Experiences and motivational aspects of virtual reality applications used by elderly

Master Thesis

For attainment of the academic degree of
Master of Science in Engineering (MSc)

in the Master Programme Digital Healthcare
at St. Pölten University of Applied Sciences

by
Karin Bartsch, BSc
1610756815

First advisor: FH-Prof. Anita Kidritsch, PT, MSc
Second advisor: FH-Prof. Romana Bichler, PT, MAS

Vienna, 15.07.2018

Declaration

I declare that I have developed and written the enclosed Master Thesis completely by myself, and have not used sources or means without declaration in the text. Any thoughts from others or literal quotations are clearly marked. This work was not used in the same or in a similar version to achieve an academic grading or is being published elsewhere.

.....	.....
Place, Date	Signature

Preface

I would like to thank all those, who helped me in some form or another to write this thesis. Without them, I could not have completed this project.

First, I wish to thank my wonderful thesis supervisor FH-Prof. Anita Kidritsch, PT, MSc for guiding me and narrowing down my work. She patiently coached me throughout the whole formation process, starting from my idea steering me into the right direction, while consistently allowing this thesis to be my own work. She always took the time to answer my questions very swift and thoroughly thought through, and made suggestions to improve my work to the highest quality. I am very grateful for her valuable recommendations on this thesis. I would also like to thank my second advisor FH-Prof. Romana Bichler, PT, MAS for her time and efforts.

Furthermore, I would like to thank the participants and the professionals at the residential care facility for the elderly “Pflegewohnhaus Simmering” who made this study possible. Many thanks to the great team of physiotherapists for sharing your knowledge and time with me. Special thanks to Kurt Höblinger for being my point of contact at the RFCE and for helping me organizing everything there.

In addition, thanks to my manager at work for making my studies possible by letting me reduce my working hours temporarily and to my colleagues for supporting me.

Last but not least, I want to thank my family, my partner Veronika, and my friends, who always supported me in every way possible. They cheered me up, motivated me, and always lent me their ears when I needed it the most. I dedicate this work to Bettina – to where you are. I hope you like it.

Abstract

Background: A lot of studies examined the effects of exergames and virtual reality applications on reducing the risk of falling by improving balance. They showed that such digital applications can improve physical shape and socialization, increase cognitive abilities, help with depression, provide more motivation to exercise and improve the overall wellbeing, especially in older adults.

Objective: The aim of this thesis is to better understand elderly users by learning more about their motivation to use virtual reality (VR) applications, by identifying problems during the usage, and by observing the participants' reactions and listening to them to gain more insight into their point of view when using new technologies.

Methods: In this qualitative study ten elderly people (5 men, 5 women, aged between 68-87 years; MMSE > 23) from a residential care facility were observed while using a VR headset (BoboVR Z5™) and playing a bowling game with the Nintendo Wii™. The observations were complemented by semi-structured interviews in two focus groups.

Results: The findings of this study suggest that watching VR videos with a VR headset was experienced as fascinating, comfortable, relaxing and immersive. The Wii™ bowling game was perceived as being actively engaging, fun, challenging, and easy-to-understand with a clear goal. All participants showed signs of fears of contact in the beginning, but were able to overcome their initial nervousness and self-doubt. Most of the participants barely asked any questions during the sessions. Though the majority watched ≥ 3 VR videos and played ≤ 2 rounds of bowling, the interviewees favoured the bowling game over watching the VR videos.

Conclusion: In conclusion, watching VR videos shows great potential to provide an escape from reality and allow older people to re-live experiences or to make new ones that they are not capable of anymore in reality. Playing Wii™ bowling with others, enjoyment, self-improvement (increasing scores and handling controls) and competition (comparing scores) were the main motivational incentives observed.

Kurzfassung

Hintergrund: Viele wissenschaftliche Studien haben sich bereits mit den Auswirkungen von Exergames und Virtual Reality Anwendungen auf die Reduzierung des Sturzrisikos durch Verbesserung des Gleichgewichts, insbesondere bei älteren Menschen, befasst. Sie haben gezeigt, dass solche digitalen Anwendungen besonders bei älteren Menschen die körperliche Verfassung und Sozialisation verbessern, die kognitiven Fähigkeiten erhöhen, bei Depressionen helfen, mehr Motivation zum Trainieren geben und das Wohlbefinden steigern können.

Ziel: Das Ziel dieser Arbeit ist es, ältere Nutzer und Nutzerinnen besser zu verstehen, indem man mehr über ihre Motivation zur Nutzung von Virtual Reality (VR) Anwendungen herausfindet, Probleme während der Nutzung erfasst, die Reaktionen der Teilnehmer und Teilnehmerinnen beobachtet und ihnen zuhört um mehr Einblick in ihre Sichtweise zu bekommen, wenn sie neue Technologien benutzen.

Methodik: In dieser qualitativen Studie wurden zehn ältere Menschen (5 Männer, 5 Frauen im Alter zwischen 68 und 87 Jahren; MMSE> 23) aus einem Pflegewohnhaus beobachtet, während sie eine VR-Brille (BoboVR Z5 ™) und ein Bowlingspiel mit der Nintendo Wii™ ausprobierten. Die Beobachtungen wurden durch semi-strukturierte Interviews in zwei Fokusgruppen ergänzt.

Ergebnisse: Die Ergebnisse dieser Studie zeigen, dass das Anschauen von VR-Videos mit einer VR-Brille als faszinierend, komfortabel, entspannend und immersiv erlebt wurde. Das Wii™ Bowling-Spiel wurde als aktiv, unterhaltsam, herausfordernd und leicht verständlich mit einem klaren Ziel empfunden. Alle Teilnehmer zeigten anfangs Anzeichen von Berührungsängsten, konnten aber ihre anfängliche Nervosität und Selbstzweifel überwinden. Die meisten Teilnehmer stellten während der Sitzungen kaum Fragen. Obwohl die Mehrheit ≥ 3 VR-Videos anschaute und ≤ 2 Runden Bowling spielte, bevorzugten die Befragten das Bowling-Spiel gegenüber dem Anschauen der VR-Videos.

Fazit: Zusammenfassend lässt sich sagen, dass die VR-Videos großes Potenzial bieten um der Realität zu entfliehen und sie älteren Menschen ermöglichen, vergangen Erlebnisse erneut zu durchleben bzw. neue Erfahrungen zu sammeln,

zu denen sie in der Realität nicht mehr in der Lage wären. Gemeinsam mit anderen Wii™ Bowling zu spielen, Vergnügen, persönliche Weiterentwicklung (mehr Punkte erzielen und Spielsteuerung beherrschen) und Wettbewerb (Punkte vergleichen) waren die wichtigsten Motivationsanreize.

Table of Content

1 Introduction

The world's population is ageing rapidly. Currently there are more than 900 million people over the age of 60 and by the year of 2050 it is assumed that there could be up to 2 billion ('WHO | Ageing and health', 2015). There is evidence that seniors (60+) often lack physical fitness, which many times lead to severe mobility problems for them in their seventies. Globally, disorders of people over 60 years (cardiovascular diseases, musculoskeletal diseases, dementia, stroke, Alzheimer, depression, etc.) represent 23% of the global expenses of diseases (Prince et al., 2015). So, while our society keeps getting older due to medical progress, we should aim to stay healthy and maintain a good overall condition – physically as well as cognitive – as long as possible.

Nowadays new technology is having more and more influence in our everyday life and on the way, we participate in activities like training programs (e.g. fitness tracker, fitness apps for smartphones, games for Nintendo Wii™, and training programs for Microsoft Kinect™). As a consequence, technology is also gaining more popularity in the field of health care, such as health promotion, prevention and rehabilitation (Glännfjord, Hemmingsson, & Larsson Ranada, 2017; Hinojosa, 2007).

Therefore, such new technologies, like virtual reality (VR), can help in achieving the goal of improving the quality of life of elderly by for example providing tailored VR training programs in consultation with therapists and by making exercises more fun through so called exergames, i.e. exercises that are embedded in an entertaining game-like environment (Glännfjord et al., 2017). Besides having positive effects on physical conditions, virtual reality applications can also decrease depression and increase cognition (Chao, Scherer, & Montgomery, 2015).

1.1 Background and Aim

Globally, about one third of the people that are 65 years or older fall minimum once a year. Especially people over 70 are more likely to fall. In Austria in 2016, for about 850 people with an average age of 79 years, a fall was the cause of death (Statistik Austria, 2016). Research has shown that older people with very low physical activity levels have a higher risk of falling recurrently (Soares et al.,

2018). Therefore, solutions to prevent elderly from falling are very important, which engage to active, regular training. Studies have shown that interactive cognitive-motor training is an effective way to reduce the risk of falling by improving balance, flexibility, stability and strength. Those trainings combine cognitive and physical exercises, which happens also in virtual reality training (Schoene, Valenzuela, Lord, & de Bruin, 2014). Research results show that virtual reality or exergaming has a high potential to improve adherence (Donath, Rössler, & Faude, 2016).

Project "FitDaheim"

One example of such an exergame is the project called "*FitDaheim*" (formerly "Train&Win"; http://fitdaheim.com) which was implemented in cooperation with the Austrian Institute of Technology (AIT), FH St. Pölten, LIFEtool, Mühlviertler Alm, wpu_gmbh and the MUW (Zentrum für medizinische Statistik, Informatik und intelligente Systeme – Medizinische Universität Wien). "FitDaheim" is a tailored training program for healthy community-dwelling elderly (60+) to be used in an unsupervised setting at home along with a TV and the MS Kinect with 3D sensor technology. An avatar functions as the trainer and shows and explains the exercises. The sensor and camera track the movements of the participants and give immediate auditive and visual feedback in regards to the quality of the performed exercises. Also, the system can record the training progress and as such adjust each training session according to the condition and progress of the participants.

During the research for the FH project „FitDaheim", it became clear that the research field of the efficacy of exergames is broad and well developed. Many studies examined the effects of exergames and virtual reality applications like reducing the risk of falling by improving balance and showed that exergames can improve physical shape, increase cognitive abilities, help with depression, and improve the quality of life and the overall wellbeing, especially in older adults. Studies have also shown that exergames can improve socialization and provide more motivation to exercise (Chao, Scherer, & Montgomery, 2015; Chiu et al., 2017; Donath et al., 2016; Duque et al., 2013; Hee Cho, Hwangbo, & Soo Shin, 2014; Li et al., 2018; Miller et al., 2013; Schoene et al., 2014; Wüest et al., 2014). Virtual reality balance training for multiple sclerosis patients also appears to be effective as shown in an meta-analysis on treating balance and gait impairments in multiple sclerosis rehabilitation (Jesús Casuso-Holgado et al., 2018). In order to better understand elderly users and further improve adherence to training programs, it is vital to identify the motivational factors older people experience, when they exercise with these future technologies.

Thus, the aim of this thesis is to learn more about the motivation of healthy elderly to use VR applications, to identify problems during the usage of VR

applications, and to observe the participants' reactions to gain more insight into their point of view.

1.2 Problem

There is still limited knowledge on the motivation of elderly for using VR-based technologies as well as their experiences when using such a product. So, there is a need for more studies in regards to older people's perception, apprehensions, experiences, acceptance, interests and difficulties regarding new technology such as virtual reality applications and gaming consoles (Glännfjord et al., 2017; Palacio, Acosta, Cortez, & Morán, 2017). In an attempt to contribute to filling this gap, this master thesis will cover the theoretical aspects of exergames, VR applications, and motivation in games, followed by a qualitative study where ten healthy seniors from the residential care facility "Pflegewohnhaus Simmering" have been observed while watching 360° HD videos with a VR headset and playing a bowling game with the gaming console Nintendo Wii™. The observations will be complemented by semi-structured interviews in focus groups.

1.3 Structure of this Thesis

This thesis starts by introducing the topic and explaining why virtual reality is important. Besides, chapter 1 provides the background that led to this study, and describes the problem and aim of this work.

Chapter 2 gives an overview of the theoretical background. It starts with defining the frequently used terminology, like exergames and virtual reality. The benefits of virtual reality applications as well as motivation in general will also be discussed.

In the beginning of chapter 3, current virtual reality technologies are described, including the ones used in this study. Additionally, related virtual reality applications are presented, such as the exergame of the FH project "FitDaheim" ('FitDaheim', n.d.).

The fourth chapter presents the methodological approaches used for this study. It is explained which and why the qualitative research method was chosen, describes the study design, and goes into further detail regarding the sampling process and how the data was collected and evaluated.

Upon the analysis of the research data, this thesis continues by describing and illustrating the gained results of the individual sessions with each of the ten

participants as well as the focus group interviews in chapter 5, structured as per the eight research question categories.

Chapter 6 looks at the results in more depth and answers each of the 28 research sub-questions. In addition, it provides a critical view on the limitations of this study as well as recommendations for future studies.

Finally, chapter 7 summarizes the aim of this thesis, presents the main findings, provides answers to the two main research questions, and concludes with the derived hypotheses for future research.

2 Theoretical Background

"Machines take me by surprise with great frequency." – Alan Turing

Chapter 2 will provide some definitions and classifications in regards to virtual reality. Furthermore, it will clarify the difference between exergames and serious games, and present some of the benefits of virtual reality applications. Finally, this chapter concludes with information about the different types of motivation.

2.1 Definitions

Digital games

Digital games are defined as games that are being generated on and played with a machine, such as smartphones, computers, gaming consoles, and so on (Dörner, Göbel, Effelsberg, & Wiemeyer, 2016, p. 2).

Serious games

A sports game, such as soccer, can be played either for enjoyment or in order to increase physical condition. Thus, a game can have a more serious purpose than just being a fun experience. When the intention behind the creation of digital games is to achieve a specific – characterizing – goal with it, then it is called a *serious game* (Dörner et al., 2016, p. 3).

A sub-category of serious games is *exergames*. As the name suggests, these games are a combination of exercises and games with the aim to make exercising more enjoyable, motivating people to get physically active, and to boost adherence to training programs by adding gaming elements such as rewards, levels, challenges, scores, and so on (Dörner et al., 2016, p. 4).

Avatar

This is "an electronic image that represents and is manipulated by a computer user in a virtual space (as in a computer game or an online shopping site) and that interacts with other objects in the space" ('Definition of AVATAR', 2018).

Immersion

Immersion is a key concept of virtual reality. It describes the submersion into and the interaction with the virtual world and is a state of being deeply engaged (Mehrholz, Elsner, & Thomas, 2017).

Virtual reality and augmented reality

Virtual reality (VR) is defined as an artificial reality that is created on a machine (computer or gaming console) and experienced interactively without delay in high resolution 3D pictures (Stasieńko & Sarzyńska-Długosz, 2016). The user can completely immerse into the virtual environment looking around 360° or the user looks at a flat screen or projected virtual environments.

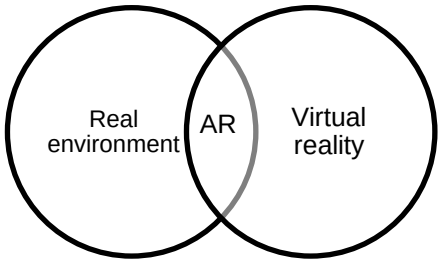

Figure 1 *Relation of reality, AR and VR.*

Augmented reality (AR) is a combination of the real-world environment and the virtual reality as illustrated in Figure 1. It can be seen as an interactive real-world environment enhanced by computer-generated VR objects (visual, auditory, haptic, somatosensory, and olfactory). A known example of AR is the game Pokémon Go™ for smartphones where the user needs to catch the Pokémon™ figures on a map (on his smartphone) of his real-world environment. Such as for VR being interactive in real-time and 3-dimensional are key characteristics (Azuma, 1997).

Virtual reality systems

Stasieńko and Sarzyńska-Długosz (2016) describe that in order to generate and use virtual reality, either a video gaming console or a computer with display devices is required. Therefore, two groups of VR systems can be categorized as follows:

Immersive VR

This group includes Head Mounted Displays (HMD), i.e. headsets with integrated screens or a mounting for smartphones in front of the user's eyes. Here the user is isolated from the real world and can only see the virtual world. In addition, noise-cancelling earphones (sound experience) or for example, special data

gloves (haptic feedback and motion tracking) can intensify the immersion into the virtual reality (Temoche, Ramirez, & Rodríguez, 2012).

Non-immersive VR

This group consists of computers or gaming consoles that create a flat image of a virtual three-dimensional environment, which is displayed by projectors or flat screens. In this case, the user can see the virtual as well as the real world at the same time. Such systems can track the movements of the user in real-time with the help of gyroscopes, accelerometers, and captured data from 3D cameras (Stasieńko & Sarzyńska-Długosz, 2016).

2.2 Benefits of virtual reality applications

Entertainment

In general, most people love to play. Furthermore, no matter if talking about HMDs, VR headsets, or gaming consoles, it can be stated that using them is fun as the number one game design aim is to entertain people. Thus, compared to traditional physiotherapy exercising with a game via a VR device promises more enjoyment. Another reason for combining virtual reality games with rehabilitation or training is that it generates positive psychological effects, like increased motivation, fun, rewards and entertainment. Because of these positive effects it can be argued that people are more likely to exercise more often and intensively (adherence), which results in better therapy success or as Burdea (2003) put it: "*They will get better while having fun*" (Wiemeyer, 2017).

Location independent

Also, they can be used at home and do not require driving or walking to a different location, such as a fitness centre, physiotherapeutic practice or the hospital. This is very beneficial for the elderly or motoric impaired people in general. As per a study by Ashworth et al. (2005), being able to stay at home for training sessions increases the adherence of the elderly to their training plan.

Decreasing costs

Furthermore, VR products tend to be expensive at first, but once they have been established and its technology improves further, the costs are decreasing and those products become affordable for a broader range of people.

Social interaction

In the last years, the target group of older people that play digital games, also called "Silver Gamers", is gaining more importance as VR applications show a possible solution to overcome social isolation and loneliness – a problem that is

widespread among seniors, as partners or friends die or cognitive and motoric impairments increase. It is believed that playing digital games could also help in promoting the interaction between younger and older generations (Li et al., 2018; Stoetter, 2017).

A systematic review (Li et al., 2018) focused on the social benefits of exergames. Their findings suggest that exergames have the ability to reduce loneliness on older people by communicating with other players within peers or their families. Another found benefit was that through those social effects exergames have the potential to increase the senior's motivation to engage in exercise.

Fall prevention

Another positive effect is that the physical activity could prevent diseases and promote health and the overall wellbeing. They can also improve the user's balance, flexibility, stability and strength. In further consequence, such virtual training programs could also prevent falls, which is very common in people over 65 years. With this positive outcome in mind, the FH project "*FitDaheim*" ('FitDaheim', n.d.) was initiated as described in section 1.1.

Furthermore, a systematic review (Neri et al., 2017) included 28 studies on the effectiveness of virtual reality games for fall prevention in the older people. Their findings suggest that VR based trainings obtained better results than conventional trainings in regards to improving balance and reducing the fear of falling. They also found six studies that showed significant improvement of balance and mobility in the elderly, but only in comparison to groups with no intervention at all.

Improving depression and overall cognitive functions and wellbeing

Another meta-analysis (Li, Theng, & Foo, 2016) reviewed studies that looked at the effect of virtual reality games on depression. The results indicate that exergames do have positive effects on improving depressive symptoms. Especially one study by Chao et al. (2015) found significant improvements on depression in older adults when playing with enhanced Wii Fit™ exergames.

Furthermore, Chiu et al. (2017) found that computerized cognitive trainings had positive effects on improving overall cognitive function, memory, attention, executive function, and visual-spatial ability of older people.

In addition, Zelinski and Reyes (2009) also concluded that digital games show great potential to provoke cognitive improvements in older adults.

As per Allaire et al. (2013), regular and occasional senior players of digital games, such as the Wii™, showed better results in e.g. social functioning, wellbeing, and depression than non-gamers.

Potential for rehabilitation virtual applications

Stoetter (2017) believes that VR and AR applications have a high potential for the field of rehabilitation. He describes that VR and AR applications require less previous experience to learn them, as the movements and controls needed are very similar to the ones performed in the real world. As such, he argues that especially older users, who lack the user experience with digital games and often have restricted fine-motor or cognitive skills, would have an easier start getting used to such applications.

This assumption is also supported by the study about the non-immersive virtual reality rehabilitation system "ReHabgame" that aims to improve the motor performance of post-stroke patients. The game used nice scenery and visual feedbacks in the virtual environment to distract the participant's attention and as such avoid getting bored. The overall subjective experience by the 20 participants was very positive (Esfahlani, Thompson, Parsa, Brown, & Cirstea, 2018).

Another study examined how older people, living in assisted living facilities, experience a mobile controlled game with the purpose of recreation and rehabilitation. The results of this study seem promising and showed that older people have a positive attitude towards trying new technical devices (Sirkka, Merilampi, Koivisto, Leinonen, & Leino, 2012).

In addition, Burdea (2003) listed several advantages of virtual rehabilitation, such as adjustability depending on the patient's condition, transparency (stored data), possibility of telerehabilitation reducing healthcare costs, fighting fears, interactivity, and the patient's motivation, among other things.

Furthermore, a systematic review comparing studies about classic cognitive trainings (traditional, paper-and-pen training approaches) with studies about digital trainings (neuropsychological software, video games) for cognitively healthy elderly, found that the computer-based trainings are a promising cognitive training approach (Kueider, Parisi, Gross, & Rebok, 2012).

To conclude, it can be said that especially older people who often suffer from neurological or physical impairments could benefit from such digital applications, as virtual reality applications can be a fun way to exercise, preserve mobility, and stay active while learning something new.

2.3 Motivation

As per Ryan & Deci (2000) the term *motivation* is defined as follows: *"to be motivated means to be moved to do something"*. The different types of motivation

have been extensively studied and revealed important insights for personal development and educational purposes (R. M. Ryan & Deci, 2000).

2.3.1 Self Determination Theory

In Self Determination Theory (SDT), Ryan & Deci differentiate between two basic types of motivation – intrinsic and extrinsic motivation. When people are intrinsically motivated they are naturally interested and enjoy doing that activity. They are having the capabilities to master challenges and thus, they are feeling competent, self-determining, and in control of the situation, which provides them with internal satisfaction (Deci & Ryan, 1985). Simply put, the rewards for intrinsically motivated behaviours are positive emotions. Examples for intrinsic motivators are listed in Table 1.

Whereas when people are extrinsically motivated, they do something expecting a specific separate outcome or consequence, i.e. to get external rewards like money, good grades or the trainer's approval (see also Table 1).

Table 1 Types of motivators.

Intrinsic motivators	Extrinsic motivators
Autonomy, control	Badges, prizes
Belonging	Approval, praise
Curiosity	Money
Meaning	Points
Learning	Fear of punishment
Love, cooperation	Competition
Mastery, challenge	Fear of failure

However, people do not only vary in type of motivation, but also in level of motivation, i.e. how much they are motivated to do something. The level of motivation seems to be linked to the orientation of someone's motivation, i.e. the actual underlying goals that cause getting active, i.e. the "why of actions" (R. M. Ryan & Deci, 2000).

