used to capture the participants' attitude and the number of points on the scale can vary from 1-5, 1-7 and 1-10. With odd number of points, the scale has a center point in the middle. It can be argued whether a center point should exist or not as it would give the opportunity for the participants to choose *no opinion.* Despite that, it has been shown that a 1-5 point scale and 1-7 point scale are more referable [64]. Despite using a 1-10 point scale in this study, it was still felt that established results do illustrate the subject's attitude toward the used of VR. Moreover, according to Göran Ejlertsson [65], the survey should be structure to start with neutral and unprovocative questions and to have more sensitive questions towards the end. In this way, the participants are more inclined to finish the survey. In addition to this, the layout was made simple by using lines to separate the statements to make it more readable.

5.2. Selection of participants

Inclusion criteria for the study included the subjects to be frail elderly attending day care centers in Södertälje. They were pre-selected as they were felt to be interested and able to participate in the study. This meant there was a wide variety of problems related to frailty which were not taken into consideration. No exclusion criteria were applied as it was felt to be feasible to study this in the entire population of frail elderly independent on their cognitive or visual function.

The gender distribution of the participants is unbalanced with 15 men (79 %) and 4 women (21 %). There are various explanations to this such as: there were more men than women at the day care centers at the particular days when the interviews were going to take place and more women were hesitant towards this unknown experience with VR.

5.3. Potential harm with virtual reality

It is important to consider any potential harms that this particular technology could bring to frail elderly. Depending on the movie and the person, this experience could potentially bring bad and unpleasant memories and if standing and walking while using VR there is a risk of falling. While the technology is meant to be immersing, it may also lead to social isolation and neglect. Therefore, VR should be used with caution with this group of people, with adequate supervision and not replacing human interaction as well as perception of the "real world". The technology itself does not pose any direct harms.

5.4. Limitations

Potential problems in the study design could be discussed.

- Several participants had difficulties seeing a good quality image due to their visual impairments. This could be partially rectified by adjusting the sharpness of the image. Optimally, perfect vision would have been preferable including adjustments with glasses.
- Their current emotional state, ability to communicate and cognitive state could have affected the way they replied to the statements/questions. This potentially affect their enthusiasm and ability to complete the interview and survey and lead to minority of internal losses as they did not complete the entire survey/interview. This can also

explain why some of the participants for example scored the experiences of both positive and negative emotions. Unfortunately, due to time constrain, the subjects could only be met on one occasion and ideally there would have been multiply encounters. By performing a mental state examination, one could reduce the error due to severe cognitive impairment.

- The selected movies were chosen as they were felt to be the most interactive and stimulating for the participants. Other types of movies could have been experienced differently depending on the participants' personal interests and therefore could have perceived as more enjoyable and stimulating.
- The Likert scale was used as it is a well-used scale to assess the subjects' replies to statements. A mistake was noticed after the 10th interview, where the value 5 had been incorrectly mistaken as the middle of the scale. The two options ("in between" and "neither yes nor no") were then removed. This may have given a lower score for the 10 initial participants than was intended.

5.5. Future research suggestions

Potential suggestion for future research could be to study VR in groups instead of individually.

In this study, the participants experienced VR individually, but it would be interesting to study if VR could be used as a group activity and in that way improve social interactions including subjects for discussion. It would also be interesting to study the participants reaction to repeat and multiple exposures to VR. This can reduce the effects of daily mood/ cognitive state as well as future familiarizing the subject with the technology and therefore being more receptive to its potential benefits. In this way one can also study the potential long term effect of VR on SWB. Another suggestion would be to allow the participants to choose movies according to their interest for example: music concert, a trip abroad and watching where they used to life when they were young. This can potentially improve the enthusiasm and life satisfaction outcome. Finally, by having stricter exclusion criteria, one could eliminate the effects of poor cognitive and visual function as well as gender distribution.

6. Conclusion

This study showed that VR goggles were comfortable to use. It also partially confirms that the use of virtual reality technology could improve subjective well-being in frail elderly people. The majority of the participants enjoyed its use and experienced more positive than negative emotions. Although these are two variables of subjective well-being, life satisfaction could not be directly and entirely improved by the use of this technology as this is a more complex domain to fulfill. Nevertheless, by enabling frail elderly to be stimulated, awakening memories and feelings, the use of VR goggles with short movies could be a tool in the puzzle of improving the overall well-being of these people.

