The Use of Virtual Reality with the Elderly
EldersVR: a case study

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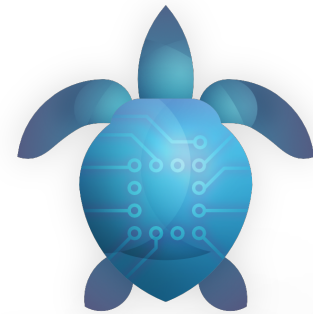UNIVERSITY OF AMSTERDAM

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ABSTRACT

The ever-increasing elderly population in the Netherlands often struggles with the feeling of loneliness. Over one million elderly in the Netherlands alone feel disconnected from society. This study discusses the elderly and their perspective and experience with virtual reality. A case study on the EldersVR platform is performed, including 30 interviews with the elderly and support personnel. Results show that virtual reality platforms indeed can decrease the sense of loneliness and have an overall positive effect on cognitive and emotional wellbeing. The elderly and the people assisting them experience virtual reality as being an interesting and exciting tool. Suggestions for the format and type of new content is also provided.

1 INTRODUCTION

The elderly population in the Netherlands has only increased since the 1950s and continues to grow into the biggest group within the Dutch population over the coming decades [3]. Many reasons for this growing population of elderly can be given, but is is mainly because of the baby boom after the Second World War [15], the improvement of advanced healthcare (which is readily available in the Netherlands) [36], improvement and variation of nutrition, and the continuous drop in birth rate [49].

Despite the growth of this population the mental health of the elderly has been degrading over the past decades [4]. Loneliness is one of the major issues seniors have in western society, where more than half of people aged over 55 feel a sense of loneliness and that they have lost connection to people around them [1]. In the Netherlands alone, over one million elderly are classified as lonely and over 500.000 are classified as severely lonely and struggle with depression and social anxiety [1]. Besides health issues, the decreasing mobility that also comes naturally with old age, affects the capabilities of the elderly to reach out and connect to the outside world [6]. This increases the chance of a collapse in their social networks [2]. Loneliness also increases with old age, because of natural experiences that are not easy for most, such as the passing of loved ones, but also the experience of a constant monotonous environment. Loneliness also increases with older age, 63% of elderly aged over 85 are lonely and is more severe in widowers, singles and divorcees [1].

The need for solutions for this problem for this increasing population is therefore urgent. According to Stef Beun from X-TRA Welzijn[1], some care homes struggle to exist and have little to offer to their residing and visiting elderly. This has a negative spiral as a result, since less elderly actually go out and undertake the journey to their local elderly home to participate in activities, which

only increases the feeling of loneliness. According to Beun, traditional activities, such as bingo and painting courses, do not have the appeal for the elderly anymore. Unfortunately, innovation often comes with a high price, which most elderly homes cannot afford.

A new technology that could be implement is the EldersVR[2] platform. This innovative virtual reality (VR) platform developed in the Netherlands by Hack the Planet[3] provides an innovative way to connect lonely elders with a VR experience and helps decrease thresholds lonely elderly may have.

1.1 Research Questions

In this thesis the use of virtual reality with the elderly is investigated, using a case study of the EldersVR platform. It has received praise[4], but no extensive research has been conducted on e.g. the opinion of the stakeholder, what kind of VR content is preferred, whether the elderly want guidance through VR experiences, and whether the platform can decreases the sense of loneliness.

Thus, this study mainly seeks to answer the following questions:

- Do VR platforms, such as EldersVR, decrease the sense of loneliness with the elderly?
- How do the elderly and support personnel experience virtual reality?
- What type of new content do senior citizens and other stakeholders prefer?
- What do senior citizens think about the length and format of the VR experiences?
- Do the elderly want to be guided through the video, or have a VR experience without dialogue?