Comello et al. (2016) explored the motivation of people who deal with serious illness like cancer. Similar to old people they often have to deal with isolation and depression. Thus, diving into the virtual reality of a game and hence escaping

reality, improves their overall wellbeing. This study showed that particularly four motivational factors played an important role:

- Stimulation and to accomplish something
- Personal development
- Social interactions
- Personal affirmation

2.3.2 Flow Model of Game Enjoyment by Sweetser and Wyeth

Becoming deeply engaged while playing a game makes it more enjoyable and as such, it is more likely to be played again. This is called being in the “flow”, which Nakamura and Csikszentmihalyi (2009, p. 195) define as “the experience of complete absorption in the present moment”. Further, being in the flow is described as being in “the mental state of operating in which a person in an activity is fully immersed in the feeling of energized focus, full involvement and the success in the process of the activity” (Csikszentmihalyi & Csikszentmihalyi, 1992). As illustrated in Figure 2, it is a state when skill and challenge are well balanced, so that the person feels neither bored nor overwhelmed but is highly concentrated and focused on the activity itself.

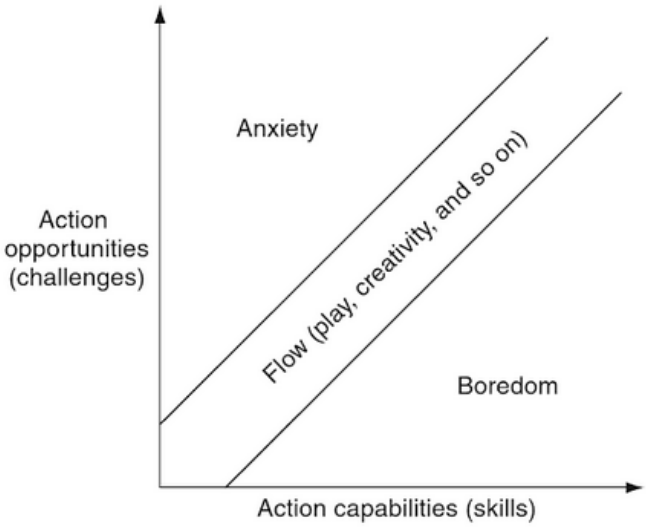

Figure 2 *Function of the quality of an experience - the original model of the flow state* (Snyder & Lopez, 2009, p. 196).

Therefore, in order to foster flow, the gameplay should be compelling, challenging, with a clear set goal and constant feedback. It seems that being in a flow state makes the user lose a sense of self-consciousness and time and provides him or her with a feeling of being in control. It also appears to improve learning (Esfahlani et al., 2018). It is an experience “so enjoyable that people will do it even at great cost, for the sheer sake of doing it” (Csikszentmihalyi, 2009).

As such, triggering deep engagement is a key element especially when designing virtual rehabilitation applications in order to enhance adherence.

In game design, keeping players in the game and making them come back repeatedly is a major goal. Following the flow model, digital games should provide enjoyment, remain slightly challenging, provide constant feedback, define clear goals, and keep the players' concentration and attention. In addition, games could also function as an escape from problems or for relaxation. Furthermore, the factor 'social interaction' can also have a great impact on the user's experience of a game (Sweetser & Wyeth, 2005).

Since there was no validated model of player enjoyment that combined all of the different aspects such as game interface, mechanics, gameplay and narrative, Sweetser and Wyeth (2005) created the *GameFlow* model (Table 2) that describes which intrinsic motivational factors increase the users' interest and tendency to play digital games. It is intended to understand, design, and evaluate enjoyment in games.

Sweetser and Wyeth describe eight elements to achieve game enjoyment. Table 2 presents an overview of these elements (adapted from (Sweetser & Wyeth, 2005, p. 7).

Table 2 Definitions of the eight elements of the GameFlow model (adapted from Sweetser & Wyeth, 2005).

Element	Definition
Concentration	Games should require concentration (stimuli, attention, and focus) and a high workload while still being appropriate for the player's perceptual and cognitive limits. The more focus required, the more absorbing the game.
Challenge	Games should be sufficiently challenging (different, increasing levels) and match the player's skill level.
Player skills	Games must be fun and easy to learn and master (without reading manuals) at appropriate pace, include online help, beginner tutorials, and rewards for skill development.
Control	Players should feel a sense of control over their actions and influence onto the game world (character, movements, interactions, interface, input devices, own strategies) while still being supported in recovering from errors made.
Clear goals	Games should provide the player with clear goals at appropriate times.
Feedback	Players must receive feedback on their progress to their goals, on their actions, and status or score should always be available.
Immersion	Players should experience deep involvement (less self-aware, less worries), an altered sense of time and feel emotionally involved in the game.
Social interaction	Games should support competition, cooperation, and social interaction between players.

In summary, it can be stated that VR applications should meet the following requirements:

- They should be adjustable according to the user's needs.
- Customizable gaming elements, e.g. personalized avatars, should be enabled.
- Adaption of difficulty should be possible.
- Reasonable instructions and feedback should be provided.
- Controls/game interaction should be intuitive and easy-to-learn.

Furthermore, studies have shown that intrinsic motivation is more relevant than extrinsic motivation when it comes to adherence to training programs in the long term (R. Ryan, Frederick, Lepes, Rubio, & Sheldon, 1997).

However, little is known about the motivation of seniors to use virtual reality applications (Meekes & Stanmore, 2017; Palacio et al., 2017).

3 State-of-the-art

"You can discover more about a person in an hour of play than in a year of conversation." – Plato, 427-347 B.C.

Chapter 3 starts by providing an overview of the current available virtual reality systems and concludes with presenting selected VR applications.

3.1 Virtual Reality Technologies

In this section, the most common VR systems will be presented in order to provide an overview of current available technologies. The first group (non-immersive) describes motion- and video-capture systems where the user interacts with the virtual environment that is displayed either on TV or projection screens. The second group (immersive) shows examples of Head Mounted Displays.

3.1.1 Non-immersive VR systems

Nintendo Wii™

The Wii is a gaming console created by Nintendo and released in 2006 ('Nintendo Wii', n.d.). The input device is called "Wiimote", which is a handheld controller that looks like a TV remote, but has built in motion and acceleration sensors. Those sensors track the location, capture the three-dimensional movements of the controller, and translate them into movements of the game character or other elements on the screen. A sensor bar that should be positioned beneath, in front of or on top of the TV or projection screen, and an infrared camera at the front of the "Wiimote", work together to determine its position and location relative to the screen. That way users can point directly at objects in the game. In addition, the controller also has buttons and a directional pad. The communication with the gaming console occurs via Bluetooth and the distance between controller and console should be not less than 1m and maximal 3m to enable tracking of the movements per infrared. Additionally, the "Wiimote" can also provide mechanical feedback in the form of vibration effects and the

user has the possibility to create and save user profiles and personalized avatars (called “Mii”).

An additional input device is the “Wii Balance Board” for the game “Wii Fit”. It consists of four sensor surfaces that the user can stand on. They capture and transfer the shifting of weight via Bluetooth to the console. While Nintendo was certainly aiming to motivate users to exercise more with their board, studies have also mentioned a risk of injury and design issues in regards to the balance board (Gerling, Schild, & Masuch, 2012).

Microsoft Kinect™

The MS Kinect™ is a three-dimensional motion-tracking device with a sensor and camera that can track the user’s movements through skeletal recognition.

The advantages of this gesture-based interaction with the system are that there is no need for manual controllers, the user can perform relatively natural movements, and players do not need to wear any particular equipment. The latter appears especially appealing to stroke patients or any impaired people. However, some elderly users reported difficulties getting the avatar to move as the Kinect sensor was not able to detect them. Thus, players need to pay attention to adequate lighting conditions, correct distance and starting positions and to not wear too loose clothing as this could affect the skeletal recognition (Garcia, Raffe, & Felix Navarro, 2018).

Cave Automatic Virtual Environment (CAVE)

The CAVE system was introduced first at the SIGGRAPH conference in 1992 (https://www.evl.uic.edu/pape/CAVE). It is a virtual reality system where wrap-around screens surround the user and hence provide a panoramic view. This leads the user to believe in being completely immersed into the virtual environment. In order to experience the 3D illusion users need to wear shutter glasses. The system consists of a computer with a professional graphic card, high quality projectors, shutter glasses, and a tracking system (camera, magnetic or optical tracking with active markers). There are different CAVE systems available, such as “CavePainting” in which the user can create 3D works of art, walk through it, and rotate it in his or her hands. Another example is “Interactive RoboCup” where users can play a soccer game with robots or simulated players. It constructs a virtual soccer field in which users from different locations – as long as they are in CAVE systems – can play together (Manjrekar et al., 2014).

3.1.2 Immersive VR systems

As already explained in section 2.1, this group consists of the Head Mounted Displays (HMD), which can be further divided into HMDs with or without

smartphones. Going forward, to provide a clear distinction within this thesis, the ones without smartphones will be called ‘full HMD systems’ (have built-in displays) and the ones with smartphones will be called ‘VR headsets’.

Full HMD systems

Sony Playstation™ VR

The Sony Playstation™ VR (‘PlayStation®VR’, n.d.) is a complete system that consists of a HMD linked to the gaming console. The HMD has a 5.7’’ OLED display, 360° field of vision, 3D-Audio and an integrated microphone facilitating full immersion. In order to interact with the virtual environment, additional equipment is needed, such as a “VR-Aim-Controller”, “Move-Motion-Controller” or the “DUALSHOCK 4 Wireless-Controller”. The “PlayStation Camera” with its dual-objectives and 3D-sensors is tracking the position of the HMD (nine LEDs placed on the headset).

The Oculus Rift™ and HTC Vive™ (‘VIVE’, n.d.) are also examples of Head Mounted Displays, but in contrast to Sony’s Playstation™ VR, they need to be connected to a high-performance computer instead of a gaming console (via cables). Special controllers, e.g. “Oculus Touch”, with buttons and sensors, allow interaction with the virtual reality. Additional equipment like the “Oculus-Sensors” is required to enable 360°-tracking.

In contrast, the Oculus Go™ ((‘Oculus Go | Oculus’, n.d.)) is an independent HMD that works without connecting it to a device, i.e. no cables or PC are needed. However, it only captures the user’s head movements (3DOF), but not the position in the room (6DOF). To interact with the virtual world a controller with buttons and a touchpad is required. The resolution of the built-in display and the overall experience is similar to Samsung’s Gear VR™ or Google’s Daydream View™.

VR headsets

These Head Mounted Displays are more affordable for personal use, but they do not feature the same resolution and power as the ones used with computers. VR headsets only work in conjunction with a high-end smartphone, which the user needs to slide-in at the front of the headset. Just as the Oculus Go™, these VR headsets can only capture the movements of the head or the smartphone respectively via gyroscope sensors.

Some representatives of this group are Google’s Cardboard™, Samsung’s Gear VR™, or Google’s Daydream View™. The device used in this study, Bobo VR Z5™ (‘BOBOVR Z5’, n.d.), is very similar to Google’s Daydream View™. Although, it has an adjustable head mount providing stability (with six soft tactile devices) and built-in headphones (connected to the smartphone via a small

cable) to make it more comfortable to immerse into VR. The lenses allow a 120° field of view. A controller helps in interacting with the virtual environment. However, in this study the controller was not used, as no interaction was needed when watching 360° videos. Furthermore, the handling can be tricky and it did not always respond or work properly during the pilot test.

To conclude, when using full HMDs, like the Oculus Rift™, the user can experience a full immersion into the synthesized world without interruptions. Whereas when using the devices that require a smartphone, like Google's Cardboard™, the user needs to perform the navigation manually and then put it into the mounting, which makes the user experience less comfortable. Although for some devices, like the Samsung Gear VR™, there are already controllers available. However, the author if this thesis tested this option and it did not result in a satisfying smooth user experience, as one cannot see but only feel the buttons on the controller when wearing the VR headset and sometimes the Bluetooth connection does not work or suddenly breaks.

3.2 Related Work

3.2.1 VR Headset Applications

There is little research in the field of VR headsets and HMD for the elderly. However, findings from related studies, on VR applications for people with dementia or Alzheimer's disease, are also applicable for the aging population.

In a study on memory and presence, Bailey et al. (2012) showed a direct influence of VR simulations on the users' behaviour afterwards in their real environment. The virtual reality requires high attention from the participants to create a feeling of "being there/present" and as such needs a lot of cognitive capacity. Consequently, it was observed that people remember situations or objects from the virtual environment, but forget certain information from the real world.

Studies in New Zealand (Watt, T., Gee, S., & Scott-Multani, M., 2017) and the United States (Thomas et al., 2017) describe personalized music for older people with dementia as a promising tool for increasing their overall wellbeing. Similarly, VR applications that trigger personal memories, e.g. show places the seniors have been to, could also have positive effects on their general feeling.

Rendever™ ('Rendever', n.d.) is a MIT startup software company that focuses on bringing virtual reality and older people together. They collaborated with Jake Kahana and created the project "BettVR With Age", which aims to improve the lives of the elderly, especially in assisted living facilities ('BETTVR WITH AGE',

n.d.). Caused by communication difficulties with his grandmother, he started researching and found that older people missed activities the most that they were not able to pursue any longer, such as going to a theatre, concert or museum. Therefore, he created ten VR films about these topics. Together with the software by Rendever™ and a Samsung Gear VR™ headset seniors can dive into these virtual reality experiences.

Furthermore, *One Caring Team* designed the "Aloha VR" program, which fosters relaxation by transferring the elderly users to a virtual beach on Hawaii. It aims to reduce emotional discomfort and increase the quality of life for older people that feel isolated and alone ('Aloha VR', n.d.; Larkin, 2017).

It has to be noted that "Aloha VR" and "BettVR With Age" are both commercial products with good user experiences, but no studies in this regard have been published so far ('article bettvrwithage', 2017).

3.2.2 VR with gaming consoles

SilverBalance

"SilverBalance" (Gerling et al., 2012) is an exergame designed to improve balance of the elderly. It uses the Nintendo™ Balance Board as input device on which the seniors can either sit or stand. The game has a simplistic and clear user interface in order to not distract or visually overload the elderly players. It consists of only two game tasks, which can be achieved by shifting the player's weight on the board. In this study, they compared 16 frail and active seniors using their game and an existing Wii Fit™ Balance Game (Wii Fit™ slalom skiing) which required similar player movements. The results show that the "SilverBalance" game was experienced more positive than the skiing game, as especially the frail group felt safer and more in control of the game. The clear and structured graphical user interface of "SilverBalance" also seemed to help them to concentrate on their movements.

FitDaheim

As described in section 1.1, one example of such an exergame is the project called "FitDaheim" ('FitDaheim', n.d.) which was implemented in cooperation with the Austrian Institute of Technology (AIT), FH St. Pölten, and other cooperation partners. "FitDaheim" is a non-immersive virtual training program for healthy community-dwelling elderly (60+) to be used at home without supervision. An avatar functions as the trainer and shows and explains the exercises on the connected TV screens. The MS Kinect™ sensor and a camera are used to track the movements. The system gives immediate auditive and visual feedback in regards to the quality of the performed exercises. Additionally, the system can

record the training progress and as such adjust each training session according to the condition and progress of the participants. This project concludes with an eight-week intervention with 30 healthy seniors from the Mühlviertler Alm and an evaluation of this project until 31-Aug-2018.

StepKinnection

Garcia et al. (2018) designed a similar exergame called "StepKinnection", also with the aim to prevent seniors from falling by improving mobility and reaction of the elderly users. As the name suggests this VR system consists of a MS Kinect™ sensor and a computer. The ten participants were encouraged to play at least 20 minutes per week for three months at their homes. The results of this study were promising, as the majority of the participants would consider using the system to exercise on a regular basis as they enjoyed playing the game and felt no frustration regarding the controllers and interaction with this exergame.

Other examples of home-based virtual training programs are the research project "Motivotion60+" (Brach et al., 2012) or the "MIRA games" ('MIRA', n.d.). The latter is a software platform containing digital games that aim to make traditional physical therapy exercises more fun. It tracks the user's performance and movements via a Kinect™ sensor and captures specific parameters that can later be discussed with a professional. In a study Meekes & Stanmore (2017) investigated the motivational factors behind the use of these exergames by the elderly. Their findings suggest that the participants were intrinsically motivated as they enjoyed playing the exergames and experienced them as challenging. Positive feedback within the game and from the instructors also motivated the participants. Immersion into the game was also experienced and the importance of social interaction is one of their principal findings. They also reported an increase of the participants' confidence regarding their perceived physical and mental capabilities and social cooperation.

Research regarding the use of the Wii™ and the elderly mainly focuses on the physical or social effects and its use as a health promotion tool (Bieryla & Dold, 2013; Clark & Kraemer, 2009; Franco, Karen, Catrina, & JoAnn, 2012; Harley, Fitzpatrick, Axelrod, White, & McAllister, 2010; Higgins, Horton, Hodgkinson, & Muggleton, 2010; Jorgensen, Laessoe, Hendriksen, Nielsen, & Aagaard, 2013; Li et al., 2018; Longhurst, 2013; Molina, Ricci, de Moraes, & Perracini, 2014; Pigford & Andrews, 2010).

Laver, Ratcliffe, George, Burgess, & Crotty (2011) found that when comparing exercising with the Wii Fit™ to traditional therapy, their participants stated to prefer the conventional therapy as they felt it was more effective. However, this study did not explore the participants' reasons for their conclusion.

Harley et al. (2010) reported results of an UK health initiative (Age Concern) to promote activity (physical and social) of the elderly in sheltered housing. They explored how the staff (of Age Concern) perceived the motivation of the older people to join playing with the Wii™. It was found that the initiative helped to decrease social isolation by conducting community events and that it also gave empowerment to the older people by providing them with new roles within their community. In addition, the participants were able to gain new technical expertise while having fun.

Only a few studies were found that focused on the elderly's perceptions, needs and motivations to use VR technologies (Glännfjord et al., 2017; Meekes & Stanmore, 2017; Nap, Kort, & IJsselsteijn, 2009).

Meekes and Stanmore (2017) examined the motivational factors of seniors to use exergames. They conducted a 6-week intervention with 12 older people from two assisted living facilities. Their results showed that the participants were motivated, because they gained confidence in regards to their mental and physical conditions, and social interaction. They also reported that the exergames were perceived as an escape from reality, challenging but enjoyable, and that individual feedback and tailored coaching were important aspects to increase the participants' motivation.

In another study (Glännfjord et al., 2017), the researchers investigated the views of elderly users who played Wii™ bowling regularly in an activity centre for seniors for approximately two years. Their main findings were that the social aspect and feelings of enjoyment kept most of the seniors continue coming to the activity centre. Further, the participants compared the Wii™ bowling to real bowling and described the advantages of virtual bowling (less equipment and effort). The study also reported indications of immersion, competition and playfulness, and acceptance of the virtual reality as the elderly players overcame the initially strange feeling of bowling with a controller. Finally, the researchers suggest to further examine older people's experience with VR or gaming consoles as conducted in this thesis.

4 Methodology

"*Not everything that can be counted counts and not everything that counts can be counted.*" – Albert Einstein

During the research for the FH project „*FitDaheim*" – a tailored exergame for healthy older people (≥ 60 years) to train in an unsupervised setting at home using a TV and the MS Kinect with 3D sensor technology – it became clear that the research field of effects and efficacy of virtual reality applications is broad and well developed, but that there is still limited knowledge on the motivation of elderly as well as their experiences and perceptions when using VR-based technologies (Glännfjord et al., 2017; Meekes & Stanmore, 2017).

In order to achieve a broader understanding of this field, to formulate detailed research questions and to decide which research approach (qualitative, quantitative or mixed-methods) should be chosen, further literature research was performed as described in the following sections within chapter 4.

4.1 Literature Research

Between March 2017 and November 2018, a review of literature published between 2010 and 2018 has been conducted. Only papers in English or German language were included.

First, a manual research was conducted to get an overview of the topic and to be better able to define relevant keywords and research questions. The following keywords were used during this manual search phase in Google Scholar and PubMed: exergames, virtual reality, Wii, seniors, elderly, motivation, perception, experience, enjoyment, engagement, and adherence.

The PICO search strategy did not apply as comparing exergames with conventional training was not a desired research question. However, further literature research was performed by searching only for a combination of „P" (healthy elderly, seniors, older people) and „I" (virtual reality, Wii, exergame, Kinect) and „O" (motivation, experience, perception, etc.) and by screening the

abstracts of the literature references of found meta-analyses and systematic review papers and other found papers.

This resulted in two categories of research questions which are further described in the following section 3.2.

4.2 Research Questions

In order to gain more insight in the motivational factors and challenges older people experience, when they use virtual reality technologies, the following research questions have been determined:

1. *Experience: How is the general applicability of virtual reality applications perceived by elderly people?*
2. *Motivation: What motivates them to start and might also motivate them to continue using those applications? I.e. which factors influence their engagement?*

During the literature research questions that could help in answering those two main research questions emerged. Those sub-questions are clustered and defined as follows:

1. Experience: How is the general applicability of virtual reality applications perceived by elderly people?

1.1. Physical and cognitive requirements

a) What are the physical requirements to use such technologies?
b) Do they show interest in learning how to use new technologies?
c) Do the players remember the instructions and control?
d) How do they learn?
e) Do they try to figure out how to achieve better results?

1.2. Attitude regarding new technologies

a) What is accepted better: VR headset or Wii™?
b) What is the general attitude of elderly towards these technologies?
c) Do they show signs of fears?

1.3. Handling

a) Do they get easily used to the concept of gaming controllers?
b) Is the handling of the controller, with its buttons, problematic?
c) How is the VR headset experienced?

1.4. Problems

a) Is wearing glasses an obstacle (with VR headset)?
b) Where are the difficulties/problems regarding usage of the used technologies?

1.5. Self-reliance

a) Can they use VR applications also alone, without a supervisor?
b) If not, what are the hurdles to do so?
c) Is the application intuitive for older people? Or get they stuck quickly?
d) Do the seniors ask questions when unsure on how to proceed?

2. Motivation: What motivates them to start and might also motivate them to continue using those applications? I.e. what factors influence their engagement?

2.1. Hurdles

a) At which point/event do they get bored / angry / frustrated / nervous / worried / impatient etc.?
b) How does this feeling become visible?
c) What discourages them?
d) What could be changed in order to make their first contact with new technology smoother?

2.2. Engagement

a) How long/many rounds do they participate?
b) What is fun for them? I.e.: what makes them laugh/smile?
c) What is experienced as fascinating or interesting?
d) What encourages and is important for them?
e) Do any memories and/or emotions get triggered while using the Wii™ or the VR headset?

2.3. Control

a) Do they have fun learning something new?
b) Do they like personalizing the Wii avatar?
c) Does an increase in self-confidence show? How?