References

[1] Department of Economic and Social Affairs, Population Division, ”World Population Prospects: The 2017 Revision, Key Findings and Advance Tables,” United Nations, New York, 2017.

[2] L. Lundkvist, ”Significant population increase is expected,” [Online]. (Last Updated: 13 April 2016), Available: https://www.scb.se/en_/Finding-statistics/Statistics-by-subject-area/Population/Population-projections/Population-projections/Aktuell-Pong/14505/Behallare-for-Press/402291/, [Accessed 5 March 2018].

[3] M. Randall, ”Overview of the UK population: March 2017,” *Office of National Statistics*, [Online]. (Last Updated: 3 March 2017), Available: https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationestimates/articles/overviewoftheukpopulation/mar2017. [Accessed 8 March 2018].

[4] V. Spidla and J. Almunia, ”The social situation in the European Union 2005-2006 -The Balance between Generations in an Ageing Europe,” European Communities, Belgium 2007, [Online]. Available: http://ec.europa.eu/employment_social/social_situation/docs/ssr2005_2006_en.pdf, [Accessed 17 March 2018].

[5] ”Kultur 365- Rapport från verksamheten 2016,” Södertälje Kommun- Kultur 365.

[6] W. Pavot, ”The Validity and Utility of Global Measures of Subjective Well-Being,” *Polish Psychological Bulletin,* vol. 44, nr 2, pp. 50-58, 2013.

[7] L. Douma, N. Steverink, I. Hutter and . L. Meijering, ”Exploring Subjective Well-being in Older Age by Using Participant-generated Word Clouds,” *The Gerontologist,* vol. 57, nr 2, p. 229–239, April 2017.

[8] B. Vanhoutte, ”The Multidimensional Structure of Subjective Well-Being In Later Life,” *Journal of Population Ageing,* vol. 7, nr 1, pp. 1-20, March 2014.

[9] WHO, ”Constitution of WHO: principles,” World Health Organization, [Online]. Available: http://www.who.int/about/mission/en/. [Accessed 8 March 2018].

[10] L. Ferrucci, J. M. Guralnik, S. Studenski, L. P. Fried, G. B. Cutler Jr and J. D. Walston, ”Designing Randomized, Controlled Trials Aimed at Preventing or Delaying Functional Decline and Disability in Frail, Older Persons: A Consensus Report,” *Journal of the American Geriatrics Society,* vol. 52, nr 4, p. 625–634, 2004.

[11] P. Scommegna, ”Today's Research on Aging: Research on Health and Well-being Aims to Improve Quality of Life in Later Years,” *Population Reference Bureau*, nr 31, June 2015. [Online]. Available: http://www.prb.org/pdf15/TodaysResearchAging31.pdf, [Accessed 23 March 2018].

[12] T. D. Parsons, A. Gaggioli and G. Riva, ”Virtual Reality for Research in Social Neuroscience,” *Brain Science, vol. 7, nr 4,* April 2017.

[13] M. Wahlström, ”Verklighetsflykt för Vinslövs äldre,” [Online]. *Norra Skåne,* Published: 28 March 2017, Available: http://www.nsk.se/2017/03/28/verklighetsflykt-for-vinslovs-aldre/, [Accessed 12 March 2018].

[14] D. Svensson, "It-arkitekten Daniel Svensson om VR för äldre: ”Vi fokuserade på glädje, enkelhet och stimulans,” [Online]. *ATEA*, Published: 27 November 2017, Available: https://www.atea.se/reportage/2017/it-arkitekten-daniel-svensson-om-vr-for-aldre/, [Accessed 12 March 2018].

[15] M. Olsson, ”Omsorgsförvaltningen testar VR-glasögon,” [Online]. *Hässleholms kommun*, Published: 24 March 2017, Available: http://www.mynewsdesk.com/se/hassleholms_kommun/pressreleases/omsorgsfoervaltningen-testar-vr-glasoegon-1876143, [Accessed 12 March 2018].