1.2 Methodology

For this thesis, a literature study of virtual reality and the elderly is conducted, with a focus on healthcare related topics. Furthermore, the EldersVR case study provides 30 in-depth semi-structured open-ended interviews [56] with the elderly and support personnel, such as nurses and elderly consultants. Participants were picked using the stratified sampling method [41]. The interviews lasted between 15 and 45 minutes and were mainly conducted in care homes and nursing homes, and community buildings where the elderly gather for activities. The specific questions asked are provided in the appendix in section 6. The interviews are anonymous and the data collected is not linked to any demographic data. Only mentally healthy elderly were interviewed and not those with dementia or

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[1]Health care institution: https://www.xtra.nl/

[2]https://eldersvr.com/
[3]https://hack-the-planet.nl/
[4]Zorginnovatieprijs

other complexities, since they introduce an array of specific needs that are outside of the scope of this research.

A protocol was set up for this research. Interviewed participants were all presented with a general information document and with a consent form, which are both provided in the appendix in section 6. Prior to the interviews, the layout and purposes together with privacy protocol was explained to the participants. All participants have the interviewers' contact information for further information.

Participants were asked a list of predefined questions, however, the natural progression of the interview was upheld, the questions were only meant as a guideline. During the interviews the focus of the interviewer was to observe the participants and make detailed notes of these observations. Most interviews were recorded and replayed in order to transcribe and find the answers to the questions which are laid out below. Not everything is transcribed, since most elderly, especially since the context of this study is loneliness, do enjoy some company and talk and share a lot about themselves. This was not hindered in order to create a safe environment for the participants. Only the answers to the questions asked are transcribed, coded, analyzed [46], and visualized in NVivo 12[5].

2 RELATED WORKS

In this section relevant studies will be discussed, such as virtual reality, loneliness, cognitive and emotional wellbeing, memory, and exercise. There is much research done on this and related topics, the papers discussed below are merely an introduction. To keep a clear overview of all the studies which are discussed and other notable researches, a table is provided with studies per topic below.

Table 1: Table of References

Topic	Reference
Virtual Reality	[51], [22], [12], [58], [47], [35]
Loneliness, Cognitive and Emotional Wellbeing	[6], [22], [54], [43], [53], [13], [29], [55], [9], [38], [21] [10], [22], [57], [20], [11], [7], [28], [39]
Memory	[40], [8], [27] [45], [23], [33], [14]
Exercise	[16], [50], [37], [44], [42], [32], [30], [17], [48]

2.1 Virtual Reality

The first VR headset design was patented in 1960 by Morton Heilig, which was named the "Telesphere Mask". This invention looks similar to the first version of Google's Gear VR headset[6]. The presence of VR has only grown ever since and is now readily available in many electronic stores for relatively low prices. Jaron Lanier, CEO and founder of VPL Research, one of the first companies developing and selling virtual reality products, coined the term virtual reality by placing existing technologies – such as virtual cockpits and virtual workstations – under one umbrella [51]. Virtual reality can be portrayed in terms of technological hardware, but also in

an experiential fashion. VR is often defined by a capable computer for real-time animation, a position tracker and or gyroscope, and a head-mounted stereoscopic display. Videos are played back on these stereoscopic displays, creating an electronic simulation of environments. An alternative world with computer generated output or real-world recordings can be visited with the use of these VR goggles [12]. Steuer also describes VR experientially with the use of presence and telepresence. Presence can be defined as the sense of being in an environment and refers to the natural perception of humans in it, where telepresence can be defined by the experience with the help of a communication medium and refers to the mediated perception of an environment. A telepresence can be achieved by a VR simulation of either the real world or computer-generated content. Thus, virtual reality is defined as an environment in which the perceiver experiences telepresence of either a real world or computer simulated scene.

2.2 Loneliness, Cognitive and Emotional Wellbeing

With old age, physical and mental changes often occur and is a natural process of physiological, anatomical, and emotional changes. These changes often result in a decline in communication capacity [6]. Communication however is vital, and a decline therein can lead to less social interactions, socialization, and an increase in loneliness. Furthermore, the demographic shift is in stark opposition with the technological improvements of the past centuries which changed and redefined how we communicate and relate to each other [22].