4.3 Study Design

Qualitative research wants to give the target audience a voice to gain more insight into the audience's point of view and to learn more about specific circumstances by observing and/or interviewing a few representatives of the potential target audience. The subjective perception of the test subjects is not seen as an obstacle but as a desired result to gain more insight in greater depth. The aim of qualitative research is to explore unknown phenomenon and to generate new theories and hypotheses (Brüsemeister, 2008).

Since little is known about if and why healthy seniors are motivated to use new technologies in the long-term, the qualitative explorative approach with a mix of qualitative research methods was chosen for this master thesis (Glännfjord et al., 2017; Meekes & Stanmore, 2017).

More precisely, this thesis comprises a qualitative study where ten healthy seniors from the residential care facility for elderly (RFCE) "*Pflegewohnhaus Simmering*" have been observed (participant observations) while watching 360° HD videos with a VR card board headset (BoboVR Z5™ with a Samsung S7 smartphone) and playing a bowling game (single player) with the gaming console Nintendo Wii™. The observations have been complemented by semi-structured interviews in two focus groups afterwards.

Figure 3 *Course of action of the study.*

4.3.1 Ethical approval

This study is conducted in full conformance within the laws and regulations of Austria. Before the recruitment process started, this study was authorized by the FH St. Pölten and the NÖ Ethics Committee. All participants signed the informed

consent forms after discussing the content of the study in detail with each of them.

4.3.2 Qualitative research

Qualitative studies were being criticized in the scientific community for not having defined quality criteria and specific methodological procedures. Especially in health-related studies evidence based medicine in the form of Randomized Controlled Trials have become the golden standard and evolved to the only scientifically recognized method.

There have been some attempts in the past to formulate standards or provide guidelines, for example the “Cochrane Handbook for Systematic Reviews of Interventions” that mentioned some options for qualitative studies to add evidence-based reviews, but without precisely defined procedures (Noyes, Popay, Pearson, Hannes, & Booth, 2008).

Mayring approached this problem by implementing and introducing the Qualitative Content Analysis which provides a structured framework for a rule guided research process that includes strict content-analytical rules for each step of the analysis as well as for the whole research process. Basically, the Qualitative Content Analysis is a mixed-methods approach starting with basic (quantitative) research steps, followed by a qualitative step of assigning categories to text, working through many text passages and resulting in the quantitative step of analyzing the frequencies of categories (Mayring, 2014, pp. 6–10).

4.3.3 Quality Criteria

Within the context of quantitative research, the quality criteria had been developed particularly with regard to the quality of measurements. Therefore, the main scientific quality criteria became objectivity, reliability and validity which can be thought of as a target going form the outer ‘objectivity’ circle to the ‘validity’ center (Lamnek, 2010, p. 127ff.).

Objectivity:

The measurement process is not being influenced by any irrelevant factors, i.e. different examiners/observers evaluating the same scenario should come to the same results. The more standardized the tools and analysis methods are, the more objectivity is given.

Reliability:

The study has to be consistent and reproducible and lead to the same results every time. For a measurement procedure to be reliable, it has to be objective first.

Validity:

The test objects have to be related to what is being assessed and every aspect of a research topic has to be fully assessed. Before considering the validity of a measurement method, objectivity and reliability have to be complied.

Since the typical scientific research criteria cannot easily be transferred to the qualitative approach, there have been different suggestions on how to address this problem, such as the concept of combining the quantitative and qualitative approaches by triangulation or Patton's work where he introduced four approaches to triangulation to help improving the "trustworthiness" (≈ validity and reliability) of research results (Flick et al., 2004; Patton, 2002). As per Mayring, introducing new terminology (such as "transferability", "dependability", "credibility", etc.) and new quality criteria that differ completely from the quality criteria used in quantitative research is counterproductive in creating a unified approach. He argues that

> […] validity in a broader sense is usually less of a problem within qualitative approaches, because they seek to be subject centered, close to everyday life (naturalistic perspective, field research), especially when the research process remains theory driven (construct validity). […] the rule guided procedures can strengthen this criterion [reliability]. […] they [qualitative approaches] discuss the interaction researcher–subject and strengthen objectivity in a broader sense (Mayring, 2014, p. 14).

In summary, Mayring aims to provide a step-by-step model for qualitative, quantitative and mixed-methods research to end the arguing on which method is better.

Due to the above, Mayring's Qualitative Content Analysis became the chosen "methods framework" for this qualitative study as it provides a clear and structured step-by-step model of the whole research process.

This model consists of seven steps, which are outlined in the following table that also includes references to the corresponding chapters of this thesis:

Table 3 Mayring's model of the research process; adapted from his book (Mayring, 2014, p. 15).

#	Steps	Chapters
1	Concrete research question	4.2
2	Linking research question to theory	2, 3
3	Definition of the research design	4.3
4	Defining of the sample or material and the sampling strategy	4.4
5	Methods of data collection and analysis	4.5, 4.6, 4.74.5 below
6	Processing of the study, presentation of results in respect to the research question	5
7	Discussion	6

4.3.4 Why not the Grounded Theory

The comparative analysis is the main characteristic of the Grounded Theory. For this purpose, Glaser and Strauss recommend the strategy of theoretical sampling which they describe as the “process of collecting data for comparative analysis” (Glaser & Strauss, 1967). This refers to an iterative process where data collection, analysis and evaluation happen simultaneously and where the researcher goes back into the field after analysing the first text material to collect more data that should ideally differ from the already collected data so that a high contrast becomes visible. This should be repeated until a theoretical saturation is achieved (Cho & Lee, 2014).

Considering the fact that the field that was being observed was not something that happened naturally, i.e. no routine (the scenarios were created on purpose on specific days), this iterative approach was not suitable for this study. In addition, the tight time schedule and the circumstances at the RFCE would not allow such an iterative process.

4.3.5 Why not a quantitative approach

Initially, it was planned to use a mixed-methods approach where approx. 30 participants should have performed the cognitive screening tests Mini-Mental-State-Examination (MMSE) to exclude participants with dementia and the Montreal-Cognitive-Assessment (MoCA)-Test to evaluate the individual cognitive capabilities. The interim results of each question of the MoCA-Test would have been defined as the measure parameters (i.e. concentration, memory, orientation, spatial perception/imagination, etc.) and should have then been used to evaluate if and how the participants’ observed results (observation and interview) correlate to their cognitive abilities. So, correlations could have been calculated and descriptive statistics could have been used in order to describe the frequency of occurrences of the parameters (measured cognitive results) and demographics (sex, age, etc.).

However, in order to get the ethical approval for this master thesis it was a requirement to drop the cognitive screening tests. The reason for this decision by the ethical review committee was that those screening tests would reflect a kind of medical diagnosis of which the impact in case of positive test results for the participants was not clear.

Hence, the study design of this thesis was converted to a qualitative work with the aim to focus in detail on each participant of the smaller sample.

4.4 Sampling

Since this study is about the motivation and experiences of healthy seniors who are older than 60 years, it was obvious that the sample has to involve persons that would fulfill this criterion in the first place.

Contacting the field

Therefore, in June 2017, the residential care facility for the elderly (RCFE) called "Pflegewohnhaus Simmering" in Vienna, Austria was contacted for the first time to find out if they would be interested in and open for this study and if there would be a suitable location and potential participants.

In November 2017, after receiving the ethical approval for this study, the RCFE was again contacted via E-Mail with a more detailed plan of this project along with an official signed and stamped letter by the study advisor on behalf of the FH St. Pölten. The study was permitted by the director of the RCFE and a first meeting over phone took place to clarify open questions on both sides. As a next step, inclusion and exclusion criteria for potential participants were defined and planned dates for the settings with the Nintendo Wii™ and the VR glasses were determined.

Information sheets

Furthermore, an information sheet (flyer) was designed to give potential participants an overview of the planned study and to clarify the most important questions like:

- What is this about?
- Why is this study conducted?
- Who is conducting this study?
- When will it happen?
- Where will it take place?

Upon reviewing this sheet with the contact person at the RCFE, it was decided to reduce the design (frames, colors, small arranged images) in favor of the space

to increase the font and image sizes and to only use black font color to make it more readable for the seniors. This flyer was given to the potential participants during the recruiting process while introducing this project to ensure that all are on the same level of knowledge. A sample of the final information sheet can be found in the Appendix of this thesis.

With the same intention a similar info sheet for the in-house therapists was created which consisted of the participants' sheet content plus the inclusion and exclusion criteria for potential participants.

Inclusion and exclusion criteria

The most important quality criterion for qualitative research is the compilation of the sample, i.e. those cases that one wants to examine. In the qualitative research sampling process there is no randomization to achieve a statistical representativity. Instead the qualitative sampling process focuses on content representativity by explicitly choosing participants that will provide relevant and valuable information to answer the research questions (Brüsemeister, 2008; Lamnek, 2010).

In this thesis inclusion and exclusion criteria have been defined based on literature research and expert opinion of the in-house personnel at the RCFE.

The initial inclusion and exclusion criteria based on literature research were as follows:

Nintendo Wii™ Bowling:

- Motor skills: grasp, hold and swing the controller and push and/or hold the buttons on the controller
- Vision: good enough to be able to follow the events from a 2-3m distance (Wii™ avatar and bowling ball) respectively to clearly see the 360° HD VR videos
- Cognitive:
    - Being able to understand verbal explanations and follow instructions
    - Capable to recognize that the Wii™ avatar represents the player and to understand the functional principle

Watching 360° HD videos with VR Cardboard glasses:

- Cognitive: being able to understand verbal explanations and follow instructions
- Vision: spectacles are no obstacle, i.e. can and should be used with the VR glasses to ensure clear vision

Recruiting participants

On 15-Dec-2017 the first personal meeting at the RCFE took place where the study was introduced to the physiotherapists and inclusion/exclusion criteria was discussed on the basis of a list of approx. 30 potential participants (selected by the therapists based on their professional experience with the residents and the in/exclusion criteria). On the same day also the other in-house personnel (other therapists, doctors, etc.) were pro-actively visited and informed to make sure that everyone is fully aware of this project. Also, the available facilities (rooms, TV set, beamer, and connectivity options) were inspected and specified. The author of this thesis had to provide a proof of specific vaccinations (form signed by doctor) and to sign a non-disclosure agreement before carrying out the study at the RFCE. Therefore, no photographs from the empirical setup are displayed in this thesis. Besides, this project was also discussed with the psychologist at the RFCE. As a result, it was decided to only include participants with a MMSE result of ≥ 24 in order to ensure to exclude seniors with strong cognitive impairments (dementia, Alzheimer disease, etc.). In summary, 13 of 30 potential participants were remaining.

During a second visit, on 21-Dec-2017, the 13 remaining potential participants were visited in their rooms where the study was introduced to them and all arising questions were answered. Also, the Virtual Reality device and the Wii™ controller were demonstrated and the required fine motor skills were checked (ability to hold the controller and push the buttons). The information sheet and an informed consent form were explained and remained with the participants. The latter were collected later that day after they had read and signed it. Of the 13 participants, one did not want to participate in the study, three more could not participate due to illness and another participant became available who did not fulfill the inclusion criteria (stroke patient with impairments returned from a hospital stay), but was included in this study to fill up the sample size to ten participants. This resulted in a total sample size of ten participants (five women, five men) with an age range from 68 to 87 – as shown in table 2.

Table 4 List of participants.

ID	Age	Gender	Group #
01	76	F	1
02	74	M	1
03	79	M	1
04	87	F	1
05	74	M	1
06	80	F	2
07	83	F	2
08	68	F	2
09	79	M	2
10	75	M	2

4.5 Data Collection

In order to increase the study's validity a mix of different procedures of data collection has been applied including participant observations with protocols, semi-structured interviews in two focus groups. A pilot test of the observation protocol and the interview guide was conducted with two pilot subjects.

4.5.1 Observation protocols

The questions in the observation protocol were derived from the sub-questions of the main research questions, for example: how the handling of the controller was, if the concept of an avatar was confusing, what caused frustration, did they get bored, did they have fun and did they like personalizing the avatar.

As specified in section 4.5.2, for the data collection in this study some statements from the Core Elements of the Gaming Experience Questionnaire (CEGEQ) were adapted and used for this observation protocol, such as "Is the participant complaining about the handling of the controller?", "How is the participant's mood prior and after the game?", "How many questions in addition to the initial instructions does the participant ask?", and so on (Calvillo Gamez, 2009).

The pilot test resulted in the following changes to the observation protocol:

- Questions with the focus on time measurement have been removed as it was not manageable to guide, instruct and help the participants while simultaneously measuring the time. This would only be possible for more than one observer which was not the case in this study.
- A list of possible questions that could occur (based on the pilot test) were added as checking off asked questions is faster than writing down the whole questions.
- Freehand comments sections have been added for the observer to allow quick note taking besides the pre-defined check-boxes and questions.

The final observation protocol can be found in the Appendix.

The participant observation as a qualitative data collection method was chosen as it is one of the standard methods for field research (Brüsemeister, 2008; Flick et al., 2004) and provides several advantages:

- The observer is better able to understand the context within participants interact
- Firsthand experience for the observer, so there is less need to rely on other reports
- Observer might discover new things
- Observer might learn things that people would not want to talk about in an interview
- Observations help providing a full picture: the perceptions of the observer (obtained through participant observations) are complemented by the perceptions of the participants (obtained through interviews) (Patton, 2002).
- To be able to ask appropriate questions in the interviews afterwards
- To build a relationship which might causes the interviewees to answer more open and honest

4.5.2 Interviews

Gamez (2009) created a framework called „Core Elements of the Gaming Experience (CEGE)“. In his work he identified the procedural elements of the experience and developed a model and questionnaire reflecting the process of the gaming experience. He describes that game play (what the game is about; limits, rules, etc.) and environment (presentation; graphics and sounds) are the two elements that influence the player's perception of a video game. He believes that these two elements need to be complemented by - what he calls - "puppetry" (ownership, control and facilitators), i.e. the interaction of the player with the game, as having control, becoming better and gaining influence, getting rewards,

etc. play an important role in how enjoyable a game is being experienced by the user.

Based on his model he designed a questionnaire with eight scales (CEGE, Video-Game, Puppetry, Game-Play, Environment, Control, Ownership and Facilitators) to be able to assess gaming experience. Each of the questions has to be rated on a 7-point Likert scale (Calvillo Gamez, 2009).

For this study, the CEGEQ per se was not used, but Gamez' model and questionnaire were used to gain more insight into this topic and to derive suggestions on what interview questions could be asked and what could be observed, such as "Was it too difficult?", "Who would want to play this game again?", "Who wanted to play longer?", "How was the handling of the controller?", and so on.

In this study, semi-structured interviews in two focus groups with six participants (the remaining four participants could not join the group interviews due to sickness) were conducted to complement the data captured during the two days of observation. An interview guide with selected questions was used to drive the conversation. The guide consisted of four general questions, six Wii™ related questions and six VR headset related questions. Open questions were chosen to enable a more reactive and open approach (compared to given answers). An open interview provides more room for individual answers and thus might reveal new findings. In addition, new follow-up questions could be generated during the discussion to extend the whole interview.

The pilot test resulted in the following changes to the interview guide:

- Important questions were highlighted, so they will not be missed during the interview.
- Attention was paid to ensure that the VR and Wii™ related questions were similar / covered the same areas.

The interview guide can be found in the Appendix.

4.6 Setting

This section will provide a detailed overview of the scenarios that were created for observation as well as a time schedule of the scenarios. In order to avoid order or sequence effects, a counter-balanced order across all participants has been used. This resulted in the following settings:

Day 1 / Group 1: All 5 participants start with the Wii, and then continue with the VR headset.

Day 2 / Group 2: All 5 participants start with the VR headset, and then continue with the Wii.

4.6.1 Wii™ scenarios

All participants played the bowling game of the “Wii™ Sports Resort” CD with the Nintendo Wii™. Each session started with an explanation of the Wii™, the controller and gameplay by the principal investigator (i.e. the author of this thesis) and a few training shots before starting the actual game. The first 1-2 rounds were played with the default avatar. Then the observer suggested to personalize the avatar and to play with the personalized avatar afterwards. The time for the Wii™ scenarios varied between 20-40min including explanations and personalizing the avatar.

4.6.2 Virtual reality scenario

All participants used the Virtual Reality headset BoboVR Z5™ (‘BOBOVR Z5’, n.d.) in conjunction with the smartphone Samsung S7™ for watching 360° HD videos of the nature (underwater world with turtles and fish, flight over mountains, Northern Lights, etc.). In the beginning the VR headset was shown to them. They could look at it and touch/hold it to get familiar with it prior putting it over their heads. It was explained where the smartphone will be placed, where they had to look through, that they could listen to the sounds through the earphones if wanted, that nothing should hurt them and that they should tell the observer if anything unpleasant occurred. They were also told that they could look around in the VR world. During watching the videos the observer invited them to describe what they could see in order to check whether they could properly see the videos.

All the scenarios took place in a seated position (either chair or wheel chair) to create comparable conditions.

It was decided to conduct single sessions, i.e. only one participant at a time, to create a calm environment in which the observer was able to focus on each participant and provide guidance and explanations when needed (hence better observation possible). This was also done to avoid a feeling of embarrassment of the participants when trying something new for the first time (without being observed by other participants).

In each session a 3rd person of the RFCE staff was present for any case of emergency. The participants were brought to and picked up from the study location by the RCFE staff. All of them were using a wheel chair or a rollator.

4.6.3 Time schedule

1st day (27-Dec-2017) with group #1:

- 09:00am – 12:15pm: Three participants
- 02:00pm – 04:15pm: Two participants
- Each first playing the Wii™ bowling game with the default avatar, then with a personalized avatar
- Then watching 360° HD videos with the VR headset

2nd day (28-Dec-2017) with group #2:

- 09:00am – 12:15pm: Three participants
- 02:00pm – 04:15pm: Two participants
- Each first watching 360° HD videos with the VR headset
- Then playing the Wii™ bowling game with the default avatar, then with a personalized avatar

3rd day (29-Dec-2017):

- Interviews in two focus groups
- 09:10am – 10:00am: first group interview with three participants
- 01:10pm – 02:20pm: second group interview with three participants

4.6.4 Decisions leading to this setting

This section elaborates some of the considerations made prior to this study that lead to the setting described previously, in section 4.6.

Playing against each other

Initially a fourth scenario – where two participants would play the Wii™ bowling game against each other – was also planned, but due to timely and organizationally reasons this had to be dropped as the participants had therapies they had to attend to, the room (where this study happened) at the RFCE could only be booked for a limited amount of time and most of the participants needed someone that would guide them from and to their rooms for safety reasons.

Why not an interactive VR game?

Since the VR setup consisted of a customized Google Cardboard™ and a smartphone the options were limited. Different games have been tested upfront where the player could interact with the gameplay by leaning right, left, back, or forward. However, all of these had a rather fast gameplay which resulted in a feeling of dizziness and slight nausea after approx. 10-15 minutes. So, it seemed that this technology was not advanced enough and definitely not appropriate for

use with seniors. Also, since the observer cannot see what the player sees in such a scenario, giving instructions and helping the player would have been impossible with such a game speed. That being said, the search changed into finding something calm and relaxing where the immersion into virtual reality could be experienced with no rush.

Why not the Wii™ Fit Board?

After researching this option and watching online videos where seniors almost fell off that board or became annoyed as the board did not recognize their movements correctly, it was decided to not use it and rather keep the setting simple to lower the hurdle. Also, from personal experience, it was known that the board needs to run through a calibration for each new player which takes at least 10 minutes. After seeing senior players (in the videos) getting impatient when the board forced them to repeat their movements, this supported the decision for not using the Wii™ Fit Board.

Why the Wii™ Bowling game and not another Wii™ game?

Several games from the Wii™ Sports Resort CD have been tested and evaluated in the pilot and the Bowling game was the only game that had no time pressure, had a slow gameplay, and an easy handling of the controller (only 1-2 buttons needed to be used). It also had a clear and easy to understand goal and enabled the navigation and control of the avatar (moving the avatar left or right) without absolute necessity and hence could be learned at the player's own pace.

Why all in three days?

Considering that this study was done within an extra occupational study, naturally time was limited and called for a tight time schedule. These three days between Christmas and New Year's Eve turned out to be an ideal period as it suited all - participants, therapists and the author of this thesis. Furthermore, conducting all three events within a short period of time had the benefit that the participants were more likely to remember their experiences and hence would better be able to talk about it during the interviews.

4.7 Data Evaluation

Qualitative Content Analysis by P. Mayring is the chosen method of data analysis in this thesis. He suggests the following different analytical techniques: summary/inductive category formation, explication, structuring/deductive category formation or mixed steps.

Mayring (Mayring, 2014, p. 64) describes them as follows:

Summary: The object of the analysis is to reduce the material in such a way that the essential contents remain, in order to create through abstraction a comprehensive overview of the base material which is nevertheless still an image of it.

Explication: The object of the analysis is to provide additional material on individual doubtful text components (terms, sentences...) with a view to increasing understanding, explaining, interpreting the particular passage of text.

Structuring: The object of the analysis is to filter out particular aspects of the material, to give a cross-section through the material according to pre-determined ordering criteria, or to assess the material according to certain criteria.

In this study, a mixture of the summary and structuring techniques has been applied. A comprehensive structuring analysis alone would not have been applicable, because little is known about the motivation of elderly for using VR-based technologies as well as their experiences when using such products. Therefore, forming categories deductively based solely on existing literature was not an option. Also, the explication method was not chosen, since the text material (interviews and protocols) was partially concise preventing the explication of ambiguous passages. In order to counteract the danger of building a final category system too fast (and as such 'forcing' the text into those categories) or missing relevant context for answering the research questions, the summary approach (group interviews) and structuring methods (observational protocols) complemented by graphic representations (see chapter 5) were chosen.

In detail:

Analysis of the group interviews

First, the text material (i.e. the two group interviews) was analysed summarizing, i.e. the categories were built inductively based on the text material (two group interviews). The text was paraphrased, then the paraphrases were generalized, semantically identical paraphrases were erased (= first reduction), and the remaining paraphrases were clustered thematically (= second reduction) resulting in four to five categories with a few differences between the two group interviews. The categories of both interviews were reviewed and revised several times which finally resulted in five categories as shown in Table 6 in Chapter 5. The summarized results were compared with the research questions, which showed that most of the motivation related questions remained unanswered after analysing the group interviews.

Analysis of the observational protocols

Due to the nature of the observational protocols (free-hand notes, verbal expressions of the participants, scalable ratings, check boxes, etc.) applying the beforehand used summarizing method was not appropriate.

Therefore, after defining categories for the research questions, a table for the coding guideline was created including definitions of each category and some coding rules and anchor examples. Then the text material was screened and relevant text passages were highlighted and assigned to the respective categories. While screening and coding the text material, definitions and anchor samples were constantly added (and revised) to the coding guideline and coding rules were formulated when deemed necessary. Categories were modified and re-arranged. As a consequence, the research sub-questions

- “Do they show interest in learning how to use new technologies?”
- “Do the players remember the instructions and control? Or are repeated explanations needed?”
- “How do they learn?”
- “Do they try to figure out how to achieve better results?”

were categorized within the first category “Cognitive and physical requirements”. This resulted in the final eight categories as displayed in Table 5 of chapter 5.