[16] M. Prochazka, E. Wallin, N. Bjurström, A. Borén, K. Brandstedt, M. Bruce and M. Lidbrink, ”Vård och omsorg om äldre, Lägesrapport 2016,” *Socialstyrelsen*, Falun 2016.

[17] G. Berleen, "A healthier elderly population in Sweden!," *National institute of public health*, Sandviken 2004.

[18] Statistics Sweden, Demographic Reports, ”The future population of Sweden 2006-2050,” *Sveriges officiella statistik*, 2008.

[19] SCB, ”Sveriges framtida befolkning 2015–2060: Tre miljoner fler bor i Sverige år 2060,” [Online]. *Statistiska centralbyrån, SCB,* Published: 19 May 2015, Nr 2015:354, Available: https://www.scb.se/sv_/Hitta-statistik/Statistik-efter-amne/Befolkning/Befolkningsframskrivningar/Befolkningsframskrivningar/14498/14505/Behallare-for-Press/389899/, [Accessed 24 March 2018].

[20] J. Holroyd-Leduc, J. Resin, L. Ashley, D. Barwich, J. Elliott, P. Huras, F. Légaré, M. Mahoney, A. Maybee, H. McNeil, D. Pullman, R. Sawatzky, P. Stolee and J. Muscedere, ”Giving voice to older adults living with frailty and their family caregivers: engagement of older adults living with frailty in research, health care decision making, and in health policy,” *Research Involvement and Engagement,* 2:23, 2016.

[21] F. Buckinx, Y. Rolland, J.-Y. Reginster, C. Ricour, J. Petermans and O. Bruyère, ”Burden of frailty in the elderly population: perspectives for a public health challenge,” *Archives of Public Health*, vol. 73, nr 1, 2015.

[22] A. Wimo, L. Jönsson, L. Fratiglioni, A. Gustavsson and A. Sköldunger, ”Demenssjukdomarnas samhällskostnader i Sverige 2012,” *Socialstyrelsen*, 2014. Available: https://www.socialstyrelsen.se/Lists/Artikelkatalog/Attachments/19444/2014-6-3.pdf, [Accessed: 18 April 2018].

[23] WHO, ”Dementia,” December 2017. [Online]. World Health Organization, (Last updated: December 2017), Available: http://www.who.int/mediacentre/factsheets/fs362/en/, [Accessed 16 April 2018].

[24] P. Tuominen and B. Norrving, ”Stroke,” [Online]. *1177 vårdguiden*, (Last updated: 14 November 2016), Available: https://www.1177.se/Stockholm/Fakta-och-rad/Sjukdomar/Stroke--slaganfall/, [Accessed 17 April 2018].

[25] Socialstyrelsen, ”Din rätt till vård och omsorg - En vägvisare för äldre,” *Socialstyrelsen*, Falun 2016. [Online]. Available: https://www.socialstyrelsen.se/Lists/Artikelkatalog/Attachments/20182/2016-5-5.pdf, [Accessed 23 March 2018].

[26] L. Boberg, ”Statistics on the Health and Medical Services of Municipalities 2015,” [Online]. *Socialstyrelsen, The National Board of Health and welfare*, (Published: 12 May 2016), Available: http://www.socialstyrelsen.se/Lists/Artikelkatalog/Attachments/20190/2016-5-10.pdf, [Accessed 24 March 2018].

[27] A. Steptoe, A. Deaton and A. A. Stone, ”Subjective wellbeing, health and ageing,” *Lancet. Author manuscript;, vol. 385, nr 9968*, p. 640–648, 2015.

[28] K. L. Siedlecki, T. A. Salthouse, S. Oishi and S. Jeswani, ”The Relationship Between Social Support and Subjective Well-Being Across Age,” *Social Indicators Research*, vol.117, nr 2, pp. 561-576, June 2014.

[29] L. Wayne Henderson and T. Knight, ”Integrating the hedonic and eudaimonic perspectives to more comprehensively understand wellbeing and pathways to wellbeing,” *International Journal of Wellbeing, vol. 2, nr 3*, pp. 196-221, 2012.

[30] F. F. Chen, Y. Jing, A. Hayes and J. M. Lee, ”Two Concepts or Two Approaches? A Bifactor Analysis of Psychological and Subjective Well-Being,” *Journal of Happiness Studies, vol.14, nr 3*, pp. 1033-1068, June 2013.