However, several studies show that introducing information and communication technologies to senior citizens can have significant and positive effects [54], [53]. Some authors have even presented it as the only possibility to mitigate isolation, loneliness and alienation in certain elderly populations [13], [29]. Other studies also suggest that the use of technology by senior citizens increases interpersonal connectivity and organizational involvement [55], [9]. It is also suggested that it reduces levels of isolation and strengthens social networks, especially for elderly coping with impaired mobility.

For senior citizens the technological revolution can widen the generational gap and create feelings of loneliness, depression, and anxiety. There are however many opportunities for the elderly to find connection with the use of technology. This can sometimes be tedious, since the elderly can struggle with the rapid changes in this field and with the lack of education [18]. Despite seniors being hesitant at first, their attitudes do improve the more they learn how to use and interact with technology [24]. Therefore, computer classes for older adults can contribute to social and cognitive aspects of aging.

Moreover, virtual reality environments have proven to stimulate the practice of communicative and cognitive skills and offer a means for senior citizens to experience various scenes in an individual and safe way [38]. Expanding the VR possibilities from entertainment has also proven useful for the elderly [26]. In elderly healthcare, technological methods have been implemented the last decades, virtual reality being one of them. This method has proven to be significant for one of the biggest issues senior citizens face: social isolation and loneliness. In a study by Lee and colleagues, lonely

seniors were more socially responsive to a virtual environment with a social embodied agent involved, such as a guide who talked about the environment or one that was visually present [34]. Participants had a better experience of the contact with the agent when taking on a visual form over contact through sound only. This suggests that having contact with even a virtual person can have an impact on the sense of loneliness. Furthermore, loneliness could also be caused due to shyness, where virtual reality is also considered as being an easier path to get in touch with others, instead of communicating in real life [25]. Altogether, virtual reality is considered a viable method to aid seniors suffering from loneliness [5].

There are also technological systems introduced to assist the elderly. One of which is the Butler platform[7] which was designed to deliver health care to the elderly in three ways: diagnosis, therapy and entertainment [10]. Botella and colleagues showed that after using this platform the elderly increased their positive and decreased their negative emotions. For the therapeutic part, two virtual environments were introduced, both of which were natural scenarios and were designed to improve positive emotions [22]. Both these environments have been validated by the scientific community. The butler platform was well received and is therefore considered an effective system for improving emotional states for its target group. A platform such as Butler can help reduce the technology gap between new technologies and senior citizens. It also proved useful for the improvement of mental health and for the prevention of depression and can also facilitate protective activities. This can improve social networks, exercising emotional capabilities, learning new communication skills, strengthening the desire to keep learning, and promoting curiosity through the development of new skills.

What stands out in VR related studies and the elderly is the use of natural environments [20], [11]. Most studies used natural scenery, such as parks and gardens. These virtual environments of nature provided in VR have found to reduce stress and improve cognitive functions in these studies.

One might say that it is somewhat odd to prescribe more screen time to a group that is somewhat aversive to technology, to combat loneliness. Using VR extensively with the elderly was found to create feelings of discomfort and result in a decrease in willingness to participate with the elderly [31]. Thus, virtual programs which are organized by professionals for senior citizens, should provide these programs within a safe environment, start with shorter sessions, preferably in groups. Furthermore, virtual reality is not proposed to be the solution to solve loneliness within this population, but rather an opportunity for interaction. Social experiences and interactions have been suggested to improve health and decrease mortality [52].

Many other studies have been conducted that provide insight to the capabilities of VR and show that it could very well improve cognitive and emotional wellbeing, as well as decreasing loneliness and improving quality of life overall (see table 1).

2.3 Memory

Memory decline comes naturally with old age and may be the first sign of cognitive pathology [40]. Using immersive virtual reality platforms is proposed to be a useful and effective treatment of memory deficits in elderly individuals. A study by Optale et al. implemented a VR training intervention with 36 participants aged over 65 to try to lessen cognitive decline and improve memory functions. The VR experiences include several tests of the participants capacity to remember the paths taken and their orientation through a VR world, using a joystick to move forward. The authors showed significant improvements in memory tests, especially in long-term recall. The authors suggest that VR memory training may improve memory function in elderly adults by enhancing focused attention. Participants showed improvement of general cognitive functioning and verbal memory after the initial training phase, even those with severe memory impairment.