In addition, a type-building content analysis based on the observed moods of the participants has been conducted. The analysis can be found in Table 8 in section 5.1.2.

5 Results

"*Technology is best when it brings people together.*" – Matt Mullenweg

Upon interpreting the interviews as per Mayring's summarizing content analysis, followed by a structuring content analysis (content and scaling) of the observation protocols, the results presented and described in the following sections could be obtained. The implications of the results are further discussed in Chapter 6.

The results will be presented based on the following categories.

Deductively built categories of the observation protocols

For the analysis of the observational protocols, the categories were built in advance based on the clustered research questions. This resulted in the following categories and sub-categories:

Table 5 Deductively built categories for the structuring analysis.

Categories	Answered research question category (see section 4.2)	Sub-categories
Physical and cognitive requirements	1.1.	Physical: • Fine-motor skills • Gross-motor skills • Overall wellbeing Cognitive: • Curiosity and willingness to learn • Concentration and short-term memory
Attitude regarding new technologies	1.2.	• Signs of fears (of contact)
Handling	1.3.	• Buttons
Problems	1.4.	• Usage of applications
Self-reliance	1.5.	• Barriers • Intuitive • Asking questions
Hurdles	2.1.	• Triggers for frustration, nervousness, etc. • Discouraging factors • Making first contact smoother
Engagement	2.2.	• Fun factor • Fascination • Encouraging factors • Emotional factors
Control	2.3.	• Fun learning • Personalizing Avatar • Self-confidence

The results will be presented in the following sections within chapter 5.

Inductively built categories of the group interviews

As described in section 4.7 the categories used to analyse the two group interviews were generated inductively derived from paraphrasing and summarizing the given text material. After several revisions of the categories and their assigned paraphrases, the five categories as shown in Table 6 were acquired.

Table 6 Inductively built categories of the summarizing analysis.

	Category	**Answered research question category (see section 4.2)**
1	Attitude	1.2.
2	Handling	1.3.
3	Problems	1.4.
4	Engagement	2.2.
5	Control	2.3., 1.1

As can be seen in the table above, the last category, called “Control”, also addresses research questions from the first research question category (in detail: 1.1. b), d) and e)), as all learning related statements were assigned to this category in the sense of “realizing and learning how to gain control over the gameplay and navigation”.

The results of these categories (eight categories with 29 sub-questions as defined in section 4.2) will be presented in the following sections within chapter 5.

5.1 Experience

The first main research question is about the elderly people’s perception of and experience with virtual reality applications. It consists of five categories of which each category has five or less sub-questions as presented in section 4.2. Therefore, the results in chapter 5 are structured in the same way to provide consistency within this thesis.

5.1.1 Physical and cognitive requirements

The first category of the first main research question will present the results derived from the observation protocols and interviews. The following results are structured as per the same order of the research sub-questions as defined in section 4.2.

a) What are the physical requirements to use such technologies?

Fine-motor skills

During the observations, it could be seen that three out of ten participants (ID 2, 5, and 6) pushed wrong buttons unintendedly due to lacking fine-motor skills. One participant (ID 1) was able to hold the Wii™ controller, but was not able to push, hold and release buttons at all. Also, five out of ten participants (ID 4, 7, 8, 9, 10) had good fine-motor skills and never touched any button unintentionally. Out of these five participants, one (ID 8) played with an impaired hand/arm by supporting herself with her other hand.

Gross-motor skills

The majority of the participants had no problem with swinging their arm back and forth with the Wii™ controller, besides some left or right twists, which the participants recognized and tried to adjust the position of the avatar accordingly. Only one participant (ID 4) – except for the one with ID 1 who aborted the Wii™ game before an assessment of her gross-motor skills could be done – was not able to perform a steady straight backswing on her own. Additionally, the last participant (ID 10) was observed to perform a very good steady and straight backswing.

Overall wellbeing

One participant (ID 4) was still recovering from being sick (gastric flu) a few days before the study sessions took place. Being still convalescent, she was confused, jittery and nervous when entering the room and did not recall that she and the researcher had already met during the recruitment phase of this study. Throughout the whole session, she was distracted and could not focus on learning the controls. She became frustrated and demotivated quickly which led to aborting the bowling game after one and a half round and starting the VR video with a depressed mood. After one VR video, she wanted to end the whole session and asked if she could repeat this on any other day, as she did not feel like herself that day.

Another participant (ID 10) complained about back pain and wanted to stop after watching VR videos and playing one round of the Wii™ bowling game, although he learned the controls and gameplay very fast.

Vision

Furthermore, it was also observed that a rather good vision is required to read the instructions on the screen, to see and follow the game play properly and to read the button labels.

b) Do they show interest in learning how to use new technologies?

Only one participant (ID 1) did not show any interest or motivation to try these new technologies and aborted the Wii™ bowling game after three throws with the words "*Why should I do that? I am not learning anything here… it is a stupid game! I don't want to do this any longer*". One participant (ID 2) wanted to continue playing the Wii™ bowling game after five rounds. The convalescent participant (ID 4) asked if another session on another day would be possible so she could try it again when feeling better.

Another participant (ID 6) actively requested to try the Wii™ after using the VR headset.

In addition, all six interviewees showed interest when asked if they would be willing to try another technology in the future.

c) Do the players remember the instructions and control?

It was observed whether the participants needed additional explanations concerning the controls during the Wii™ bowling game. The results are displayed in the table below.

Table 7 Additional explanations required.

	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
In the 1st round	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Towards the end	Yes	No	No	Yes	Yes	Yes	No	No	No	No

From Table 7 above it can be seen that within the first round of bowling every participant needed additional explanations. For a better overview, Figure 4 has been created, which illustrates that towards the end of the game only four of the ten participants needed repeated explanations regarding the gameplay and controls, whereas six participants did not need continuous verbal guidance anymore.

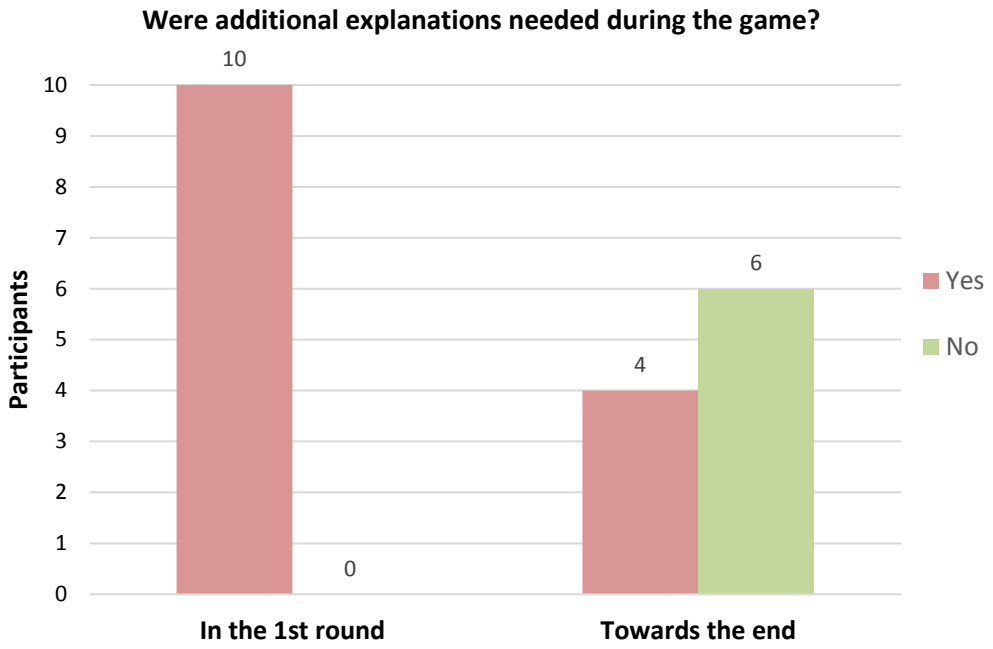

Figure 4 *Additional explanations needed during the game.*

Furthermore, it was observed that five participants (ID 2, 5, 8, 9, and 10) could remember the controls. Four of those five participants also memorized the menu navigation (in between rounds).

Also, two participants (ID 2 and 4) were observed to forget to release the button on the Wii™ controller when throwing the bowling ball. ID 2 learned and improved during the second round of bowling, but ID 4 could not remember when to hold and when to release the button until the end. Moreover, three participants (ID 3, 6, and 7) did sometimes forget the correct handling (when to press what).

To recap, half of the participants (ID 2, 5, 8, 9, and 10) could remember the controls, while the other half could memorize the handling either partially (ID 3, 6, and 7) or not at all (ID 1 and 4).

d) How do they learn?

Four out of ten participants tried to learn the Wii™ controls on their own by concentrating, reading and following the messages with instructions on the screen, and by trying different buttons on purpose to see what would happen. Two of those four participants observed the researcher's actions and applied this acquired knowledge afterwards.

One participant (ID 8) mentioned during the interview: "*I learned that if I bend over double [while moving the arm back for the swing], then it works better*", which was reinforced by another participant (ID 2): "*Yes, the more you bend down, the more boost you'll get*".

Another participant (ID 3) said, "*You need to hit exactly the centre, and then all [pins] will drop*".

e) Do they try to figure out how to achieve better results?

Four out of ten participants were very attentive and eager to learn. Two of those four players tried to improve independently by correcting the position of their avatar before throwing the bowling ball.

5.1.2 Attitude regarding new technologies

The second category of the first main research question will present the results derived from the observation protocols and interviews. The following results are structured as per the same order of the research sub-questions as defined in section 4.2.

a) What is accepted better: VR headset or Wii™?

The Wii™ was accepted better as stated by all six participants in the interviews.

The participant with ID 8 explained, "*Because you can do something and not only look around... I do not really need the glasses [VR headset]… I can watch TV instead…* " and another participant (ID 2) confirmed laughingly: "*Yes, exactly! There [playing Wii™ bowling] is some action going on*".

Another participant (ID 7) gave the following reason: "*I always wanted to try bowling since I was a girl, but this was a man's thing back then, you know*".

Furthermore, one senior (ID 3) said that the VR headset caused "*claustrophobic feeling. I don't want to wear anything on my head*", although he enjoyed watching the videos as he looked around a lot while watching three videos. In addition, his memories were triggered as he began to talk about past (good) experiences.

b) What is the general attitude of elderly towards these technologies?

During the sessions, the participants' initial moods have been noted on the observation protocols. In order to answer this and the next research question (as listed below), these observed moods have been analysed as per Mayring's type-building content analysis (Mayring, 2014, p. 105).

1.2. Attitude regarding new technologies

b) What is the general attitude of elderly towards these technologies?
c) Do they show signs of fears?

The terms 'general attitude' and 'signs of fears' have been defined as follows.

Definition of 'signs of fears'

If participants show at least two of the following nine observed negative moods, it implies that they have fears of contacts towards trying new technologies: nervous, afraid, worried, annoyed, grumpy/down, stressed, tense, demotivated or sceptical in the beginning.

Definition of 'general attitude'

If participants show at least two of the following seven observed moods (marked with an * in Table 8), it implies their general attitude towards trying new technologies: curious, cheerful, or motivated and annoyed, grumpy/down, or demotivated in the beginning.

Table 8 Type-building content analysis of the observed moods.

Mood		ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10	#
Curious*			x	x	x	x	x	x	x	x	x	**9**
Cheerful*			x				x	x		x		**4**
Motivated*			x				x	x	x	x		**5**
Nervous		x	x	x	x	x	x	x	x	x		**9**
Afraid		x			x		x		x			**4**
Worried				x	x			x	x		x	**5**
Annoyed*		x										1
Grumpy/down*		x										1
Stressed					x							1
Tense		x	x	x		x			x	x	x	**7**
Demotivated*		x										1
Sceptical				x						x		2
Signs of fears		x	x	x	x	x	x	x	x	x	x	10
General attitude	+	0	**x**	x	x	x	**x**	**x**	**x**	**x**	x	5
	-	**x**	0	0	0	0	0	0	0	0	0	1

Result regarding 'general attitude'

Nine of ten participants seemed to be very curious when entering the room, looking around and having a small talk to make them feel comfortable. Of those nine participants four appeared overall rather cheerful and motivated to start the sessions. One person (ID 8) was not cheerful in the beginning but motivated to try the technologies. Only one participant (ID 1) showed signs of being demotivated, grumpy and annoyed right from the beginning and soon aborted the session.

In Figure 5 the number of the relevant moods, as defined on page 56, have been illustrated by a diagram. It can be seen that nine participants (ID 2-10) attended the study with a positive attitude, and only one participant showed up with an overall negative attitude. However, it should be noted that as per definition only five of those nine participants radiated at least two positive moods.

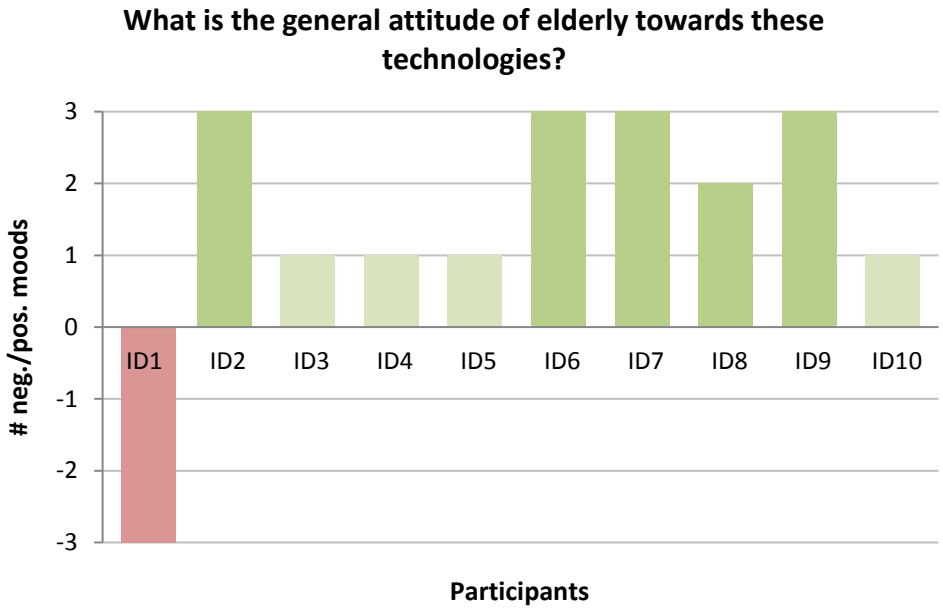

Figure 5 *Number of observed negative and positive moods regarding the general attitude.*

To sum up, four participants showed all of the three positive moods (besides being also nervous, afraid, tense or sceptical), while two positive moods could be observed for one more participant (ID 8), and only one participant was all negative at the beginning of the session.

c) Do they show signs of fears?

Looking at Table 8, it can be seen that all participants were either nervous (nine participants) and/or tense (seven participants) and/or worried (five participants) before trying new technologies. Of the nine nervous participants, six appeared

tense, four seemed worried, four were also afraid and two were rather sceptical. The one participant that did not appear nervous seemed worried and tense.

For a better visualization, as per the definition of 'signs of fears' on page 56 the number of moods per person of the above analysis (Table 8) have been illustrated by the diagram in Figure 6.

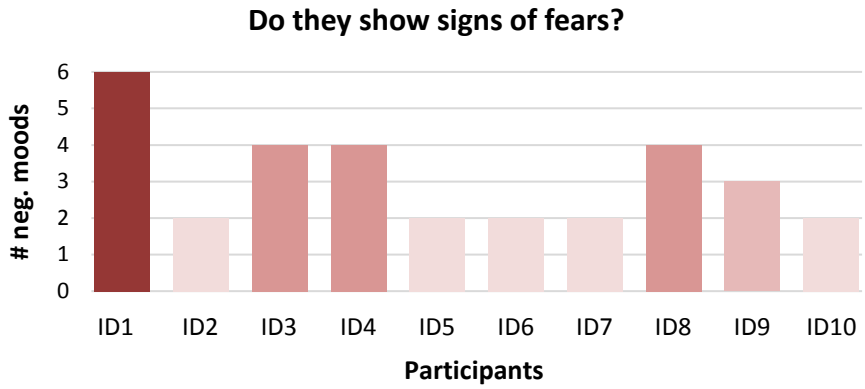

Figure 6 *Number of observed negative moods.*

The above diagram illustrates that one person (ID 1) showed six negative moods, three persons (ID 3, 4, and 8) showed four negative moods, and for the remaining five participants (ID 2, 5, 6, 7, and 10) two negative moods could be observed.

When one of the female participants (ID 4) saw the smartphone used in conjunction with the VR headset, she anxiously remarked that she has always problems when using her own phone.

In addition, for another two participants (ID 5 and 7) an initial scepticism towards the VR headset was observed. This was recognized by their sceptical looks and because they only slowly, after several invitations to move their head, started to look around the virtual environment. The researcher also noted during the observations that the woman with ID 7 also did not dare to navigate through the Wii™ menus on her own and always waited for the researcher to help her.

At the beginning of the session, one female participant (ID 8) remarked worriedly, "*I don't know any of that… I don't know how to do it*".

Also, during the interview, one participant (ID 3) mentioned "*It was easy… although I was nervous the night before… fear of failing… but then I thought that wearing these glasses [VR headset] and a little bit of bowling cannot be that hard*".

To sum up, all participants showed at least two signs of fears of contacts before trying something new for the first time.

5.1.3 Handling

The third category of the first main research question will present the results derived from the observation protocols and interviews. The following results are structured as per the same order of the research sub-questions as defined in section 4.2.

a) Do they get easily used to the concept of gaming controllers?

There have been no problems observed or mentioned during the interviews with the concept of the Wii™ controller. Every participant understood the concept after explaining and showing how it works.

During the interviews, the woman with ID 8 mentioned that she liked the controller, as she "*couldn't lift a real bowling ball*".

b) Is the handling of the controller, with its buttons, problematic?

The handling of the controller was rated on a scale, similar to grades, from "1" (very good), "2" (good), "3" (satisfying), "4" (enough) to "5" (not enough) after the participants' first round and in the end by the investigator. 'Very good' was defined as 'being able to learn and master the controls', whereas 'not enough' was defined as 'not able to learn and master the controls at all'.

Table 9 Rating of the handling of the controller.

	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
After 1st round	5	3	3	4	3	2	2	1	1	1
In the end	5	**1**	**2**	4	**2**	2	2	1	1	1

As it is shown in Table 9, the participants showed already different performances in the handling of the controller after the first round. Only three improved towards the end of the game. The best grade was given three times (ID 8, 9, and 10), because those participants were able to learn and master the controls already after a few throws of the virtual bowling ball. The performance of the participant with ID 1 was graded as 'not enough' as she would not push, hold and release the buttons as instructed. The only other "bad rated" participant (ID 4) was still convalescent and kept forgetting when to push and release the buttons and was also not able to perform a straight steady backswing until the end (see also section 5.1.1).

Furthermore, it was observed that three participants (ID 2, 5, and 6) unintendedly touched/pressed the wrong buttons sometimes due to age-related restrictions of their fine-motor skills as mentioned in section 5.1.1.

During the interviews, two participants had ideas on how to improve the controller for their needs:

Female participant (ID 8): „*It would be better, if this round button [‚A'-button] would stand out a bit more.*"

Male participant (ID 5): „*It would be better, if the round button [‚A'-button] and the directional pad would be moved downwards. Then they could be reached better with the thumb.*"

c) How is the VR headset experienced?

During the observations, the researcher graded the VR headset experience of the participants, based on their reactions and statements, on a 5-Point-Likert-Scale ranging from "-2" (very bad) to "2" (very good). Figure 7 illustrates the results of these observations.

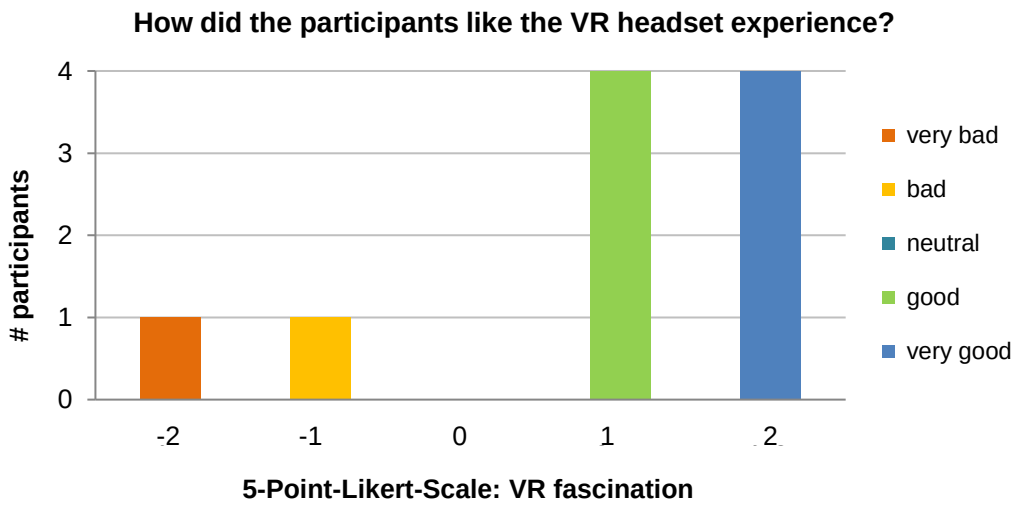

Figure 7 *Rating of the VR headset experience.*

In the above diagram, it can be seen that eight of ten participants experienced the immersion into the 360° HD videos as quite fascinating or at least seemed to like and enjoy it as they watched willingly three or four videos as shown in Figure 11.

During the interviews, one participant (ID7) said that she would want to watch more videos: *"Yes, I would be interested in sailing. My son did this a few times and would love to know and feel what he is raving about".*

When asked how it felt one participant (ID 3) said the VR headset caused a "*claustrophobic feeling. I don't want to wear anything on my head*".

Whereas others expressed their perception of the immersion as follows:

Participant with ID 2: "*It feels closer than TV… like being right in the middle of it!*"

Participant with ID 8: "*In the beginning it felt a little strange… but you get used to it!*"

When asked if they would want to use it again sometimes in the future, this is what they answered:

Participant with ID 2: "*Yes, for adult movies [laughs]!*"

Participant with ID 8: "*Yes, but I don't know if I could stand for example a romantic movie that close to my face [laughs]!*"

The researcher also felt that the majority of the participants appeared relaxed after watching the VR videos compared to the beginnings of the sessions.

5.1.4 Problems

The fourth category of the first main research question will present the results derived from the observation protocols and interviews. The following results are structured as per the same order of the research sub-questions as defined in section 4.2.

a) Is wearing glasses an obstacle (with VR headset)?