[31] A. Bowling, ”Do older and younger people differ in their reported well-being? A national survey of adults in Britain,” *Family Practice, vol. 28, nr 2*, pp. 145-155, April 2011.

[32] ”About the Gallup-Sharecare Well-Being Index,” [Online]. Gallup-Sharecare Well-being index, Available: http://www.well-beingindex.com/about, [Accessed 17 March 2018].

[33] E. Diener, R. A. Emmons and R. J. Larsen, ”An evaluation of subjective well-being measures,” *Social Indicators Research,* vol. 17, nr 1, pp. 1-17, 1985.

[34] OECD, "OECD Guidelines on measuring subjective well-being," chapter: ”ANNEX A: Illustrative examples of subjective well-being measures,”, OECD publishing, Paris 2013. Available: https://www.oecd-ilibrary.org/docserver/9789264191655-en.pdf?expires=1524130568&id=id&accname=oid023441&checksum=BC5B366E0A914B5FDDB5A32A455E8BD7, [Accessed 17 March 2018].

[35] A. Kapteyn, J. Lee, C. Tassot, H. Vonkova and G. Zamarro, ”Dimensions of Subjective Well-Being,” *Social Indicators Research, vol. 123, nr 3,* pp. 625-660, 2015.

[36] T. Rose, C. S.Nam and K. B. Chen, ”Immersion of virtual reality for rehabilitation - Review,” *Applied Ergonomics,* vol.69, pp. 153-161, 2018.

[37] A. Innocenti, ”Virtual reality experiments in economics,” *Journal of Behavioral and Experimental Economics, vol.69,* pp. 71-77, 2017.

[38] B. K. Wiederhold and S. Bouchard, "*Advances in Virtual Reality and Anxiety Disorders*, chapter " Introduction", Springer, 2014, pp. 3-7.

[39] J. Tham, A. Hill Duin, L. Gee, N. Ernst, B. Abdelqader and M. McGrath, ”Understanding Virtual Reality: Presence, Embodiment, and Professional Practice,”, IEEE Transactions on Professional Communication, *2018 (To be published in this journal).*

[40] G. Giraldi, R. Silva and J. C. de Oliveira, ”Introduction to Virtual Reality,” *LNCC-National Laboratory for Scientific Computing*, Available: http://www.lncc.br/~jauvane/papers/RelatorioTecnicoLNCC-0603.pdf, [Accessed: 10 April 2018].

[41] C. Cruz-Neira, D. J.Sandin, T. A. DeFanti, R. V. Kenyon and J. C. Hart, ”The CAVE-Audio Visual Experience Automatic Virtual Environment,” *Communications of the ACM, vol. 35, nr 6,* pp. 64-72, June 1992.

[42] M. Ortiz-Catalan, S. Nijenhuis, K. Ambrosch, T. Bovend’Eerdt, S. Koenig and B. Lange, "Emerging Therapies in Neurorehabilitation," chapter ”Virtual Reality,” SpringerLink, 2013, pp. 249-265.

[43] S. Xueni Pan and M. Gillies, *Virtual Reality- Hardware and History,* [Online], Coursera, The University of London, 2018.

[44] W. R. Sherman and A. B. Craig, "*Understanding Virtual Reality- Interface, application, and design*," chapter ”Introduction to Virtual Reality,” Elsevier Science, pp. 6-13, San Francisco 2003.

[45] M. A.Muhanna, ”Virtual reality and the CAVE: Taxonomy, interaction challenges and

research directions," *Journal of King Saud University - Computer and Information Sciences 27*, pp. 344-361, 2015.

[46] A. W. de Vries, G. Faber, I. Jonkers, J. H. Van Dieen and S. M.P. Verschueren, "Virtual reality balance training for elderly: Similar skiing games elicit different challenges in balance training," *Gait & Posture,* vol. 59, pp. 111-116, January 2018.

[47] E.-C. Park, S.-G. Kim and C.-W. Lee, "The effects of virtual reality game exercise on balance and gait of the elderly," *Journal of Physical Therapy Science,* vol. 27, nr 4, pp. 1157-1159, April 2015.