Similarly, a study by Benoit and colleagues found that VR scenery stimulates autobiographical memory [8]. It also showed that VR is well received by the elderly and is suitable to use in reminiscence therapy with senior citizens. What is more, multiple studies suggest that virtual reality also has an impact on episodic memory [45], [27], [33]. VR provides an egocentric experience of a scene, which places VR between a mere observation, such as looking at a video, and real action execution. VR allows egocentric encoding and retrieval in the brain, which suggested to be a compelling tool for episodic memory training.

2.4 Exercise

Physical states, like muscular strength, sensory sensitivity, and functional capacity often deteriorate with old age [43]. VR in a healthcare context proved to be a useful tool in many studies, enabling physical activity and clinical rehabilitation (see table 1). A virtual reality exercise was introduced with the aim to be an entertaining method of therapy. This virtual reality environment was an active kayaking program, which involved the upper body muscles and balance control most. The kayak program was done for 20 minutes, twice a week for a period of 6 weeks, and results show a significant improvement over the control group. Park and Yim therefore concluded that the VR kayak program is a viable method for improving the cognitive function, muscle strength, and balance of senior citizens. This notion is supported by many other studies [16], [17]. Besides that, the study also concluded that the kayak program reduced risks of cognitive impairment, since decline in cognitive function is found to be connected with limited physical activity and a decline in functions. What is more, a study using a VR game in combination with a dance pad for stepping suggests that "by creating a strong presence in a virtual, interactive environment, distraction can be taken to greater levels while maintaining the benefits of indoor exercises which may result in a shift from negative to positive thoughts about exercise" [17].

3 ELDERSVR: A CASE STUDY

For this research I was situated at the Q42 venture called Hack the Planet, in The Hague, the Netherlands. Q42[8] is a strategic technology agency and has about 85 employees, divided over the headquarters in The Hague and an office in Amsterdam. The Hack the Planet team consists of two other people and was founded by ING.

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[7]Butler Platform Video

[8]https://www.q42.nl/

Tim van Deursen and takes on global challenges using pragmatic tech[9].

EldersVR started when the municipality of The Hague organized a hackathon in 2016; Hacking Elderly Care[10]. Hack the Planet participated and won the contest and developed EldersVR in collaboration with X-TRA Welzijn. EldersVR is a Virtual Reality platform tailored to the elderly and is divided in a Shared and Home experience. The elderly often feel surpassed in the context of technology and feel like it is all going to fast. They experience technology as something anti-social and harmful for social connections [19]. Therefore, importantly, EldersVR focuses on user-friendliness and conversation-starting footage, so that seniors are not scared by the seemingly advanced technology. These experiences have an ice breaking and threshold lowering effect and result into valuable conversation material. EldersVR provides a new experience in a different place and/or time.

3.1 Interaction Design

This section illustrates step by step how the platform works and what it consists of. The EldersVR platform runs on smartphones, of which one is the company phone of the support personnel. There is a difference between the master and slave application. The master application is just like any other mobile app, which only operates when turned on. The slave application is triggered by clicking on the lock button, the smartphone that is put into the VR headset simply functions as a monitor for the platform only.