During the interviews, all that wore spectacles said that it was not a problem at all, they were able to see very well and that it did not feel uncomfortable (ID 2 and 7). This can also be confirmed based on the observations during the sessions.

b) Where are the difficulties/problems regarding usage of the used technologies?

The observed difficulties are mostly the same as already described under section 5.1.3 under point b) on page 60.

Two participants stood out as negative samples. One of them (ID 1) could not hold the controller while pushing and releasing the required buttons on her own. The other one (ID 4) mentioned that she felt an unpleasing pressure on her nose caused by the VR headset. This is being discussed further in section 6.1.4.

The diagram in Figure 8 illustrates the most common physical and cognitive problems that have been observed during the sessions. It can be seen that the

occurrence of physical and cognitive related problems among the participants balanced each other.

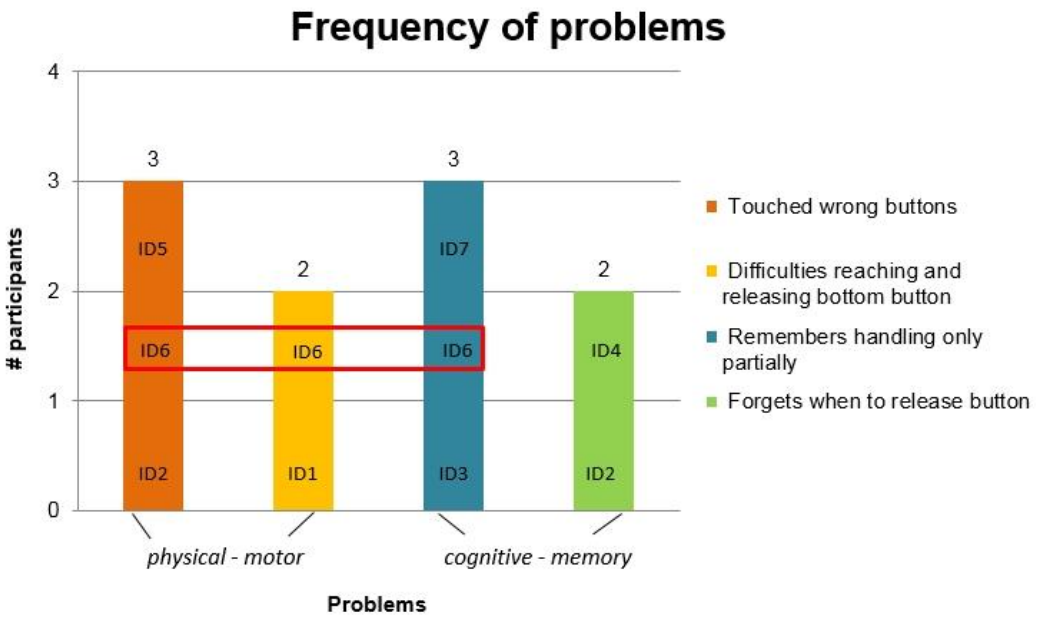

Figure 8 *Diagram of the most frequent problems occurred.*

Furthermore, the participant with ID 6 was observed to have three of the four observed problems. Another participant (ID 2) also showed cognitive as well as physical problems, although he had these problems only during the first round.

It should also be mentioned that the female participant with ID 1 appears only one time in this diagram (under 'difficulties reaching and releasing bottom button') as she aborted the game after three throws. As such, she did not play long enough to also show other problems.

5.1.5 Self-reliance

The fifth category of the first main research question will present the results derived from the observation protocols and interviews. The following results are structured as per the same order of the research sub-questions as defined in section 4.2.

a) Can they use VR applications also alone, without a supervisor?

During the sessions, the participants could only try navigating on their own while playing with the Wii™ as selecting and playing the 360° HD videos on the smartphone and putting it into the VR headset correctly was done by the researcher.

So, when asked, during the interviews, if they would have the confidence to use it alone, this was referring to the Wii™. All six interviewees were confident that they could use the Wii™ on their own, i.e. navigating through the menus, as can be seen in the following comments:

Female participant with ID 8 said: "*Yes! I did watch you! This didn't look difficult… it was almost always just reading [the messages on screen] and pushing the round button ['A' button]! We can do that [laughs]*".

Male participant with ID 5 stated: "*Yes, I already tried all buttons on purpose [laughs]*".

And another female participant (ID 7) mentioned: "*Yes, but only if nothing [bad] happens, if I would do something wrong*".

Based purely on the results of the observations, only three participants (ID 8, 9, and 10) were able to play Wii™ bowling on their own.

b) If not, what are the hurdles to do so?

The only observed and noted hurdle was their fear of doing something wrong as expressed by the woman with ID 7 in section 5.1.5 a) previously.

c) Is the application intuitive for older people? Or get they stuck quickly?

During the observations, it was noted that more than half of the participants (ID 3, 4, 5, 6, 7, and 9) waited for the researcher's help to navigate through the Wii™ menus at some point during the session. The player with ID 9 only waited for the instructor to navigate through the menus in the beginning, i.e. within the first round. Two (ID 8 and 10) understood how to navigate and which buttons to press after a few throws. The participant with ID 1 aborted the Wii™ session after three guided throws.

During the interviews all six participants said that the Wii™ bowling game was neither too difficult nor have there been too many buttons.

d) Do the seniors ask questions when unsure on how to proceed?

In order to answer this question, it was observed how often participants asked questions. Figure 9 shows that two participants (ID 2 and 4) asked the same questions more than ten times – namely: "*Why is this not working?* (ID 2)" and "*When should I release the button again?* (ID 4)" when they forgot to release the bottom button when throwing the bowling ball – but that the majority (eight players) asked less than five questions.

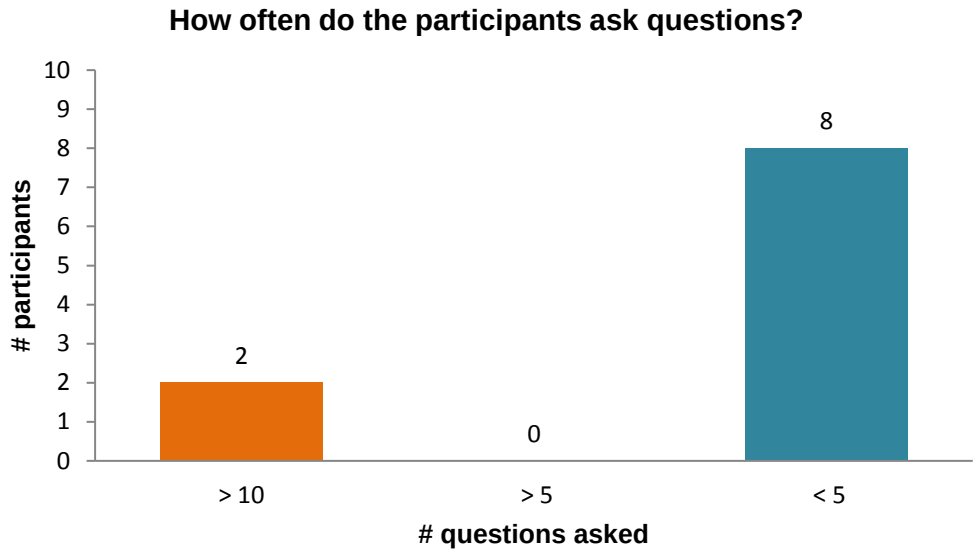

Figure 9 *Number of asked questions during the sessions.*

5.2 Motivation

The second main research question is about the elderly people's motivation to use virtual reality applications. It consists of three categories of which each category has 3-5 sub-questions as presented in section 4.2. Therefore, the following results are structured in the same way to provide consistency within this thesis.

5.2.1 Hurdles

The first category of the second main research question will present the results derived from the observation protocols and interviews. The following results are presented as per the same order of the research sub-questions as defined in section 4.2.

a) At which point/event do they get bored / angry / frustrated / nervous / worried / impatient etc.?

b) How does this feeling become visible?

In order to answer these two questions, negative feelings and/or reactions and its triggers have been observed.

Participant with ID 1 was observed to become frustrated and angry as she could not handle the controller and said that she did not see anything while wearing the

VR headset. She slouched her shoulders, appeared grumpy and did not move her head after several invitations to do so.

One woman (ID 4) was frustrated, as she could not memorize the controls (Wii™). She aborted the game after one and a half rounds. Additionally she then also stopped the VR headset session after watching only one video with a wave of her hand. She was down and disappointed which she expressed by shrugging her shoulders and shaking her head.

Another male player (ID 5) was observed to be a bit annoyed with his bad throws as he shook his head and exclaimed statements like "*Can this be true?*" or "*Why this again?*" when making a mistake.

Four participants (ID 3, 6, 9, and 10) got impatient when personalizing their Wii™ avatar.

One men (ID 3) was tense and nervous when putting on the VR headset as he kneaded his hands constantly.

Furthermore, one participant (ID 9) mentioned that the VR nature videos were boring and that he would like to see something with more action.

c) What discourages them?

During the sessions, the following discouraging factors have been observed:

- Cannot handle the Wii™ controls due to lack of fine-motor skills
- Cannot see anything during the videos with the VR headset
- Cannot memorize the handling of the Wii™ controller
- A frustrating Wii™ session spoiled the enjoyment of the videos with the VR headset
- Poor general condition spoiled the first attempt of learning something new
- Aborted the session because of back pain

d) What could be changed in order to make their first contact with new technology smoother?

The conclusions drawn from the observations and interviews to answer this question will be discussed under section 0.

5.2.2 Engagement

The second category of the second main research question will present the results derived from the observation protocols and interviews. The following results are presented as per the same order of the research sub-questions as defined in section 4.2.

a) How long/many rounds do they participate?

During the sessions, the rounds of Wii™ bowling played and VR videos watched by each participant were noted in order to answer this question. It was observed that one to five rounds of Wii™ bowling were played. Figure 10 illustrates how many rounds the participants played with the Wii™. It can be seen that most (six out of ten) participants played two rounds, two participants played one (or less – like ID 1) round, another one played three rounds, and one participant played five rounds of bowling and would have continued if time had permitted that.

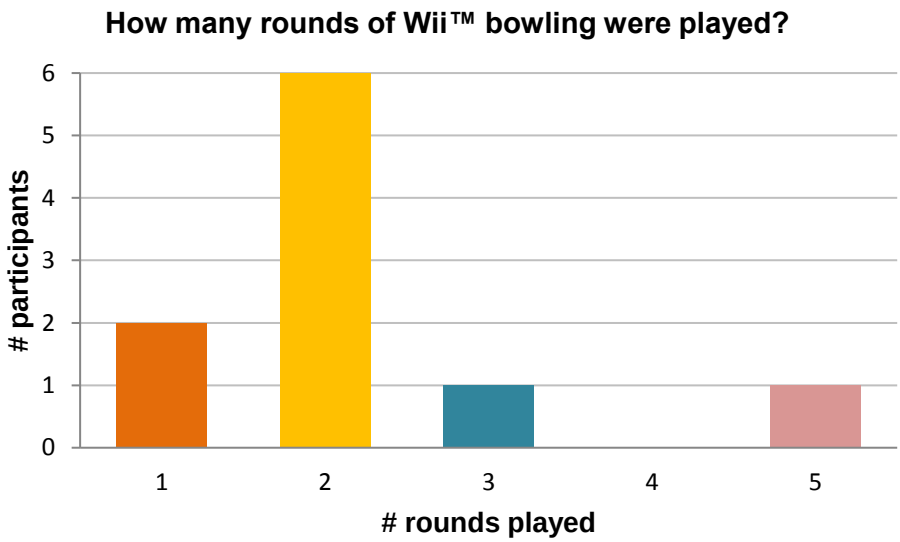

Figure 10 *Number of rounds played with Wii™.*

Figure 11 presents the numbers of watched 360° HD videos with the VR headset per participant. The majority (eight participants) watched either three or four videos. Two participants watched two or less videos and nobody watched five nature videos with the VR headset.

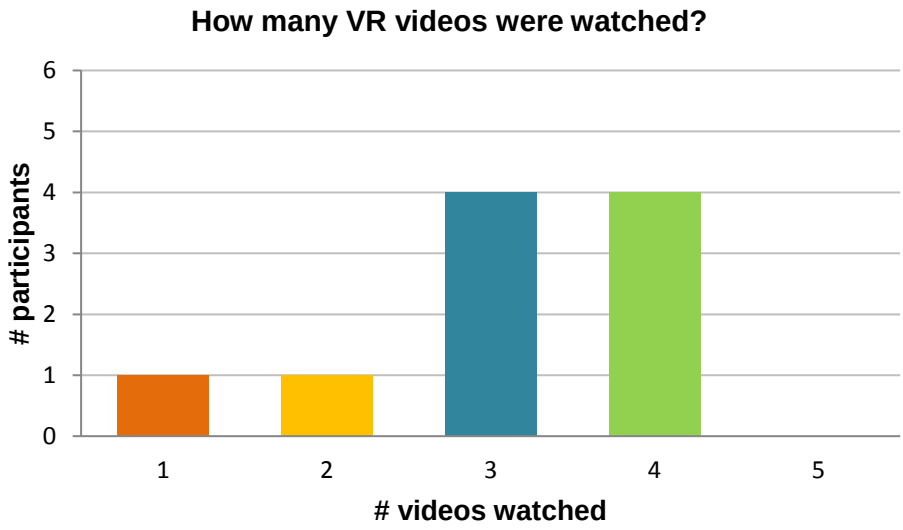

Figure 11 *Number of 360° HD videos watched with VR headset.*

b) What is fun for them?

In order to answer this question, situations where the participants laughed, smiled or expressed their positive feeling in other ways, were observed and noted.

Three participants were openly happy about good throws or other achievements, such as being able to play Wii™ with an impaired arm (ID 8). Two women had fun during personalizing their Wii™ avatar which was also confirmed during the interviews as one of them (ID 7) said "*I wanted the laughing mouth [for her avatar], because I have fun when bowling*".

Besides, the majority, i.e. all participants except for the ones with ID 1 and 4, enjoyed making big realistic bowling movements when swinging the Wii™ controller.

c) What is experienced as fascinating or interesting?

During the observations, in order to measure the perception of the immersion into the virtual nature of the VR videos, the participants' overall appearances (based on their reactions and expressions) were rated on a 5-point-Likert-Scale by the researcher.

Eight out of ten participants experienced the immersion into the 360° videos as quite fascinating or at least seemed to like and enjoy it as they watched willingly three or four videos as can be seen in Figure 7. Only two participants did not enjoy the VR videos.

One participant (ID 9) mentioned during the interview that diving into a virtual reality was exciting for him and that he liked especially the video with the "*hammerhead sharks – they were great! One headed directly towards me, haha*". Another men (ID 5) stated "*The underwater world did fascinate me*", followed by the comment by this woman (ID 8): "*The turtle… when she came that close to me… such a big thing!*"

Another point that one participant (ID 5) found interesting was to figure out the controls, i.e. what happens when pressing a specific button on the Wii™ controller, as he tried pressing each button on purpose to see what would happen.

d) What encourages and is important for them?

Scores – competition

During the sessions, it was observed that four volunteers (ID 2, 3, 5, and 6) wanted to know their scores achieved during the Wii™ bowling game.

Social interaction

One woman (ID 4) mentioned that the bowling game would be more fun if playing it together with others.

During the interviews, this became also visible as all six participants agreed that playing with others would be more fun than playing alone.

Furthermore, two participants (ID 2 and 8) expressed their need for more social interaction by explaining that they do not have many conversations with other residents at the RFCE.

When asked if they would like to play more often, one participant (ID 5) said "*Yes, but only with others…*" followed by participant with ID 2 who pointed out, "*I would play every day! Every day! Especially if we could play against each other*". The woman with ID 8 added, "*Yes, me too… maybe we could also get a few residents to get up from their beds, if we play together*".

Ambition

One female player (ID 8) was testing her boundaries by willingly handling the Wii™ controller with her impaired arm. She supported herself with her other arm during the swinging bowling movement. This achievement was important to her as she declared, "*One can even play with a damaged hand, if one wishes to do so! Write that down*". She also said that she liked the personalized avatar, as "*you don't just see the ball rolling*".

When asked if they would like to play one vs. one (duels), their ambition became clear:

ID 8: "*That would be fun!*"

ID 2: "*Yes, a lot [of duels]! … If enough ambition is there…*"

ID 8: "*It [ambition] is!*"

ID 5: "*Yes, I would hit them all!*"

e) Do any memories and/or emotions get triggered while using the Wii™ or the VR headset?

When watching the 360° HD nature videos, the male volunteer with ID 3 began to talk about real-life experiences, such as the one time he tried turtle soup and the mountains he visited in Switzerland.

Another female participant (ID 7) was moved when playing bowling with the Wii™ as she "*always wanted to try bowling! But it was just for men in the past… now with 83 years, ha, I can finally try it*".

5.2.3 Control

The third category of the second main research question will present the results derived from the observation protocols and interviews. The following results are presented as per the same order of the research sub-questions as defined in section 4.2.

a) Do they have fun learning something new?

In order to answer this question, situations where the participants seemed happy, proud, satisfied or eager to learn were observed. The following occurrences were noted during the observations:

- A strong desire to proceed playing with the Wii™
- At the end of the session, proud/satisfied with himself despite initial fears of contact
- Having fun testing each button on the Wii™ controller
- Having fun learning quickly by watching the researcher's actions

b) Do they like personalizing the Wii avatar?

One participant (ID 2) did not want to personalize the avatar, as he wanted to keep playing and not lose time.

One woman (ID 8) had fun personalizing the avatar. During the interviews she said "*I liked it [personalizing the avatar] very much… so cute! I am the girl with the two braids, haha*". Another woman (ID 7) had a similar experience as she

explained that she wanted a laughing mouth for her avatar as she had fun playing bowling with the Wii™.

That being said, a majority of six participants (ID 3, 4, 5, 6, 9, and 10) agreed to personalize the avatar, but were overwhelmed by the wide choice of settings. The researcher had to expedite the process by giving them less choice and only focusing on a few key points like the hair and eye colors. Otherwise, the participants got impatient and lost interest in personalizing the avatar.

c) Does an increase in self-confidence show?

The researcher noted the following signs during the sessions:

In the beginning, one participant (ID 3) appeared nervous, tense, and worried that he would embarrass himself. However, towards the end of the session, he was happy and satisfied with himself, which he expressed through a proud grin. During the interview, he explained that he was nervous the night before the session, but then thought he could manage a little bowling and wearing a VR headset.

In addition, proud exclamations during the bowling game were observed in three participants (ID 5, 7, and 8).

5.3 Summarized results of the interviews

Concluding the Results chapter, this section will present the reduced results of the two focus group interviews. The interviews had been analysed as described in section 4.7 on page 48, which resulted in the following tables (one per group interview). On the left side, the five categories are shown and on the right side, the corresponding paraphrased and reduced results are listed.

Table 10 Results of the first group interview.

Attitude	• Aversion to computers in general • Initial fears of contact/nervousness • No further interest in VR headset • Frequent playing with the Wii desired • **Liked the Wii bowling game** • **Good feeling afterwards**
Handling	• Handling of Wii controller good; not too many buttons • **VR headset comfortable to wear**
Problems	• Claustrophobic feeling of VR headset • Wheels on the wheelchair interfered during the backswings

	• Spectacles used under VR headset are no problem
Engagement	• **Checking scores against each other** • **Playing together or against each other desired** • **Desire for interacting with the game/being active** • Wish to experience sailing (not possible in real life anymore) • Trying bowling was an old unfulfilled wish (only for men in the past) • **Frequent and longer playing with others is desired** • **Immersing into VR environment is fascinating** • **More VR videos are desired**
Control	• Bowling game was not too difficult • Control over game realized and strategy developed • Confidence to navigate through the menu if no negative consequences • **Liked personalizing the avatar** • Personalizing the avatar doesn't matter

Table 11 Results of the second group interview.

Attitude	• **Wii better than VR headset** • Fun despite lack of prior experience
Handling	• VR headset comfortable to wear • Buttons of Wii controller: buttons should be closer to the thumb to make it easier reaching them; buttons should stand out more • Wii controller great as real bowling ball would be too heavy
Problems	• Videos with VR headset is passive, replaces TV set • VR headset strange at first • VR headset needs settling-in period • Wheels on the wheelchair interfered during the backswings • Spectacles used under VR headset are no problem

Engagement	• **Playing together or against each other**
	  ○ Would fuel ambition/enthusiasm
	  ○ Checking scores against each other
	  ○ More fun
	  ○ Would motivate other people as well
	  ○ Would enable more communication and exchange among themselves
	• **Frequent and longer playing with others is desired**
	• **Desire for interacting with the game/being active**
	• Immersing into VR environment is fascinating
	• VR environment feels closer than TV
	• VR environment feels like being right in the middle of it
	• **More VR videos are desired**
	• Wish for more action/exercise
	• Desire to share their enthusiasm

Control	• **Learned controls through watching the researcher and by trial and error** • **Control over game realized and strategy developed (throwing technique)** • Liked personalizing the avatar

These tables illustrate the essential points of the interviews. The statements that were mentioned more than once were highlighted in bold for better visibility. As can be seen, the six interviewees had mostly the same experiences except for one participant (ID 3) who actually enjoyed the sessions, but had an aversion against computers. So, during the interview, when asked if he would like to play more often with the Wii™, he first replied "*I want to have my peace!*", but after listening to the other participants he added smirking "*If a woman would also play… goofing around a bit… then I would want to play*".

The sections 5.1 and 5.2 include additional appropriate excerpts from the interviews to help answering the 29 research sub-questions.

6 Discussion

"*New technology is not good or evil in and of itself. It's all about how people choose to use it.*" – David Wong

6.1 Experience

This section will cover how elderly users experience the general applicability of virtual reality applications. Physical and cognitive requirements, the seniors' attitude towards the used technologies, the general handling and problems during the usage of the VR devices as well as the participants' ability to use them without supervision, will be discussed.

6.1.1 Physical and cognitive requirements

1. What are the physical requirements to use such technologies?

Fine-motor skills

During the recruitment process, all participants had to grasp the Wii™ controller to check whether they would be able to play the bowling game.

As previously mentioned (see section 5.1.1), it was observed that some participants touched the wrong buttons unintendedly due to lacking fine-motor skills. However, it was also the researcher's perception that this did not bother the participants or lower their ambition. They either learned how to quickly work around these short interruptions (the game would pause when pressing the wrong button during shooting the ball and by pressing a specific button it would continue) or started to be more conscious of their finger and hand movements. The question is if they would still have fun after playing it several times and still pushing the wrong buttons unintendedly. In other words, would a lack in fine-motor skills destroy their enthusiasm in the long term?

This consideration resulted in two hypotheses:

1. Participants are able to improve the fine-motor skills when playing the Wii™ bowling game more often over a larger period of time, e.g. 2 times per week for 30 minutes over a period of 12 weeks.