[48] L. Li, F. Yu, D. Shi, J. Shi, Z. Tian, J. Yang, X. Wang and Q. Jiang, "Application of virtual reality technology in clinical medicine," *American Journal of Translational Research,* vol. 9, nr 9, pp. 3867-3880, 2017.

[49] H. Motomatsu, "Virtual Reality in the Medical Field," *UC Merced Undergraduate Research Journal Submit,* vol.7, nr 1, pp. 207-217, 2014.

[50] D. McEwen, A. Taillon-Hobson, M. Bilodeau, H. Sveistrup and H. Finestone, "Two-week virtual reality training for dementia: Single-case feasibility study," *Journal of Rehabilitation Research & Development,* vol 51, nr 7, pp. 1069-1076, 2014.

[51] L. Garcia, A. Kartolo and E. Méthot-Curtis, " Virtual Reality in Psychological, Medical and Pedagogical Applications, chapter "A Discussion of the Use of Virtual Reality in Dementia," September 2012, Avaliable: https://www.intechopen.com/books/virtual-reality-in-psychological-medical-and-pedagogical-applications/a-discussion-of-the-use-of-virtual-reality-in-dementia, [Accessed 19 April 2018].

[52] L. A. Cushman, K. Stein and C. J. Duffy, "Detecting navigational deficits in cognitive aging and Alzheimer disease using virtual reality," *Neurology,* vol. 71, nr 12, pp. 888-895, 2008.

[53] K. Iglesia Molina, N. Aquaroni Ricci, S. Albuquerque de Moraes and M. Rodrigues Perracini, "Virtual reality using games for improving physical functioning in older adults: a systematic review," *Journal of Neuroengineering and rehabilitation, 11:156,* 2014.

[54] K. J. Miller, B. S. Adair, A. J. Pearce, C. M. Said, E. Ozanne and M. M. Morris, "Effectiveness and feasibility of virtual reality and gaming system use at home by older adults for enabling physical activity to improve health-related domains: a systematic review," *Age and Ageing,* vol. 43, nr 2, pp. 188-195, March 2014.

[55] J. Crosbie, S. Lennon, M. McGoldrick, M. McNeill and S. McDonough, "Virtual reality in the rehabilitation of the arm after hemiplegic stroke: a randomized controlled pilot study," *Clinical Rehabilitation,* vol. 26, nr 9, pp. 798-806, September 2012.

[56] J. W. Creswell, "Research design : qualitative, quantitative, and mixed methods

approaches," Los Angeles, Calif. : SAGE, 2014.

[57] J. Schoonenboom and R. Burke Johnson, ”How to Construct a Mixed Methods Research Design,” *Kolner Zeitschrift Fur Soziologie Und SozialPsychologie,* vol. 29, nr 2, pp. 107-131, 2017.

[58] M. Maguire and B. Delahunt, ”Doing a Thematic Analysis: A Practical, Step-by-Step Guide for Learning and Teaching Scholars,” nr.3, 2017. [Accessed at: http://ojs.aishe.org/index.php/aishe-j/article/viewFile/335/553 on 25 May 2018].

[59] D. McEwen, A. Taillon-Hobson, M. Bilodeau, H. Sveistrup and H. Finestone, ”Two-week virtual reality training for dementia: Single case feasibility study,” *Journal of Rehabilitation Research & Development ,* 1069-1076, vol.51, nr.7, 2014.

[60] R. Che Me, S. M. Gramegna and A. Biamonti, ”Virtual Reality in Assessing the Supportive Environment that Promotes Navigability of Persons with Alzheimer's disease,” *Studies in Health Technology and Informatics,* 951-956, vol. 217, 2015.

[61] D. A. Foloppe, J. Besnard, T. Yamaguchi, F. Etcharry-Bouyx, D. Le Gall, P. Nolin, P. Richard and P. Allain, ”Detecting Everyday Action Deficits in Alzheimer’s Disease Using a Nonimmersive Virtual Reality Kitchen,” *Journal of the International Neuropsychological Society,* 468-477, vol. 20, nr 5, 2014.

[62] J. W. Creswell and V. L. Plano Clark, Designing and Conducting Mixed Methods Research, SAGE Publications, California, USA, 2011.