When the master application is opened, the home screen pops up after a brief loading screen. On the home screen (appendix - figure 3a) a scrollable interface can be found with all the available VR content. All the separate videos contain a title, a short description and a play button. A button with which you can link the master to the slave via Bluetooth is provided on the bottom of the screen. Tapping this button directs you to the pairing screen (appendix - figure 3b). This screen provides info on the number of devices already connected, as well as the notion that at least one slave device has to be connected in order for the application to work properly. When tapping "start" on the pairing screen, the master will ask for permission to send out and receive Bluetooth pairing requests for 180 seconds. When accepted, the connecting display (appendix - figure 3c) will pop up, which also provides a reminder that the slave devices have to be on and activated. Meanwhile, the connecting display on the slave devices (appendix - figure 4a) run constantly until the slave finds a master to connect to. Once connected, the master device will return to the home screen, displaying all the content, while the slave devices idle on a working horizon (appendix figure 4b). This horizon depicts a real-world horizon and gives the sense of looking at one. Support personnel can play a video by simply tapping the play button. When a video is selected, the master loads screen (appendix - figure 3d) appears, and shows the countdown of 10 seconds together with a cancel button. The slave device displays a black loading screen (appendix - figure 4c) with similar attributes, it displays a 10 second countdown with a loading bar decreasing in size from both sides. The video will start after 10 seconds, both on the VR set and the master device. On this screen (appendix -

figure 4d) the support personnel can simply slide on screen to move perspective in the video, see the video's progress and stop the video.

3.2 System Description

This section describes the architecture and the technical details of the EldersVR platform, which currently runs on Android devices. The connection between the master, which in this case is the company smartphone of the support personnel, and the slave device, the smartphone used as a monitor, is established with a Bluetooth connection. Besides the Google Daydream View, the hardware used can vary. As of now, the Motorola Moto Z is used the most.

3.2.1 System architecture. Both the master and slave devices must have Bluetooth turned on when starting the EldersVR app. When pressing the connect button on the master device, it will ask permission to send out connective information for just 180 seconds, to save battery life. The master and slave will then connect automatically when the apps are both active, since the slave device automatically sends out connective information when EldersVR is active.

When the devices - which can consist out of multiple slaves and one master - are connected, they will communicate constantly on one key topic; time. This is a crucial aspect, since all videos have to run synchronously. The slave devices will send packages to the master dynamically. These packages contain a timestamp of when the package was sent from the slave device. On arrival, the master adds a timestamp of arrival and sends the package back. With the information of this ping the slave can determine the latency between the devices and what the clock time is of the master.

This relation of sending packages back and forth is also called a ping-pong relation, which in this case increases the accuracy of the latency, since the slave devices will send out packages until there is a stable average. The slave devices will keep pinging the master until a stable latency is found, which normally is around 20 milliseconds for this application.

Besides time, the master device also sends packages to the slave devices for particular events, such as the start of a video in a video-select-event and the stopping of a video in a video-stop-event. Upon arrival, slave devices will select the video which is locally stored and buffer it. This package will also contain an accurate timestamp of when the master expects the slave devices to start the selected video. The same goes for a stop-video-event, which will return the slave device to the horizon.

A UML diagram is provided below, displaying the relation between master and slave devices.

Figure 1: UML Diagram Architecture

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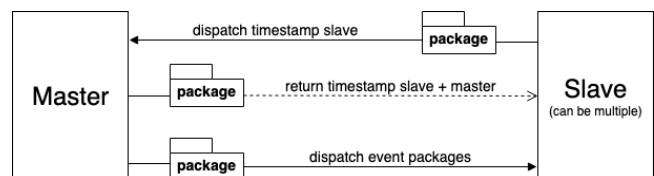
[9]http://www.hack-the-planet.io/
[10]Article on winning the hackathon

3.2.2 Hardware Description. One of the major strong points of the EldersVR platform is its mobility. The three main components are the Google Daydream View, and two smartphones, one functioning as a stereoscopic display (slave device) and a master which controls the content displayed. Suppoert personnel that make use of the platform have the needed application on their company phone, which then functions as the master, together with an 32GB SD-card with all the VR content. All they need to have present is a slave smartphone and the relatively light Google Daydream View.

The Google Daydream View is made of a soft, lightweight fabric which is adjustable and weighs 220 grams[11]. It supports a 90 degrees field of view and has an accelerator, gyrometer, and proximity sensor. This smartphone headset also has a simple to use controller that can be linked to the slave smartphone. Simply pointing and clicking on the preferred items takes away the hassle of having to take out the smartphone from the goggles every time the user wants to click on a button. It is also possible to stream the VR experience to a television or monitor with the use of a Google Chromecast. The most appealing however is the price, it currently costs about 80 Euros. The remote control and streaming capabilities are however not used in the EldersVR platform at this stage.