2. Participants get demotivated, frustrated and lose interest in the Wii™ bowling game if they cannot improve their fine-motor skills over time.

Gross-motor skills

Being able to lift and slightly swing the arm was considered a “hard” requirement during the recruitment phase. Although performing a directed steady backswing with the controller was considered a “soft” requirement – as the Wii™ allows initiating the bowling action also with only a small manual movement – it was observed that the participants executed big energetic backswings with the controller to simulate the real bowling movement. This seemed to help them to immerse into the game’s virtual environment. Some were even convinced that bending down was important for building up momentum. As one participant (ID 8) mentioned during the interview: *"I learned that if I bend over double [while moving the arm back for the swing], then it works better*”, which was reinforced by another participant (ID 2): *"Yes, the more you bend down, the more boost you'll get"*.

This led the author of this thesis to the following hypotheses:

1. Simulating the real movements (though might not necessary) helps the players to immerse into a game's virtual environment and get into a flow-like state.
2. Playing a VR game as if it was the "real thing", is more fun than doing just the bare minimum (regarding controls and handling).

Overall wellbeing

As described in section 5.1 a), one participant (ID 4) was still convalescent after a gastric flu, which made her jittery and confused, and not able to focus and concentrate on the instructions and game play. Another participant (ID 10) did not want to continue due to back pain. Thus, the state of health and overall wellbeing are important factors when it comes to learning and enjoying a VR game. In a future study, it could be examined whether those participants suffering from a slightly affected (but temporary) health condition at first, would 1) be willing to try the VR game again once they convalesced and 2) be better and have more fun then.

On further reflection, the following hypotheses were generated:

1. If the first attempt of a new technology is affected by the participant feeling unwell, then he or she is more likely to develop an aversion to this technology.
2. Seniors who have a temporary sickly constitution lack concentration and short-term memory when learning something new.

3. Do they show interest in learning how to use new technologies?

Although one participant (ID 4) was jittery and rather confused due to still being convalescent after a flu, nevertheless she asked if she could try it again as soon as she would have recovered. Considering the fact that she was still convalescent, this is a clear indicator for a strong interest in learning these new technologies.

Some of the participants also showed great interest in learning the controls on their own and to improve their gameplay by adjusting the position of their avatar before throwing the bowling ball.

Furthermore, as shown in Table 8, the majority of participants (9 out of 10) seemed to be very curious when entering the room, looking around interested and motivated to start the session. On the contrary, there might be a risk of bias, i.e. people would probably not agree to participate in a study if they would not be curious.

However, one participant (ID 6) even actively asked to switch from the VR videos to the Wii™ as he could not wait to also try the bowling game.

Therefore, the following hypothesis was deduced:

If someone is naturally curious and likes to play, then he or she will learn the usage of new technologies easier and faster than seniors who are neither into playing games nor curious to learn something new.

4. Do the players remember the instructions and control?

Looking at the results within section 5.1 c), it should be mentioned that some of those six participants managed the basic controls, but needed to be remembered that they could also move their avatar to the left or right side or that they could turn sideways before shooting the bowling ball. That being said, it can be concluded that, with more exercise, remembering the controls and navigating through the menu should be no hurdle for 60% of the participants.

5. How do they learn?

As mentioned in section 5.1.1 d) four participants were observed to be highly concentrated by reading and following the on-screen messages during playing Wii™ bowling. One participant preferred clicking on each button to see what would happen. Others observed the instructor and followed her actions. Furthermore, the researcher also found that it is also very important to give the elderly the time they need to learn new things at their own pace.

To sum up, the participants learning strategies ranged from the trial and error principle, via self-study to watching and replicating the instructor's actions.

6. Do they try to figure out how to achieve better results?

The time to try the Wii™ bowling game and the VR headset was limited, but first signs of trying to figure out strategies regarding their throwing technique could be observed. During the interviews, the participants liked to talk about their findings.

Glännfjord et al. (2017) also found in their study that the participants liked to discuss their tactics on how to throw the virtual bowling ball best.

6.1.2 Attitude regarding new technologies

a) What is accepted better: VR headset or Wii™?

In general, all interviewees agreed upon that they preferred the virtual bowling game to the VR videos. Besides, almost nobody told anyone about the VR sessions, because, as per them, nobody would care about it, which is a sign for loneliness and missing social interactions. Playing Wii™ bowling together with others could counteract this situation. Li et al. (2018) also found that the use of exergames (including the Wii™) showed positive results for reducing isolation amongst the elderly. Feeling lonely and isolated could also be the reason why they preferred the Wii™ to the VR headset since the usage of such a headset would just lead to being even more reclusive from the outside world. The following hypothesis should be investigated:

When comparing the application of a HMD (must be used alone) to an exergame (played with/against others), participants prefer the exergame for being more social.

The participants might had more vivid memories of the Wii™ experience as it was more active and required more mental capacity (learning and memorizing movements and controls), which is similar to learning a motoric activity like riding the bike compared to watching a movie.

Furthermore, one participant was very happy about being able to play bowling with the Wii™ since she wanted to try bowling since she was a girl.

Thus, it could be motivating for seniors to try virtual reality applications that help them fulfill wishes from their youth, such as riding a hot-air balloon or learning how to sail. Nap, Kort, & IJsselsteijn (2009) came to the same conclusion in their study.

b) What is the general attitude of elderly towards these technologies?

As mentioned in section 5.1.2 the participant with ID 1 appeared demotivated and annoyed right from the beginning of the session, although she seemed happy to participate in this study during the recruitment phase. Her mood did not light up during watching the 360° HD videos with the VR headset. She claimed that she could not see anything. The researcher checked that the video on the smartphone was being displayed correctly multiple times. Thus, it can be argued that the participant simply had a bad day and did not want to actively learn anything new. Also, it should be mentioned that she was not able to use the Wii™ controller solely on her own as she could not push and release the required buttons. That circumstance seemed to turn the balance and finally made her quit the game after only three throws. Looking at Table 8 and as described in section 5.1.2, it is clear that she was in a negative and hostile mood right from the beginning, which certainly made it difficult to get her interested in anything new.

Whereas the participant with ID 8 had an impaired arm, but managed to help herself by using her other arm to support her impaired arm when throwing the VR bowling ball. She was very proud of her achievement and emphasized, "*One can even play with a damaged hand, if one wishes to do so! Write that down!*". Being able to even play with her impaired arm seemed to really boost her self-confidence. Though she was also nervous, afraid, tense, and worried (see Table 8) in the beginning, as she did not know how to use these technologies at first, she was also curious and motivated and soon her ambition, enthusiasm and competitive spirit took over and changed her mood to being happy and engaged.

Looking at these two contrasting participants, it becomes clear that it is difficult to make a generalized statement. However, it can be concluded that not *only* does the initial mood or condition play an important role but also someone's personality and attitude.

From this, it follows that if the participant's general attitude is mostly positive, then a positive overall experience is more likely.

Another study supports the researcher's impression that in general the elderly are rather open-minded and curious to use virtual technologies as the authors describe an overall positive experience of the seniors when trying mobile controlled games (Sirkka et al., 2012).

c) Do they show signs of fears?

As shown in Table 8, all participants showed signs of fears when trying a new technology for the first time. Possible reasons for this could be for fear of technology or because it was an unusual new activity for them, or due to the study situation where they have been under constant observation by the researcher.

6.1.3 Handling of controller

a) Do they get easily used to the concept of gaming controllers?

Every participant understood that basically this works like a remote control as also used for TV sets. The fact that the Wii™ controller also has the same elongated shape as a TV remote had the additional advantage that the hurdle before entering was even smaller for these novice players. Also, showing each participant how to handle this controller in a relaxed environment without an audience seemed to lower the barrier to entry.

b) Is the handling of the controller, with its buttons, problematic?

Based on the researcher's impression during the observations and the results in section 5.1.3, it can be concluded that almost all participants (except for the one with ID 1) would be able to fully master the correct control with a little bit more time and training. Especially the four seniors rated with a 'good' in the end would surely benefit from a few more sessions in order to gain more confidence by realizing that nothing bad happens when pushing the wrong buttons.

That being said, it needs to be considered that the participant graded with 'enough' was still convalescent and as such confused, jittery and much stressed. She could barely concentrate and she quickly became discouraged as she could not memorize the controls and needed constant help from the instructor. However, it is the investigator's assessment that even this participant could learn the controls once she has fully recovered and is willing to try it again, because she was very interested and curious to try these technologies during the recruitment phase.

In sum, it is the author's impression that the handling of the controller is an initially challenging (mentally and regarding fine-motor skills), but manageable task for seniors (to remember when to push and release buttons, to do it with one hand, and coordinate the fingers simultaneously). In contrast, Palacio et al. (2017) found the interaction with the Wii™ difficult, complicated and not favorable for seniors when compared to other devices (Xbox™, MS Kinect™, and touchscreens). It is also interesting to note that the participants sometimes touched buttons unintendedly due to age-related fine-motor skill impairments, but that this did not lead to much anger, frustration or abortion of the game in most cases. This finding suggests that an enjoyable experience of VR applications is not influenced by age-related restrictions, which was also found in another study (Gerling et al., 2012)

Upon further consideration, it could be a motivating approach to let the three best attendees (ID 8, 9, and 10) teach the others how to use the controller. Nap et al. (2009) support this hypothesis as they found that the elderly players really enjoyed to explain the gameplay to the researcher. This would also increase

social interaction, which was one of the most requested aspects during the group interviews. At the same time, it would fight isolation and loneliness, which seem to be major problems throughout this age group (Li et al., 2018).

c) How is the VR headset experienced?

It is interesting to notice that all interviewees stated that they preferred the Wii™ to the VR headset as it gave them the possibility to actively engage in the gameplay, whereas watching VR videos was compared to the more passive scenario of watching TV. However, their statements contradicted the researcher's impression during the sessions as the VR headset experience was observed to be perceived as very good and fascinating or enjoyable as the majority of the volunteers watched three to four VR videos willingly. This has already been discussed under section 6.1.2 a).

While many of the participants seemed to enjoy the VR videos and fascinated looked around in the 360° virtual environment, one participant mentioned in the interviews that the VR headset caused claustrophobic feelings. This was also supported by the observation of him being tense and kneading his hands constantly. However, he also smiled and started to talk about memories and experiences.

Based on other statements during the interviews (see section 5.1.3), it can be concluded that the majority of the participants experienced immersion and were motivated to watch more VR videos in the future.

6.1.4 Problems

a) Is wearing glasses an obstacle (with VR headset)?

The participants that wore spectacles all confirmed that they could see everything clearly and experienced the VR headset as soft and comfortable.

b) Where are the difficulties/problems regarding usage of the used technologies?

As mentioned in the Results chapter under section 5.1.4, participant ID 1 had troubles holding the controller while pushing and releasing the required buttons on her own and participant ID 4 felt an unpleasing pressure on her nose caused by the VR headset. However, both are exceptional cases and have to be treated with caution. This means that the woman with ID 1 was extremely negative and grumpy right from the beginning, which surely influenced her behavior a lot. So, it cannot be taken for granted that she really physically was not able to handle the controller but that she most of all did not want to do it or did not want to find an alternative solution, such as participant ID 8 who supported her impaired arm with her healthier arm. Also, the claim that the VR headset pinched the other

woman's (ID 4) nose, came surprisingly, because when asked during the session, she said everything was fine. One possible reason for her complaint could be that she said it just because she did not want to continue watching videos anymore or maybe she was more sensitive due to still being convalescent. It would be interesting to look at such negative samples again in a longer study to see whether their conditions of that day played a major impact.

The following hypothesis was derived:

If you have the confidence and motivation, minor age-related handicaps will not prevent you from trying new VR products.

6.1.5 Self-reliance

a) Can they use VR applications also alone, without a supervisor?

All of the interviewed participants were confident that they could handle the Wii™ on their own. However, one participant clearly expressed her fears when saying that she would only do it, if nothing bad could happen. As this matches with the sensation that the participants also barely asked questions, it appears that this is preventing most of the seniors from trying new technologies or as a participant in another study expressed it: *"I am afraid that I am not good enough"* (Nap et al., 2009).

By giving the elderly more time for discovering VR applications through trial and error in a calm environment and by designing the software in a way so that they won't get stucked or kicked out of a game when pressing a wrong button, it should be possible to overcome this fear and give them the confidence they need to use those devices without being dependent on others.

On further reflection, a supervisor might be an additional motivation for using VR applications. He or she could encourage the participants by applauding, providing positive feedback and praising them. The added social interaction with the supervisor could also be a motivational aspect as also found in another study by Meekes & Stanmore (2017).

The selection and playing of the VR videos on the smartphone was done by the researcher as the challenge of putting on the VR headset for the first time, adjusting it accordingly, figuring out how to find and play the VR videos in the correct VR mode on the smartphone, would have probably been too difficult or at least adhering to the set time schedule for the sessions would not have been possible.

b) If not, what are the hurdles to do so?

As explained previously under 6.1.5 a), in this study, the only observed hurdle was their fear of being not good enough or doing something wrong. Thus, making the first contact with new technology as relaxed as possible and designing software applications with seniors in mind could help overcoming this hurdle. Further considerations on the first contact with a new VR application can be found under 6.2.1 d).

c) Is the application intuitive for older people? Or get they stuck quickly?

Based on the results on page 64, in order to answer this question, it has to be looked at the circumstances, such as that the participants only had about 20-35min for trying the bowling game with the Wii™. That is a short amount of time and hence with more time and more trials, the six participants that needed help for the navigation through the menus, would probably gain the confidence to just try it by themselves, which was the case for the participant with ID 9. He did not ask for help but instead waited for the researcher to chime in and help him, so he could watch what actions were required to continue. He was very observant and learned everything very fast.

It could also help, if they could watch the better players just as some of them observed the researcher to learn which button to press, where to point the controller and so on.

For an independent usage of the Wii™, it is essential that the player is able to understand and memorize the controls.

Furthermore, we have seen that with enough will power and motivation a lack of fine-motor skills can be compensated. However, in order to make the gaming experience more enjoyable, especially in the long-term, players should have the fine-motor skills to press and release buttons with their thumbs and index fingers.

In addition, it was also recognized that a lack of confidence showed in the form of fear that something bad happen if pressing the wrong button. Thus, there is need to boost the seniors' confidence by giving them as much time as they need to feel comfortable enough to use a VR application on their own. This might involve repeated explanations, a few guided sessions, and to praise their achievements to motivate them.

During the interviews all six participants said that it was neither too difficult nor have there been too many buttons and they all believed that they could use the Wii™ without a supervisor. These statements support the two possible reasons mentioned above.

d) Do the seniors ask questions when unsure on how to proceed?

The volunteers tended to not ask many questions. They rather waited for the instructor to help them when they were stuck. It was the researcher's impression that this was mainly due to pride (towards a much younger researcher) or being afraid to embarrass themselves. Another reason for them barely asking any questions could be that the reaction time to new situations for the elderly is longer and hence they need more time to grasp the situation and then articulate possible questions. Furthermore, it could be that the participants were highly concentrated (learning something new) and immersed in this virtual gaming experience that they did not realize that they could ask the researcher.

Based on the above, the following hypotheses were formulated:

- When giving the elderly as much time as they need, thus allowing them to learn at their own pace, they will ask more questions.
- Older people are too afraid of embarrassing themselves to ask questions when trying a new technology for the first time.
- Learning a new technology requires high concentration and deep focus, which makes the elderly participants forget their surroundings.

6.2 Motivation

This section will cover the motivational aspects of older people to try virtual reality applications. The hurdles and discouraging factors during their first contact with a new technology, the circumstances that encourage them, and the level of control they gained, will be discussed.

6.2.1 Hurdles

a) At which point/event do they get bored / angry / frustrated / nervous / worried / impatient etc.?

b) How does this feeling become visible?

These two questions are answered at once as they go hand in hand.

One participant was in a negative mood right from the beginning of the session. She could neither handle the Wii™ controller nor see anything when watching the VR videos. She also felt that the Wii™ bowling game did not provide any meaning or value to her. As per her, it was a stupid game from which she could not learn anything. Giving meaning to the day is an important motivational factor for seniors (Nap et al., 2009). From the short amount of time spent during the session, it is hard to tell if this participant really did not have the required skills to

properly handle and enjoy the applications or if her negative attitude and the lack of meaning resulted in an overall negative experience.

Another participant was still being convalescent, which made her jittery, confused and unable to concentrate. This led to frustration and finally she aborted the session. Thus, it can be followed that overall wellbeing is essential for enjoying and learning new technologies. This has also been discussed under 6.1.1 a).

During the observations, some of the elderly became impatient when selecting different eyes, nose, and hair to personalize their avatar. Having to choose between so many options was apparently overwhelming. Based on the researcher's experience with the participants in this study, a few different ready-to-go avatars to choose from or less choice would be better for senior players.

Another participant appeared slightly annoyed and impatient after a bad throw.

Impatience was also observed by Nap et al. (2009) as the elderly volunteers in their study seemed to be in a rush and quickly clicked away any pop-up messages or introduction sequences to be able to start and immerse into the game.

c) What discourages them?

Some of the discouraging factors observed, were lack of memorizing and handling the controls, a frustrating previous experience that spoiled the next one, and feeling unwell (see also section 5.2.1 c)). These factors have been discussed in more detail in section 6.1.1.

Furthermore, as suggested in another study (Meekes & Stanmore, 2017), playing with others could decrease the participants' self-confidence as they could feel watched or judged or because the other players might achieve higher scores. In order to avoid such discouraging situations that could potentially decrease the participants' motivations and deteriorate the overall experience, individual sessions with each volunteer were arranged in this study.

d) What could be changed in order to make their first contact with new technology smoother?

Based on the observations during the sessions, the researcher developed the following ideas to make the first contact with a new VR application more pleasant:

- Since some participants touched the wrong button unwillingly, gesture control (as with the MS Kinect™) instead of a controller with tiny buttons might be better for senior players, as this could compensate for missing fine-motor skills. However, gesture control needs to work precisely and fast in order to avoid frustrating the elderly users.

- Based on the impressions gathered during the sessions, it would be beneficial to give senior players more time to try new technologies at their own pace.
- As some participants were overwhelmed by the wide choice and became impatient while personalizing their Wii™ avatar, less choice and/or some preconfigured avatars they could select, would be recommended for the elderly community.
- The font size of the messages and the menus on the screen should be bigger and with high contrast. This also applies to the buttons on the Wii™ controller.
- Additional guidance through vibrating or blinking buttons could be provide in order to make it easier to find and press the correct button.

6.2.2 Engagement

a) How long/many rounds do they participate?

Though six out of ten participants played two rounds of Wii™ bowling, it should be noted that the duration of each session was limited to approx. one hour per participant and that this was their first try. That being said, it requires a lot of mental effort to learn something new, so two rounds were probably enough for the majority of the senior gamers, i.e. with more practice it gets easier and more rounds would most likely be desired.

They watched more VR videos than they played rounds of Wii™ bowling. Did they do this because they enjoyed the VR headset more than playing virtual bowling? During the interviews, they stated the opposite, i.e. that they preferred the Wii™ to the VR headset. On the other hand, did they just watch more VR videos, because watching a HD video was shorter than playing a round of Wii™ bowling?

The following hypotheses were derived:

- The VR experience is so enjoyable that the motivation to watch more videos is higher (than to play virtual bowling).
- The VR experience is so immersing that users lose track of time.
- The participants forget how much they like watching VR videos when directly compared to a more interactive and more challenging virtual game.

b) What is fun for them? I.e.: what makes them laugh/smile?

Overall, the Wii™ bowling game was experienced as a fun and enjoyable activity. Participants took pleasure in good throws or other achievements (like being able

to play with an impaired arm or fulfilling a childhood dream), praise and positive feedback from the researcher, had fun personalizing their avatar and enjoyed making realistic swings.

This observation of big swings to simulate the real movement and hence immerse into the virtual environment was also indicated in another study (Glännfjord et al., 2017).

Based on the above the following hypothesis can be derived:

Making realistic movements is fun and helps immersing into virtual reality.

c) What is experienced as fascinating or interesting?

The majority of the participants experienced the immersion into the VR videos as fascinating. During the interviews, they remembered what they had seen in the videos by giving vivid descriptions. One participant admitted that wearing the VR headset and diving into another world felt a little strange, but that he got used to it quickly.

Thus, feeling comfortable wearing a HMD and immersing into a virtual world, might take a bit longer for seniors than for younger generations.

Another participant was interested in the Wii™ controls and pressed each button to see what would happen. This was also discussed under 6.1.1 b).

d) What encourages and is important for them?

Some of the observed positive influences on the participants' motivation have already been discussed under 6.2.2 b). However, main findings in this regard were actively engaging into and gaining control over the gameplay (engagement and control), competition (comparing scores), social interaction (desire to play and exchange experiences with others), and ambition for self-improvement (achieving better scores).

Similarly, Nap et al. (2009) found that improving their skills, achieving better scores, and reaching the next level were the main motivational factors for the elderly participants to play digital games.

e) Do any memories and/or emotions get triggered while using the Wii™ or the VR headset?

One participant told the researcher about real-life experiences from his past. This was triggered through watching the VR videos. Another participant was really happy and thankful as she could finally try bowling which has been a childhood dream of her. These factors could also increase motivation to use the VR application.

Another study also reported that one participant started smiling and talking about the places she and her husband, who had dementia, had been together, which was probably caused by the Egyptian game setting. Immersing into the digital game made the participants forget their pain (Nap et al., 2009).

Playing the Wii™ bowling game mostly promoted feelings of fun and enjoyment.

The researcher assumes that even more emotions and memories were triggered through the VR videos. However, this is difficult to ascertain from an observer point of view.

6.2.3 Control

a) Do they have fun learning something new?

One participant (ID 2) still did not have enough and wanted to continue playing even after five rounds of Wii™ bowling. He also refused to build a personalized avatar, as he was eager to quickly continue the game with the default avatar. At the end of the session, he also asked smiling "*Tomorrow again?*", which shows his engagement and motivation to continue using the Wii™.

Besides, participants were observed to be proud and satisfied with themselves and were able to quickly overcome initial fears of contact through positive experiences and feelings of success. They also were very curious and motivated to learn the controls (see section 6.1.1 d)).

Overall, it can be concluded that the participants had fun trying these virtual reality applications. Although the questions remains whether this was just because they tried it for the first time and whether they would still continue using it in case their (fine-motor and mental) skills would not improve due to age-related impairments.

This was also discussed in a study (Glännfjord et al., 2017) where one participant said, *"I was more interested at the beginning, but as with new things the novelty of it is what's exciting"*. Findings suggested that some participants just kept using the Wii™ due to the social aspect of meeting the activity group weekly.

b) Do they like personalizing the Wii avatar?

Two female participants had fun personalizing the avatar. One woman explicitly wanted long blonde hair. Men were rather unimpressed or neutral in this regard. This leads to the following hypotheses:

- Women are more drawn to cute comic-like avatars than men are. This assumption is also supported by Nap et al. (2009) who found that male participants preferred realistic game design, whereas the female participants rather liked comic-like graphics.