[63] P. A. Bishop and R. L. Herron, ”Use and Misuse of the Likert Item Responses and Other Ordinal Measures,” *International Journal of Exercise Science,* 297-302, vol 8, nr 3, 2015.

[64] J. Dawes, ”Do data characteristics change according to the number of scale points used?,” *International Journal of Market Research,* 61- 77, vol 50, nr 1, 2007.

[65] G. Ejlertsson, "Enkäten i praktiken- en handbok i enkätmetodik," [questionnaire in practice- a manual in questionnaire methodology], *Göran Ejlertsson och Studentlitteratur*, 1996, 2014.

Appendix A- Modified questionnaire (in Swedish)

ENKÄT

GENOMFÖRANDE AV PROJEKTET:
ANVÄNDNING AV VIRTUELL VERKLIGHET FÖR ATT ÖKA VÄLMÅENDET HOS ÄLDRE

Anonym No: Man ☐ Kvinna ☐ Ålder: .....

Bor själv: ☐ Bor med någon: ☐ Övrigt: ……

Är någon i din närhet IT/ tekniskt kunnig? Ja ☐ Nej ☐

Antal barn: ..... Ålder: ..... Övrigt: ……

Glasögon: Ja ☐ Nej ☐ Övrigt: ……

Har du hört talats om Virtuell Verklighet (VR)? Ja ☐ Nej ☐
Har du någonsin testat Virtuell Verklighet? Ja ☐ Nej ☐
Har du gått på bio tidigare? Ja ☐ Nej ☐

Hur tror du att det här kommer bli att vara med i detta försöket? Vad förväntar du dig?

Finns det aktiviteter du brukade göra förut som du inte längre kan vara med på? Som till exempel?

Föreställ dig en skala från 1 till 10. Där 1 representerar det Värsta möjliga liv för dig och där 10 representerar det Bästa möjliga livet för dig. På en skala från 1–10:

	Sämsta möjliga liv									Bästa möjliga liv
Hur upplever du ditt liv just nu?	1	2	3	4	5	6	7	8	9	10
Hur tror du att ditt liv kommer att vara om cirka fem år?	1	2	3	4	5	6	7	8	9	10

Intervju

Kommentarer:

	Håller absolut inte med									Håller absolut med
Upplevde du några positiva känslor*	1	2	3	4	5	6	7	8	9	10
Upplevde du några negativa känslor*	1	2	3	4	5	6	7	8	9	10
Upplevelsen blev som jag förväntade mig	1	2	3	4	5	6	7	8	9	10
Det var en rolig och underhållande upplevelse	1	2	3	4	5	6	7	8	9	10
Det var en dålig upplevelse	1	2	3	4	5	6	7	8	9	10
Filmen väckte minnen hos mig*	1	2	3	4	5	6	7	8	9	10
Jag tror att mina vänner på dagverksamheten skulle känna likadant som jag	1	2	3	4	5	6	7	8	9	10
Jag vill besöka platser som jag inte har sett på flera år med hjälp av (VR) glasögonen*	1	2	3	4	5	6	7	8	9	10
Det var bekvämt att använda (VR) glasögonen	1	2	3	4	5	6	7	8	9	10

*Vilka positiva känslor upplevde du?
Exalterad ☐ Intresserad ☐ Entusiastisk ☐ Inspirerad ☐ Lugn ☐ Övrigt:

*Vilka negativa känslor upplevde du?
Orolig ☐ Ledsen ☐ Arg ☐ Stressad ☐ Trött ☐ Övrigt:

*Vilka typer av minnen väcktes hos dig?

*Vilka platser skulle du vilja besöka, som du inte har sett på flera år, med hjälp av VR?

Hur skulle du beskriva att du mår nu jämfört med innan VR upplevelsen.

Hur tror du att VR skulle kunna påverka ditt välmående?

Har Du varit med om något liknande?

Vilka typer av filmer skulle Du vilja titta på med VR?

Om du har gått på bio tidigare, tycker du att denna upplevelse är liknande?

Tror du att VR upplevelser skulle kunna stärka gemenskapen med dina vänner på dagverksamheten? Varför?

Skulle du rekommendera denna upplevelse till dina vänner på dagverksamheten?

Har du några övriga synpunkter?