- Women see avatars as digital self-representations – more than men do.
- Managing an avatar is influenced by gender.

Furthermore, Lin & Wang (2014) investigated users' motivation on creating avatar and identified four motivational factors: identity representation, social navigation, contextual adaption, and virtual exploration.

Research also found that women use avatars for representing their gender and rather change their digital appearance than men (Triberti, Durosini, Aschieri, Villani, & Riva, 2017).

Besides, most of the participants in this study seemed overwhelmed by the amount of personalization settings for their avatar. Therefore, the author's suggestion would be to reduce the selection size or to provide a few different ready-to-use avatars that could also be customized if desired.

Only one male participant was not interested in the avatar at all, as he enjoyed the game a lot and hence he did not want to pause it for personalizing the avatar. The author concludes that this participant was so immersed into the virtual gaming experience that any interruption would have caused a needless distraction for him.

c) Does an increase in self-confidence show?

All participants showed signs of fears of contact in the beginning of the sessions. However, at the end of the sessions most of them were satisfied with their achievements and left the room with a proud grin. The researcher concludes that more practice would lead to an independent handling of the controller and navigation through the Wii™ menus by most of the participants In further consequence, this would lead to an increase in self-confidence once they gained control over their actions, as gaining control is an important motivational factor for enjoying games (Sweetser & Wyeth, 2005).

6.3 Limitations

Quality of observation protocols

Due to the condition of the participants and no prior experience with such technologies, a lot of assistance and guidance was needed. Using the Wii™ completely on their own was barely possible – four out of ten participants needed help when to push and/or release or choose buttons and when navigating through the Wii™ menu. Therefore, maintaining/completing the observation protocols was challenging and some points had to be skipped throughout the observations. For future studies, two investigators and shorter observation protocols including more check boxes that are easy and quickly to handle would be recommended.

Quality of coding

In bigger qualitative studies, usually a team of researchers or at least two persons, i.e. coders, analyse the text material (interviews, protocols, etc.) independent from each other and compare their results with the aim of reaching the same conclusion. Mayring refers to this as the *intercoder reliability* (Mayring, 2015), while Kuckartz widens this term to *consensual coding* where he emphasizes the importance of consensus-building as a team effort (Kuckartz, 2016). Either way, a precise coding guideline (with clear defined categories) is the essential foundation for the coding process.

Since only one person was conducting and analysing this study, two analysis approaches were chosen to increase the quality of the coding procedure:

1. The two focus group interviews were analysed following the inductive category building approach, i.e. categories were derived from the interviews.

2. The observation protocols were analysed following the deductive category building approach, i.e. a detailed coding guideline with category definitions, anchor examples and coding rules was created prior the analysis and revised several times while analysing the material.

VR headset and technical hurdles

Based on the interview results, watching the 360° VR videos was not as enjoyable for the participants as playing bowling with the Wii™. Besides the fact that watching videos is a rather passive activity compared to actively engaging in a bowling game scenario, there are several other circumstances that could have influenced their decision.

On the one hand, the handling of a smartphone along with the VR headset is not very smooth and needs further improvement, for example: one has to remove the

smartphone of the mounting after each video and start the next video manually via touchscreen of the phone as the controller was not working properly during the pre-tests.

On the other hand the mobile connection in the room at the RFCE was very unstable and there was no Wi-Fi, so searching and loading the videos (which required mobile data, i.e. internet access) sometimes took longer than expected which in some cases led to impatience and annoyed the participants as they had to wait with the VR headset on.

Furthermore, there was no possibility for the researcher to verify what the participant was or was not seeing (other than removing the smartphone and checking the screen). In order to bypass this hurdle, the researcher asked the participants to describe in their own words what they could see. A positive side effect of this was that through their verbal expressions, it was better possible to experience their excitement and other feelings.

That being said, cutting edge (but also much more expensive) immersive VR technologies which are more convenient (regarding controls, screen resolutions, usage, etc.) - like the Oculus Rift or HTC Vive - would most likely generate a much more positive overall experience for the seniors. So, based solely on the used VR headset in this study, it is not advisable to make a generalization for all seniors using VR headsets as the above described technological inconveniences need to be taken into consideration.

Size of the sample

It should also be acknowledged that a sample consisting of ten elderly participants is too small in order to generalize the findings to the senior population. This small size was chosen due to the qualitative approach, enabling deeper analysis as explained in section 4.3.5. It is also important to note that the participants in this study did never try a VR headset or the Wii™ before, which allows a unique view on elderly people trying VR technologies for the first time.

Choice of the sample and participation

Five women and five men of different ages and with different cognitive and physical conditions have been included in this study. Such an inhomogeneous group might decrease internal validity; however, it also reflects reality, which in return increases external validity.

Four participants did not participate in the group interviews (e.g. due to illness or feeling unwell), i.e. the opinion and feedback of these participants is missing in this study. This was due to sickness or feeling unwell and could not be influenced. Further focus group appointments were not possible due to organisational resources of the RFCE and investigator.

It should also be considered that the participants within this study were recruited in a residential care facility and that community-dwelling seniors that are more autonomous might lead to different results.

6.4 Future studies

Considering the small sample size, there is need for further larger trials that conduct quantitative studies with a larger group of seniors investigating the gained impressions and hypotheses within this study. In addition, when conducting cognitive screening tests with the participants, the results of each sub-task (memory, concentration, attention, etc.) could be used to verify if there would be any correlations between the cognitive test results and the observed behavior.

The cognitive and physical requirements found in this study, could be used as inclusion and exclusion criteria for further research in this field. In addition, the ideas inferred from the observations could be used to make the first contact with a new VR application more pleasant.

Since some participants did not show an improvement in handling the controller, but had fun playing Wii™ bowling, an interesting follow-up question would be to observe if participants would continue having fun over a longer period of time (weeks or months), if they are not able to improve.

During the interviews, the participants all agreed that the Wii™ bowling experience was much more fun than watching the videos with the VR headset. Whereas during the actual sessions, eight out of ten participants enjoyed and liked watching the VR videos and watched three to four VR videos, while the majority of the participants played only two rounds of Wii™ bowling. Future studies should investigate this contradiction. Did the participants just forget how much they liked watching the VR videos when directly compared to the more active Wii™ game? Or were they so immersed that they lost their sense of time and forgot that they watched more VR videos than they played bowling rounds? What are their experiences when solely using a VR headset? In addition, future studies could also investigate the elderly's experiences when using more advanced HMD also allowing interaction with the virtual environment, as the interviewees in this study stated that watching the VR videos felt passive, like watching TV. To have an impact on the virtual experience can be a motivational incentive in the sense of having control (Sweetser & Wyeth, 2005).

The majority of the participants barely asked any questions during the sessions. Another researcher or second person that is older or closer to the average age of the sample could be beneficial in lowering the barrier of asking for help.

Alternatively, the volunteers that learned the controls and gameplay the fastest could teach the others how to use the controller and play the game. This could also increase self-confidence (in the sense of “When she can do it, I can do it!” as well as for the ones who are teaching), social interaction and decrease isolation (Nap et al., 2009).

7 Conclusion

"We do not stop playing because we grow old, we grow old because we stop playing!" – Benjamin Franklin

The purpose of this study was to gain a better understanding of elderly users by learning more about their motivation to use VR applications, by identifying problems during the usage, observing the participants' reactions and listening to them to gain more insight into their point of view when using VR technologies.

The findings of this study show that playing the Wii™ bowling game was mainly perceived to be entertaining, challenging and easy to understand (clear goal), although the handling of the Wii™ controller with its tiny buttons was tricky for some of the participants due to age-related handicaps (reduced grip strength, slight tremors, arthritis, etc.). Watching the 360° HD videos with the VR headset was mostly experienced as fascinating and interesting.

It was found that the main motivating factors to play virtual bowling were enjoyment, competition (comparing scores), and self-improvement (increasing scores and handling controls). The participants also expressed their wish to play together and against others to foster social connectedness and competition. It could also have positive impacts on frail elderly people (dementia or physical impairments), since one participant was even able to motivate herself to play with an impaired arm, which in return boosted her self-confidence.

Observed underlying motivations were to fulfil a childhood dream and to experience situations that were no longer possible in real life, such as sailing. Additionally, the researcher felt that most participants seemed relaxed after watching the VR videos. Therefore, relaxation also appears to be a motivational aspect.

From the elderly that participated, it appeared that virtual reality applications offer means to be more active and provide a reason to get out of their bed or rooms (at the RFCE). Overall, they were eager to learn something new and to gain control by improving their gameplay.

Most of the participants preferred playing the Wii™ bowling game to watching the VR videos. They described the bowling game as more active. Though the participants appeared to enjoy watching the videos, in the interviews, they compared it to the rather passive activity of watching TV. A possible reason for this could be that they were so engaged that they lost their sense of time and forgot how much they enjoyed it and that they watched more VR videos than they played bowling rounds. Another reason could be that they were missing the interaction with the virtual reality and hence the VR headset experience did not leave a lasting impression. Feeling lonely could be another reason why they preferred the Wii™ to the VR headset since the usage of such a headset would just lead to being even more reclusive from the outside world. Furthermore, fulfilling wishes from the youth that are no longer possible in the real world, such as experience sailing or riding a hot-air balloon, could also be another motivational factor for seniors to use virtual reality applications. In addition, it is questionable whether the enthusiasm for the Wii™ would last or if it was just the initial rush and excitement of trying something new for the first time. This is supported by a study by Glännfjord et al. (2017) where some people mainly continued going to the playing sessions at an activity center for seniors due to the social aspect of meeting other people.

Another remarkable aspect is that all participants showed signs of fears of contact before the sessions. It could be that this is connected to the fear of not being good enough. Considering the fact that most of the participants completed their sessions, it becomes clear that they were curious and motivated enough to overcome their initial nervousness and fears.

It is worth noting that the majority of the participants barely asked any questions during the sessions. It is possible that the participants were highly concentrated and immersed into the virtual reality so that they forgot the researcher's presence. Alternatively, pride and fear of embarrassment by asking something obvious might have kept the seniors from asking more questions. In addition, the age of the author of this thesis (about the age of the participants' grandchildren) could have also played a role. An interesting approach would be to let the best volunteers teach the other seniors how to use the controller as elderly players seem to enjoy explaining the gameplay to others (Nap et al., 2009). This would also increase social interaction, which was one of the most requested aspects during the group interviews.

While participants sometimes touched buttons unintendedly due to age-related fine-motor skill impairments, the majority did not become frustrated or angry. This finding suggests that an enjoyable experience of VR applications is not influenced by age-related restrictions, which was also found in another study (Gerling et al., 2012).

Another interesting observation was that some participants liked to execute energetic backswings with the Wii™ controller to simulate the real bowling movement. This seemed to help them to immerse into the game's virtual environment.

In conclusion, watching VR videos with a VR headset was experienced as fascinating, comfortable, relaxing and immersive. Therefore, they show great potential to provide an escape from reality and allow older people to re-live experiences or to make new ones that they are not capable of anymore in reality. The Wii™ bowling game was perceived as being actively engaging, fun, challenging, and easy-to-understand with a clear goal. Playing with others, enjoyment, self-improvement and competition were the main motivational incentives observed.

Literature

Allaire, J. C., McLaughlin, A. C., Trujillo, A., Whitlock, L. A., LaPorte, L., & Gandy, M. (2013). Successful aging through digital games: Socioemotional differences between older adult gamers and Non-gamers. *Computers in Human Behavior*, *29*(4), 1302–1306. https://doi.org/10.1016/j.chb.2013.01.014

Aloha VR. (n.d.). Retrieved 11 July 2018, from https://onecaringteam.com/

article bettvrwithage. (2017, April 27). Retrieved 14 July 2018, from https://www.wired.com/2017/04/vr-for-seniors/

Ashworth, N. L., Chad, K. E., Harrison, E. L., Reeder, B. A., & Marshall, S. C. (2005). Home versus center based physical activity programs in older adults. *Cochrane Database of Systematic Reviews*. https://doi.org/10.1002/14651858.CD004017.pub2

Azuma, R. T. (1997). A Survey of Augmented Reality, *Presence: Teleoperators and Virtual Environments*(6), 48.

Bailey, J., Bailenson, J. N., & Won, A. S. (2012). Presence and Memory: Immersive Virtual Reality Effects on Cued Recall, 8.

BETTVR WITH AGE. (n.d.). Retrieved 11 July 2018, from http://bettvrwithage.tumblr.com/

Bieryla, K. A., & Dold, N. M. (2013). Feasibility of Wii Fit training to improve clinical measures of balance in older adults. *Clinical Interventions in Aging*, *8*, 775–781. https://doi.org/10.2147/CIA.S46164

BOBOVR Z5. (n.d.). Retrieved 11 July 2018, from http://www.bobovr.com/product/bobovrz5/

Brach, M., Hauer, K., Korn, O., Konrad, R., Unkauf, S., Hardy, S., & Göbel, S. (2012). Motivotion60+: Entwicklung eines computeranimierten Systems zum Kraft- und Balancetraining für Senioren (P53). https://doi.org/10.13140/rg.2.1.2245.5126

Brüsemeister, T. (2008). *Qualitative Forschung*. Wiesbaden: VS Verlag für Sozialwissenschaften. https://doi.org/10.1007/978-3-531-91182-3

Burdea, G. C. (2003). Virtual rehabilitation--benefits and challenges. *Methods of Information in Medicine*, *42*(5), 519–523.

Calvillo Gamez, E. H. (2009). *On the core elements of the experience of playing video games* (Doctoral). UCL (University College London). http://discovery.ucl.ac.uk/18510/1/18510.pdf

Chao, Y.-Y., Scherer, Y. K., & Montgomery, C. A. (2015). Effects of using Nintendo Wii™ exergames in older adults: a review of the literature. *Journal of Aging and Health*, *27*(3), 379–402. https://doi.org/10.1177/0898264314551171

Chao, Y.-Y., Scherer, Y. K., Montgomery, C. A., Wu, Y.-W., & Lucke, K. T. (2015). Physical and psychosocial effects of Wii Fit exergames use in assisted living residents: a pilot study. *Clinical Nursing Research*, *24*(6), 589–603. https://doi.org/10.1177/1054773814562880

Chiu, H.-L., Chu, H., Tsai, J.-C., Liu, D., Chen, Y.-R., Yang, H.-L., & Chou, K.-R. (2017). The effect of cognitive-based training for the healthy older people: A meta-analysis of randomized controlled trials. *PloS One*, *12*(5), e0176742. https://doi.org/10.1371/journal.pone.0176742

Cho, J., & Lee, E.-H. (2014). Reducing Confusion about Grounded Theory and Qualitative Content Analysis: Similarities and Differences. *The Qualitative Report*, *19*(32), 1–20.

Clark, R., & Kraemer, T. (2009). Clinical use of Nintendo Wii bowling simulation to decrease fall risk in an elderly resident of a nursing home: a case report. *Journal of Geriatric Physical Therapy (2001)*, *32*(4), 174–180.

Comello, M. L. G., Francis, D. B., Marshall, L. H., & Puglia, D. R. (2016). Cancer Survivors Who Play Recreational Computer Games: Motivations for Playing and Associations with Beneficial Psychological Outcomes. *Games for Health Journal*, *5*(4), 286–292. https://doi.org/10.1089/g4h.2016.0003

Csikszentmihalyi, M. (2009). *Flow: The Psychology of Optimal Experience*. Harper Collins.

Csikszentmihalyi, M., & Csikszentmihalyi, I. S. (1992). *Optimal Experience: Psychological Studies of Flow in Consciousness*. Cambridge University Press.

Deci, E., & Ryan, R. (1985). *Intrinsic Motivation and Self-Determination in Human Behavior* (Vol. 3). https://doi.org/10.2307/2070638

Definition of AVATAR. (2018). Retrieved 14 July 2018, from https://www.merriam-webster.com/dictionary/avatar

Donath, L., Rössler, R., & Faude, O. (2016). Effects of Virtual Reality Training (Exergaming) Compared to Alternative Exercise Training and Passive Control on Standing Balance and Functional Mobility in Healthy Community-Dwelling

Seniors: A Meta-Analytical Review. *Sports Medicine*, *46*. https://doi.org/10.1007/s40279-016-0485-1

Dörner, R., Göbel, S., Effelsberg, W., & Wiemeyer, J. (2016). *Serious Games: Foundations, Concepts and Practice*. Springer.

Duque, G., Boersma, D., Loza-Diaz, G., Hassan, S., Suarez, H., Geisinger, D., … Demontiero, O. (2013). Effects of balance training using a virtual-reality system in older fallers. *Clinical Interventions in Aging*, *8*, 257–263. https://doi.org/10.2147/CIA.S41453

Esfahlani, S. S., Thompson, T., Parsa, A. D., Brown, I., & Cirstea, S. (2018). ReHabgame: A non-immersive virtual reality rehabilitation system with applications in neuroscience. *Heliyon*, *4*(2), e00526. https://doi.org/10.1016/j.heliyon.2018.e00526

FitDaheim. (n.d.). Retrieved 9 July 2018, from http://fitdaheim.com/

Flick, U., Kardorff, E. von, & Steinke, I. (Eds.). (2004). *A companion to qualitative research*. London ; Thousand Oaks, Calif: Sage Publications.

Franco, J. R., Karen, J., Catrina, I., & JoAnn, K. (2012). The effect of the Nintendo Wii Fit and exercise in improving balance and quality of life in community dwelling elders. *Technology and Health Care*, (2), 95–115. https://doi.org/10.3233/THC-2011-0661

Garcia, J., Raffe, W., & Felix Navarro, K. (2018). Assessing User Engagement with a Fall Prevention Game as an Unsupervised Exercise Program for Older People. https://doi.org/10.1145/3167918.3167943

Gerling, K., Schild, J., & Masuch, M. (2012). Exergaming for Elderly: Analyzing Player Experience and Performance. https://doi.org/10.1524/9783486712742.401

Glännfjord, F., Hemmingsson, H., & Larsson Ranada, Å. (2017). Elderly people's perceptions of using Wii sports bowling – A qualitative study. *Scandinavian Journal of Occupational Therapy*, *24*(5), 329–338. https://doi.org/10.1080/11038128.2016.1267259

Glaser, B. G., & Strauss, A. L. (1967). *The discovery of grounded theory: strategies for qualitative research*.

Harley, D., Fitzpatrick, G., Axelrod, L., White, G., & McAllister, G. (2010). Making the Wii at Home: Game Play by Older People in Sheltered Housing. In G. Leitner, M. Hitz, & A. Holzinger (Eds.), *HCI in Work and Learning, Life and Leisure* (Vol. 6389, pp. 156–176). Berlin, Heidelberg: Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-16607-5_10

Hee Cho, G., Hwangbo, G., & Soo Shin, H. (2014). The Effects of Virtual Reality-based Balance Training on Balance of the Elderly. *Journal of Physical Therapy Science*, *26*, 615–617. https://doi.org/10.1589/jpts.26.615

Higgins, H. C., Horton, J. K., Hodgkinson, B. C., & Muggleton, S. B. (2010). Lessons learned: Staff perceptions of the Nintendo Wii as a health promotion tool within an aged-care and disability service. *Health Promotion Journal of Australia: Official Journal of Australian Association of Health Promotion Professionals*, *21*(3), 189–195.

Hinojosa, J. (2007). Becoming Innovators in an Era of Hyperchange. *American Journal of Occupational Therapy*, *61*(6), 629–637. https://doi.org/10.5014/ajot.61.6.629

Jesús Casuso-Holgado, M., Martín-Valero, R., F Carazo, A., M. Medrano-Sánchez, E., Dolores Cortés-Vega, M., & José Montero-Bancalero, F. (2018). Effectiveness of virtual reality training for balance and gait rehabilitation in people with multiple sclerosis: a systematic review and meta-analysis. *Clinical Rehabilitation*, 026921551876808. https://doi.org/10.1177/0269215518768084

Jorgensen, M. G., Laessoe, U., Hendriksen, C., Nielsen, O. B. F., & Aagaard, P. (2013). Efficacy of Nintendo Wii Training on Mechanical Leg Muscle Function and Postural Balance in Community-Dwelling Older Adults: A Randomized Controlled Trial. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences*, *68*(7), 845–852. https://doi.org/10.1093/gerona/gls222

Kuckartz, U. (2016). *Qualitative Inhaltsanalyse. Methoden, Praxis, Computerunterstützung*. Beltz Juventa.

Kueider, A. M., Parisi, J. M., Gross, A. L., & Rebok, G. W. (2012). Computerized Cognitive Training with Older Adults: A Systematic Review. *PLOS ONE*, *7*(7), e40588. https://doi.org/10.1371/journal.pone.0040588

Lamnek, S. (2010). *Qualitative Sozialforschung: Lehrbuch*. Beltz.

Larkin, M. (2017). for cognitive and physical rehabilitation. *The Journal on Active Aging*, 7.

Laver, K., Ratcliffe, J., George, S., Burgess, L., & Crotty, M. (2011). Is the Nintendo Wii Fit really acceptable to older people? A discrete choice experiment. *BMC Geriatrics*, *11*, 64. https://doi.org/10.1186/1471-2318-11-64

Li, J., Theng, Y.-L., & Foo, S. (2016). Effect of Exergames on Depression: A Systematic Review and Meta-Analysis. *Cyberpsychology, Behavior, and Social Networking*, *19*(1), 34–42. https://doi.org/10.1089/cyber.2015.0366

Li, J., Witedwittayanusat, K., Chen, L., Cao, Y., Lee, S. Q., Erdt, M., & Theng, Y. L. (2018). The Social Effects of Exergames on Older Adults: A Systematic Review and Metric Analysis (Preprint). *Journal of Medical Internet Research*. https://doi.org/10.2196/10486

Lin, H., & Wang, H. (2014). Avatar creation in virtual worlds: Behaviors and motivations. *Computers in Human Behavior*, *34*, 213–218. https://doi.org/10.1016/j.chb.2013.10.005

Longhurst, G. (2013). Feasibility of using the Nintendo Wii to improve balance in the elderly. *European Journal of Sport Studies*. https://doi.org/10.12863/ejssxs1x-2013

Manjrekar, S., Sandilya, S., Bhosale, D., Kanchi, S., Pitkar, A., & Gondhalekar, M. (2014). CAVE: An Emerging Immersive Technology -- A Review (pp. 131–136). IEEE. https://doi.org/10.1109/UKSim.2014.20

Mayring, P. (2014). Qualitative Content Analysis, 144.

Mayring, P. (2015). *Qualitative Inhaltsanalyse: Grundlagen und Techniken* (12.). Beltz.

Meekes, W., & Stanmore, E. K. (2017). Motivational Determinants of Exergame Participation for Older People in Assisted Living Facilities: Mixed-Methods Study. *Journal of Medical Internet Research*, *19*(7), e238. https://doi.org/10.2196/jmir.6841

Mehrholz, J., Elsner, B., & Thomas, S. (2017). Virtuelle Realität: Was ist im Einsatz? *neuroreha*, *09*(01), 9–14. https://doi.org/10.1055/s-0042-124244

Miller, K. J., Dye, R. V., Kim, J., Jennings, J. L., O'Toole, E., Wong, J., & Siddarth, P. (2013). Effect of a computerized brain exercise program on cognitive performance in older adults. *The American Journal of Geriatric Psychiatry: Official Journal of the American Association for Geriatric Psychiatry*, *21*(7), 655–663. https://doi.org/10.1016/j.jagp.2013.01.077

MIRA. (n.d.). Retrieved 11 July 2018, from http://www.mirarehab.com/

Molina, K., Ricci, N., de Moraes, S., & Perracini, M. (2014). Virtual reality using games for improving physical functioning in older adults: a systematic review. *Journal of NeuroEngineering and Rehabilitation*, *11*(1), 156. https://doi.org/10.1186/1743-0003-11-156

Nap, H. H., Kort, Y. A. W. D., & IJsselsteijn, W. A. (2009). Senior gamers: Preferences, motivations and needs. *Gerontechnology*, *8*(4). https://doi.org/10.4017/gt.2009.08.04.003.00

Neri, S., Cardoso, J., Cruz, L., Lima, R., Oliveira, R., Iversen, M., & Carregaro, R. (2017). Do virtual reality games improve mobility skills and balance measurements in community-dwelling older adults? Systematic review and meta-analysis. *Clinical Rehabilitation*, *31*, 1292–1304. https://doi.org/10.1177/0269215517694677

Nintendo Wii. (n.d.). Retrieved 10 July 2018, from https://www.nintendo.at/Wii/Wii-94559.html

Noyes, J., Popay, J., Pearson, A., Hannes, K., & Booth, A. (2008). Qualitative Research and Cochrane Reviews. In *Cochrane Handbook for Systematic Reviews of Interventions* (pp. 571–591). Wiley-Blackwell. https://doi.org/10.1002/9780470712184.ch20

Oculus Go | Oculus. (n.d.). Retrieved 11 July 2018, from https://www.oculus.com/go/

Palacio, R. R., Acosta, C. O., Cortez, J., & Morán, A. L. (2017). Usability perception of different video game devices in elderly users. *Universal Access in the Information Society*, *16*(1), 103–113. https://doi.org/10.1007/s10209-015-0435-y

Patton, M. Q. (2002). *Qualitative Research & Evaluation Methods*. SAGE.

Pigford, T., & Andrews, A. W. (2010). Feasibility and Benefit of Using the Nintendo Wii Fit for Balance Rehabilitation in an Elderly Patient Experiencing Recurrent Falls, *2*(1), 9.

PlayStation®VR. (n.d.). Retrieved 11 July 2018, from https://www.playstation.com/de-at/explore/playstation-vr/

Prince, M. J., Wu, F., Guo, Y., Gutierrez Robledo, L. M., O'Donnell, M., Sullivan, R., & Yusuf, S. (2015). The burden of disease in older people and implications for health policy and practice. *The Lancet*, *385*(9967), 549–562. https://doi.org/10.1016/S0140-6736(14)61347-7

Rendever. (n.d.). Retrieved 11 July 2018, from https://rendever.com/

Ryan, R., Frederick, C., Lepes, D., Rubio, N., & Sheldon, K. (1997). Intrinsic Motivation and Exercise Adherence. *International Journal of Sport Psychology*, *28*, 335–354.

Ryan, R. M., & Deci, E. L. (2000). Intrinsic and Extrinsic Motivations: Classic Definitions and New Directions. *Contemporary Educational Psychology*, *25*(1), 54–67. https://doi.org/10.1006/ceps.1999.1020

Schoene, D., Valenzuela, T., Lord, S. R., & de Bruin, E. D. (2014). The effect of interactive cognitive-motor training in reducing fall risk in older people: a systematic review. *BMC Geriatrics*, *14*(1), 1.

Sirkka, A., Merilampi, S., Koivisto, A., Leinonen, M., & Leino, M. (2012). User experiences of mobile controlled games for activation, rehabilitation and recreation of elderly and physically impaired. *Studies in Health Technology and Informatics*, *177*, 289–295.

Snyder, C. R., & Lopez, S. J. (2009). *Oxford Handbook of Positive Psychology*. Oxford University Press.

Soares, W. J. S., Lopes, A. D., Nogueira, E., Candido, V., Moraes, S. A., & Perracini, M. R. (2018). Physical Activity Level and Risk of Falling in Community-Dwelling Older Adults: Systematic Review and Meta-Analysis. *Journal of Aging and Physical Activity*, 1–28. https://doi.org/10.1123/japa.2017-0413

Stasieńko, A., & Sarzyńska-Długosz, I. (2016). Virtual Reality in Neurorehabilitation. *Advances in Rehabilitation*, *30*(4). https://doi.org/10.1515/rehab-2015-0056

Statistik Austria. (2016). Todesursachen im Überblick. Retrieved 18 April 2018, from https://www.statistik.at/web_de/statistiken/menschen_und_gesellschaft/gesundheit/todesursachen/todesursachen_im_ueberblick/056591.html

Stoetter, N. (2017). Gaming 2016 – Beobachtungen aus der Spieleindustrie. *neuroreha*, *09*(01), 15–18. https://doi.org/10.1055/s-0043-101146

Sweetser, P., & Wyeth, P. (2005). GameFlow: a model for evaluating player enjoyment in games. *Computers in Entertainment (CIE)*, *3*(3), 3–3.

Temoche, P., Ramirez, E., & Rodríguez, O. (2012). A Low-cost Data Glove for Virtual Reality (p. TCG 31-36).

Thomas, K. S., Baier, R., Kosar, C., Ogarek, J., Trepman, A., & Mor, V. (2017). Individualized Music Program is Associated with Improved Outcomes for U.S. Nursing Home Residents with Dementia. *The American Journal of Geriatric Psychiatry*, *25*(9), 931–938. https://doi.org/10.1016/j.jagp.2017.04.008

Triberti, S., Durosini, I., Aschieri, F., Villani, D., & Riva, G. (2017). Changing Avatars, Changing Selves? The Influence of Social and Contextual Expectations on Digital Rendition of Identity. *Cyberpsychology, Behavior, and Social Networking*, *20*(8), 501–507. https://doi.org/10.1089/cyber.2016.0424

VIVE. (n.d.). Retrieved 11 July 2018, from https://www.vive.com/de/

Watt, T., Gee, S., & Scott-Multani, M. (2017). Music to our ears: Personalised music and dementia. Retrieved 11 July 2018, from https://www.researchgate.net/publication/318685627_Watt_T_Gee_S_Scott-Multani_M_2017_Music_to_our_ears_Personalised_music_and_dementia_OT_Insight_385_8-9

WHO | Ageing and health. (2015). Retrieved 18 April 2018, from http://www.who.int/mediacentre/factsheets/fs404/en/

Wiemeyer, J. (2017). Serious Games in der Neurorehabilitation – Ziele, Anforderungen und Perspektiven. *neuroreha*, *09*(01), 19–23. https://doi.org/10.1055/s-0043-101147

Wüest, S., Borghese, N. A., Pirovano, M., Mainetti, R., van de Langenberg, R., & de Bruin, E. D. (2014). Usability and Effects of an Exergame-Based Balance Training Program. *Games For Health Journal*, *3*(2), 106–114. https://doi.org/10.1089/g4h.2013.0093

Zelinski, E. M., & Reyes, R. (2009). Cognitive benefits of computer games for older adults. *Gerontechnology : International Journal on the Fundamental Aspects of Technology to Serve the Ageing Society*, *8*(4), 220–235.

List of Figures

List of Tables

Appendix

A. Informed Consent

PatientInneninformation[1] und Einwilligungserklärung zur Teilnahme an der Beobachtungsstudie

SeniorInnen und deren Motivationsaspekte und Wahrnehmung bei Virtual Reality Anwendungen

Sehr geehrte Teilnehmerin, sehr geehrter Teilnehmer!

Wir laden Sie ein an der oben genannten Beobachtungsstudie teilzunehmen. Die Aufklärung darüber erfolgt in einem ausführlichen Gespräch.

Ihre Teilnahme an dieser Studie erfolgt freiwillig. Sie können jederzeit ohne Angabe von Gründen aus der Studie ausscheiden. Die Ablehnung der Teilnahme oder ein vorzeitiges Ausscheiden aus dieser Studie hat keine nachteiligen Folgen für Ihre medizinische Betreuung.

Beobachtungsstudien sind Studien, bei denen in der Regel nur Daten aufgezeichnet und ausgewertet werden, die im Rahmen der normalen Patientenversorgung anfallen. In manchen Fällen kann es auch sein, dass zusätzliche, nicht belastende Untersuchungen oder Befragungen vorgenommen werden. In keinem Fall wird die für Sie vorgesehene Behandlung durch Ihre Studienteilnahme verändert. Beobachtungsstudien sind notwendig, um zusätzliche Erkenntnisse über bereits bewährte medizinische Verfahren zu gewinnen.

Zu dieser Beobachtungsstudie, sowie zur Patienteninformation und Einwilligungserklärung wurde von der zuständigen Ethikkommission eine befürwortende Stellungnahme abgegeben.

1. Was ist der Zweck dieser Studie?

Der Zweck dieser Beobachtungsstudie ist es herauszufinden, welche motivierenden Faktoren SeniorInnen dazu bringen, Virtual Reality Anwendungen zu benutzen und etwaige Probleme im Umgang mit diesen Anwendungen zu identifizieren.

Diese Studie wird im Zuge meiner Diplomarbeit (an der FH St. Pölten) in Ihrem Pflegewohnhaus Simmering durchgeführt.

2. Wie läuft die Beobachtungsstudie ab?

Diese Studie wird im Pflegewohnhaus Simmering durchgeführt, und es werden insgesamt ungefähr 10-30 Personen daran teilnehmen. Ihre Teilnahme wird voraussichtlich an 3-4

[1] Wegen der besseren Lesbarkeit wird im weiteren Text zum Teil auf die gleichzeitige Verwendung weiblicher und männlicher Personenbegriffe verzichtet. Gemeint und angesprochen sind – sofern zutreffend – immer beide Geschlechter.

Terminen in den nächsten Wochen im Dez 2017 und Jan 2018 stattfinden. Derzeit sind folgende Termine angedacht:

- 15. Dez 2017
- 21. Dez 2017
- Mögliche Ersatz- od. Zusatztermine: 22., 28. oder 29. Dez 2017
- 1 Termin im Jan 2018

Folgende Maßnahmen werden ausschließlich aus Studiengründen durchgeführt:

Sie werden gebeten, mit der Nintendo Wii (Kegeln, Tennis, Bogenschießen, usw. am Computer/Fernseher) und mit einer Virtual Reality Brille zu spielen bzw. sich Videos anzusehen, nachdem ich Ihnen alles in Ruhe erklärt habe. Ich stehe die ganze Zeit für Hilfestellungen an Ihrer Seite und werde Sie dabei beobachten, mir Notizen machen und sie abschließend in Gruppen zu Ihrer Meinung befragen, um mehr über Ihre Sichtweise zu erfahren.

3. Worin liegt der Nutzen einer Teilnahme an der Beobachtungsstudie?

Es ist nicht zu erwarten, dass Sie aus Ihrer Teilnahme an dieser Studie gesundheitlichen Nutzen ziehen werden, aber möglicherweise werden künftige Patienten mit der gleichen Erkrankung von den Ergebnissen profitieren.

4. Gibt es Risiken, Beschwerden und Begleiterscheinungen?

Nein.

5. In welcher Weise werden die im Rahmen dieser Beobachtungsstudie gesammelten Daten verwendet?

Sofern gesetzlich nicht etwas anderes vorgesehen ist, haben nur die Studienleiterin und deren Mitarbeiter Zugang zu den vertraulichen Daten, in denen Sie namentlich genannt werden („personenbezogene" Daten). Weiters können ggf. Beauftragte von in- und ausländischen Gesundheitsbehörden, der zuständigen Ethikkommission und Personen, die vom Studienleiter und/oder Auftraggeber der Studie mit der Kontrolle der Datenqualität beauftragt wurden, Einsicht in diese Daten nehmen, um die Richtigkeit der Aufzeichnungen zu überprüfen. Diese Personen sind zur Verschwiegenheit verpflichtet.

Die Weitergabe der Daten erfolgt ausschließlich zu statistischen Zwecken und Sie werden ausnahmslos nicht namentlich genannt. Auch in etwaigen wissenschaftlichen Veröffentlichungen der Daten dieser Studie werden Sie nicht namentlich genannt.

Die Bestimmungen des Datenschutzgesetzes in der geltenden Fassung werden eingehalten.

6. Möglichkeit zur Diskussion weiterer Fragen

Für weitere Fragen im Zusammenhang mit dieser Studie stehen Ihnen Ihre Studienleiterin und seine Mitarbeiter gern zur Verfügung.

Name der Kontaktperson: Karin Bartsch

Ständig erreichbar unter: [redacted]

7. Einwilligungserklärung

Name d. Teilnehmers in Druckbuchstaben: .....

Geb.Datum: ..... Code: .....

Ich habe dieses Informationsblatt gelesen und verstanden. Alle meine Fragen wurden beantwortet und ich habe zurzeit keine weiteren Fragen mehr.

Mit meiner persönlich datierten Unterschrift gebe ich hiermit freiwillig mein Einverständnis, dass meine Daten gespeichert und ohne direkten Personenbezug für wissenschaftliche Zwecke verwendet werden dürfen. Mir ist bekannt, dass zur Überprüfung der Richtigkeit der Datenaufzeichnung Beauftragte der zuständigen Behörden und der Ethikkommission, sowie mit der Kontrolle der Datenqualität beauftragte Personen Einblick in meine personenbezogenen Krankheitsdaten nehmen dürfen.

Ich weiß, dass ich diese Zustimmungen jederzeit und ohne Angabe von Gründen widerrufen kann.

Eine Kopie dieser Patienteninformation und Einwilligungserklärung habe ich erhalten. Das Original verbleibt bei der Studienleiterin.

.....
(Datum und Unterschrift des Teilnehmers)

.....
(Datum, Name und Unterschrift der verantwortlichen Studienleiterin)

(Der Patient erhält eine unterschriebene Kopie der Patienteninformation und Einwilligungserklärung, das Original verbleibt im Studienordner der Studienleiterin.)

B. Information Sheet

STUDIENTEILNAHME

Spielen mit der Wii und einer Virtual Reality Brille

WAS: Hallo! Mein Name ist Karin Bartsch. Hätten Sie Lust mit mir etwas Neues auszuprobieren?
Ich komme ein paar Mal zu Ihnen ins Pflegewohnhaus mit der Nintendo Wii (= z.B. Bowling am Computer/Fernseher) und einer Virtual Reality Brille.
Bei diesen Geräten geht es darum sie auszuprobieren.
Ich lade Sie dazu ein eine interessante virtuelle Welt kennen zu lernen und beim Bowling mit der Wii zur Abwechslung die Kegelfiguren im Fernseher um zu werfen.
Ich erkläre Ihnen bei jedem der Geräte in Ruhe wie sie funktionieren.
Für Fragen und Hilfestellungen stehe ich die ganze Zeit an Ihrer Seite.
Am Ende würde ich gerne von Ihnen erfahren was Ihnen besonders gut gefallen hat oder was Sie verbessern würden.
Ihre Meinung ist gefragt!

WIESO: Ich schreibe eine Diplomarbeit in der es darum geht herauszufinden, was Sie begeistert und was Ihnen weniger gefällt bei den Spielen und Geräten, die ich für Sie vorbereitet habe.
Das soll TechnikerInnen in Zukunft dabei helfen zu verstehen, wie sie Spiele entwickeln können, die Ihnen auch Spaß machen.

WANN: Geplant sind vorerst der 27.12.2017, der 28.12.2017 und der 29.12.2017.

WIE LANGE: Pro Spiel pro Person ca. 20-30min - kürzere oder längere Spieldauer möglich je nach Wunsch ☺
Sie dürfen natürlich auch jederzeit aufhören – alles freiwillig!

WO: Im Pflegewohnhaus Simmering im Aufenthaltsraum mit Fernseher oder Beamer.
Bitte bringen Sie Ihre Brille mit, falls Sie eine benötigen!
Ich würde mich freuen, wenn Sie mir ein bisschen Ihrer Zeit schenken!

C. Observation Protocol

Allgemeines

ID #	
Gruppe #	
Alter	
Geschlecht	Weibl. / Männl.
Vorerfahrung: Wii VR-Brille	 Ja / Nein Ja / Nein
Ausgangsstimmung (vor Spielen)	traurig / down / gelangweilt / entspannt / neugierig / heiter / nervös / ängstlich / besorgt / frustriert / genervt / grantig / gestresst / angespannt / demotiviert / motiviert
Beginnzeit	
Endzeit (insg. nach allen Szenarien)	

Szenario: Wii, Gast Avatar

Kurzzeitgedächtnis	
Sind zusätzlich (zu meinen anfänglichen) weitere Erklärungen nötig während des Spiels?	Ja / Nein
Wie oft wird nachgefragt?	< 5 Mal // > 5 Mal // > 10 Mal
Wie oft wird dasselbe gefragt: • Wann muss ich den Knopf loslassen? • Was steht da? • Kann ich schon (anfangen/schießen)? • Und jetzt?	

Handling / Handhabung	
Wie oft wird falsch gedrückt?	
Wie oft wird die Kombination/Abfolge aus Bowling-Bewegung und Drücken/Loslassen des Knopfes falsch ausgeführt?	
Wie viele Würfe sind nötig bis die Handhabung sitzt und richtig ausgeführt wird?	
Beschwert sich TN über Controller-Handling? Falls ja, worüber:	Ja / Nein
Am Ende: Wie ist die Geschicklichkeit/der Umgang mit dem Controller?	1 2 3 4 5 (Schulnoten)
Punktestand Ende	

Daueraufmerksamkeit	
Zeit ab Spielbeginn bis Unmut / Ermüdung	
Will TN mehr als 1 Runde spielen?	Ja / Nein

Wie viele Runden / Durchgänge (Wii)?	
Wie lange bis TN (von sich aus) abbricht?	
Stimmung am Schluss?	traurig / down / gelangweilt / entspannt / neugierig / heiter / nervös / ängstlich / besorgt / frustriert / genervt / grantig / gestresst / angespannt / demotiviert / motiviert

Notizen (Freitext):

Was ist mir sonst noch aufgefallen?

_____

_____

Was hat der TN sprachlich geäußert?

_____

_____

Wie drückte sich Begeisterung, Frustration etc. aus? (Körpersprache? Kommentare? Reaktionen?)

_____

_____

Szenario: Wii, personalisierter Avatar

Kurzzeitgedächtnis	
Sind zusätzlich (zu meinen anfänglichen) weitere Erklärungen nötig während des Spiels?	Ja / Nein
Wie oft wird nachgefragt?	< 5 Mal // > 5 Mal // > 10 Mal
Wie oft wird dasselbe gefragt: • Wann muss ich den Knopf loslassen? • Was steht da? • Kann ich schon (anfangen/schießen)? • Und jetzt?	

Handling / Handhabung	
Wie oft wird falsch gedrückt?	
Wie oft wird die Kombination/Abfolge aus Bowling-Bewegung und Drücken/Doslassen des Knopfes falsch ausgeführt?	

Wie viele Würfe sind nötig bis die Handhabung sitzt und richtig ausgeführt wird?	
Beschwert sich TN über Controller-Handling? Falls ja, worüber:	Ja / Nein
Am Ende: Wie ist die Geschicklichkeit/der Umgang mit dem Controller?	1 2 3 4 5 (Schulnoten)
Punktestand Ende	

Daueraufmerksamkeit	
Zeit ab Spielbeginn bis Unmut / Ermüdung	
Will TN mehr als 1 Runde spielen?	Ja / Nein
Wie viele Runden / Durchgänge (Wii)?	
Wie lange bis TN (von sich aus) abbricht?	
Stimmung am Schluss?	traurig / down / gelangweilt / entspannt / neugierig / heiter / nervös / ängstlich / besorgt / frustriert / genervt / grantig / gestresst / angespannt / demotiviert / motiviert

Notizen (Freitext):

Was ist mir sonst noch aufgefallen?

_____

_____

Was hat der TN sprachlich geäußert?

_____

_____

Wie drückte sich Begeisterung, Frustration etc. aus? (Körpersprache? Kommentare? Reaktionen?)

_____

_____

Szenario: VR-Brille

Wie lange lässt TN die Brille auf?	
Schwindel?	
Übelkeit?	
Andere Gründe für Abbruch?	
Stört die Brille (falls vorhanden)?	
Begeisterung	-2 -1 0 1 2 (*gar nicht* bis *sehr gut*)

Notizen (Freitext):

Was ist mir sonst noch aufgefallen?

_____

_____

Was hat der TN sprachlich geäußert?

_____

_____

Wie drückte sich Begeisterung, Frustration etc. aus? (Körpersprache? Kommentare? Reaktionen?)

_____

_____

D. Interview Guide

		TN 1 (ID	TN 2 (ID
A-1	Wie haben euch das Bowling Spielen mit der Wii und die Videos mit der VR-Brille gefallen?		
A-2	Wie habt ihr euch, nachdem ihr beides ausprobiert hattet, gefühlt?		
A-3	Hat euch eins davon besser gefallen? Welches? Warum?		
A-4	Hat jemand von euch vielleicht anderen, Verwandten oder Bekannten, davon erzählt?		
VR-1	Was hat euch besonders gut gefallen bei der VR-Brille?		
VR-2	Wie hat sich das angefühlt in eine virtuelle Welt so eintauchen zu können?		
VR-3	Wer hätte gerne noch mehr Videos gesehen?		
VR-4	Wer könnte sich vorstellen die VR-Brille in Zukunft hin und wieder zu benutzen?		
VR-5	Gibt es etwas, das ihr an der VR-Brille verändern oder verbessern würdet?		
VR-6	Wie war es für diejenigen von euch, die eine Brille tragen?		

Wii-1	Was hat euch gut gefallen beim Bowling Spielen mit der Wii?		
Wii-2	Wer hätte gern noch länger gespielt?		
Wii-3	Wer würde es gerne noch öfters spielen?		
Wii-4	Hat es jemand als zu schwer empfunden? Was genau war zu schwer?		
Wii-5	Wer fand es witzig das Manderl (Avatar) mit anderen Haaren, Augenfarbe usw. herzurichten? Wem war es eher egal/nicht wichtig?		
Wii-6	Wie ging es euch mit der Fernbedienung? a. Was sagt ihr zu den Knöpfen auf der Wii Fernbedienung? b. Den Knopf hinten, den ihr mit dem Zeigefinger drücken musstet, wie war der für euch zu erreichen/erwischen?		