Appendix B- Modified questionnaire (in English)

SURVEY

FEASIBILITY OF PROJECT:
USING VIRTUAL REALITY TO ENHANCE SUBJECTIVE WELL-BEING FOR FRAIL ELDERLY PEOPLE

Anonymous Nr: Man ☐ Woman ☐ Age: .....

Live alone: ☐ Live with someone: ☐ Other: ……

Is someone in your vicinity IT/ technical knowledgeable? Yes ☐ No ☐

Number of children: ..... Age: ..... Other: ……

Glasses: Yes ☐ No ☐ Other: ……

Have you heard of Virtual Reality (VR)? Yes ☐ No ☐
Have you ever tested Virtual Reality? Yes ☐ No ☐
Have you been to the cinema earlier? Yes ☐ No ☐

How do you think it will be to be part of this attempt? What are you expecting?

Are there any activities you used to do before that you no longer can participate in? Such as?

Imagine a scale from 1 to 10. Where 1 represents the worst possible life for you and where 10 represents the best possible life for you. On a scale from 1–10:

	Worst possible life									Best possible life
How do you experience your life right now?	1	2	3	4	5	6	7	8	9	10
How do you think your life will be in roughly five years?	1	2	3	4	5	6	7	8	9	10

Interview

Comments:

	Strongly disagree									Strongly agree
Did you experience any positive emotions*	1	2	3	4	5	6	7	8	9	10
Did you experience any negative feelings*	1	2	3	4	5	6	7	8	9	10
The experience was as I expected	1	2	3	4	5	6	7	8	9	10
It was a fun and entertaining experience	1	2	3	4	5	6	7	8	9	10
It was a bad experience	1	2	3	4	5	6	7	8	9	10
The movie brought memories to me*	1	2	3	4	5	6	7	8	9	10
I think that my friends at the day care center would feel the same as me	1	2	3	4	5	6	7	8	9	10
I want to visit places I have not seen for several years using the (VR) goggles*	1	2	3	4	5	6	7	8	9	10
It was comfortable to use (VR) goggles	1	2	3	4	5	6	7	8	9	10

*What positive feelings did you experience?

Excited ☐ Interested ☐ Enthusiastic ☐ Inspired ☐ Calm ☐ Other:

* What negative feelings did you experience?
Worried ☐ Upset ☐ Angry ☐ Stressed ☐ Tired ☐ Other:

*What types of memories were awoken for you??

*What places would you want to visit, that you have not seen from several years, using VR?

How would you describe that you feel now compared to before the VR experience.

How do you think VR could affect your well-being?

Have you experienced something similar to this?

What types of movies would you like to watch with VR?

If you have been to the cinema before, do you think this experience is similar?

Do you think VR experiences could strengthen the community with your friends at the day care center? Why?

Would you recommend this experience to your friends at the day care center?

Do you have any other comments?

Appendix C- Consent letter (in Swedish)

SAMTYCKE

Datum

SAMTYCKE FÖR MEDVERKAN I STUDIE:
GENOMFÖRANDE AV PROJEKTET:
ANVÄNDNING AV VIRTUELL VERKLIGHET FÖR ATT ÖKA VÄLMÅENDET HOS ÄLDRE

Safia Tahar Aissa (xxxxxx-xxxx) genomför sitt examensarbete inom Masterutbildningen Medicinsk teknik vid Kungliga Tekniska Högskolan (KTH). Hon handleds av undertecknad professor. Syftet med hennes studie är att undersöka om äldre personer är mottagliga till ny teknik, så som virtuell verklighet, VR, och om den kan bidra till ökad välmående.

I samband med studien kommer Safia att intervjua ett urval av personer som är 65 år eller äldre vid dagverksamheter i Södertälje i samarbete med Kultur 365, Södertälje Kommun och Film Stockholm.

Att delta i studien innebär att Du kommer att få svara på en enkät angående Ditt välmående och sedan får Du välja mellan fyra kortfilmer att se med VR-glasögon. Efter filmen kommer Du att få svara på intervjufrågor.

Safia kommer i sin studie att under överinseende av en professor som är handledare följa vedertagna vetenskapliga krav på etik och sekretess. Detta innebär att följande krav uppfylls:

- Krav på information: Du har rätt att få all den information du önskar om din medverkan före och under tiden studien pågår. Det betyder att Safia har skyldighet att förvissa sig om att du fått tillräcklig information och att hon svarar på dina frågor.
- Krav på sekretess: Alla uppgifter anonymiseras på ett sätt så att Du som deltagare inte kan identifieras. Ditt namn får en kod och kommer inte att figurera i dokument när det du sagt renskrivs.
- Krav på samtycke: betyder att din medverkan kräver att du signerat detta samtycke. Det betyder också att din medverkan är frivillig och att Du när som helst kan avbryta din medverkan om du finner det önskvärt. Du behöver inte uppge något skäl för att göra det.
- Krav på användningen av data: De uppgifter Safia samlar in kommer inte att användas för något annat syfte än det som anges här och inte distribueras till någon annan. Data arkiveras i Safias dator som kräver lösenord. Resultatet av studien kommer att publiceras i Safias masteruppsats och finnas tillgänglig för dig.

Jag har i min roll som professor och handledare vid KTH, Skolan för Teknik och hälsa, ansvar för att Safia genomför sin studie i enlighet med ovanstående. För frågor eller andra synpunkter är ni välkomna att ta kontakt med mig eller Safia. Ni hittar våra adresser längst ner på den här sidan.

****

Härmed är jag fullt införstådd med vad det innebär att delta i studien och ger härmed mitt samtycke till att delta:

Södertälje den / 2018

Signatur……..

Namnförtydligande……..

****

Kontaktpersoner:

Britt Östlund Professor
KTH Institutionen för Medicinsk teknik och hälsosystem
Telefon: 08-790 97 97
brittost@kth.se

Safia Tahar Aissa
safiata@kth.se

Lars Ahlin, Kulturmäklare
Lars.ahlin@sodertalje.se
08- 523 03 449
Södertälje Kommun

Appendix D- Information letter (in Swedish)

Information om medverkan i forskningsstudien:

Genomförande av projektet: Användning av virtuell verklighet för att öka välmåendet hos äldre

Mitt namn är Safia Tahar Aissa och jag går Masterprogramet inom medicinsk teknik på KTH, Institutionen för Medicinsk teknik och hälsosystem och genomför nu ett projekt i syfte att undersöka äldre personers användning av virtuell verklighet, VR, och om den kan bidra till ökat välmående. Jag frågar Dig, som besökare på dagverksamhet, om Du vill delta i denna forskningsstudie som är i samarbete med Kultur 365 och Södertälje Kommun.

Vad innebär det att delta

Att delta i studien innebär att du svarar på en kort enkät, tittar på en kortfilm med VR-glasögon och sedan svarar på intervjufrågor. Enkäten och frågorna är relaterade till ditt välmående. Examensarbetet utförs på uppdrag av Safia Tahar Aissa. Ansvarig handledare är Professor Britt Östlund vid KTH, Institutionen för Medicinsk teknik och hälsosystem.

Det finns inga omedelbara fördelar för Dig att delta men Din medverkan kommer att bidra till att öka förståelsen om det går att öka välmående för äldre personer med hjälp av VR.

Du kommer att få svara på en enkät angående Ditt välmående och sedan se film med VR-glasögon. Efter filmen kommer Du att få svara på intervjufrågor. All information som samlas in är anonym för att det inte ska gå att spåra vilka som har deltagit.

Hantering av data och sekretess

Redovisning av resultat kommer att ske så att inga personuppgifter kommer att kunna spåras till någon enskild individ. Det innebär att vi kodar och därmed anonymiserar samtliga deltagare från början.

Resultatet av studien

Resultatet av studien kommer att publiceras i form av en vetenskaplig rapport.

Frivillighet

Att delta i studien är helt frivilligt och Du kan avbryta Din medverkan när som helst utan att ange orsak och utan att det kommer att påverka Din fortsatta kontakt med kommunen.

Kontaktpersoner för studien är

Safia Tahar Aissa
E-post: safiata@kth.se

Lars Ahlin, Kulturmäklare
Lars.ahlin@sodertalje.se
08-523 03 449
Södertälje Kommun

Britt Östlund, professor
KTH, Institutionen för Medicinsk teknik och hälsosystem
Tel: 08-790 97 97
E-post: brittost@kth.se