The master and slave smartphones in use for the EldersVR platform vary at this point. The Motorola Moto Z 32GB[12] is currently the most used device caretakers use as both master and slave. This smartphone is introduced in June 2016, has a 5.5" OLED display with a 2560x1440 (Quad HD) resolution, which means it has a dpi of 534. It has 4GB of LPDDR4 RAM and a Qualcomm Snapdragon 820, with 4 cores at 1.8 Ghz and a Adreno 530 GPU.

3.3 Shared and Home Experience

The platform is split into two types of experiences, within the same application. EldersVR started off as a tool to trigger memories and create conversation topics for the elderly. However, the platform evolved into a means to help the elderly to overcome thresholds. This evolution created the dichotomy between EldersVR Shared and Home, respectively.

3.3.1 Shared. EldersVR Shared aims to join elderly into a single VR experience, to create new and valuable experiences that can be shared together. Three trial runs in different community centers in The Hague showed positive results. These 360° scenes, of which the freely-accessible supply is now exponentially rising, evoke memories, spark conversations, and stimulate new friendships[13].

After gradually introducing the VR headset and explaining the experience to the elderly, a pair of seniors experience a completely different environment. It works fairly simple and is designed to be operated by elderly with e.g. decreased sight. As of now, the elderly can choose from an array of different VR experiences. The care taker can choose a VR experience by simply tapping them on a touchscreen; a safari with animals, diving in the Maldives, and a gondola tour in Venice and much more. the VR experience starts synchronously and take 2 to 5 minutes. Interactive features stimulate conversation between the elderly. In these experiences,

the elderly find themselves in an environment they have never been in before and therefore share an unique experience.

3.3.2 Home. EldersVR home mainly aims to decrease social thresholds that lonely elderly may have in the Netherlands, in order to get them out of social isolation. Support personnel follow the same procedures, but instead of having a shared experience, the elderly experience informative videos. One of the current videos illustrates how the neighborhood taxi works. Experiencing how you can be picked up in a special taxi van designed with immobile elderly in mind in VR, can nudge them to order one for free when they want to join an activity in the local center. There are also videos showing how mobility scooters and the public transportation works. Both topics carry a lot of uncertainties for the elderly according to Beun. Giving the elderly the confidence to use public transportation, a mobility scooter or the neighborhood taxi could help them out of social isolation. There is also a VR experience for the activities provided at local centers in The Hague. If the final step, the activities for the elderly, is the main hurdle in a particular case, the care taker can show how it looks like, before going on that journey.

3.4 Perspectives and Experiences

In order to gain insight into the main stakeholders' opinion and experience on the EldersVR platform, 30 semi-structured open-ended interviews were conducted. 12 of these were with support personnel and 18 with senior citizens, with a minimum age of 60. These interviews were either in groups or individually taken in homes, care homes, nursing homes and other local activity centers in The Hague which organize activities for the elderly. The interviews followed the questions that can be found in the appendix. What is more, a hierarchy chart produced in NVivo 12 is also provided in the appendix, which illustrates the distribution of the coded attributes in this study, such as positive and negative attitudes towards the EldersVR experience.

3.4.1 Elderly Perspective. The initial feedback on the EldersVR platform was mainly positive, especially the safari and the diving experience are favorites within the elderly community, according to care takers that have the platform in use. Normally quiet residents who did not communicate which each other suddenly had common ground on which friendships could bloom after using EldersVR Shared. Some elderly even started using the experience without guidance together with their initial partners weeks after the first experience.

During these interviews I was often introduced to the group before the activities started, after which I often let the elderly settle in first. I always had the sense that the elderly were quite happy that there was someone active in researching new solutions to support them. Before they even knew what it is about or what VR actually is, they would respond with phrases like; "that's great!". I have not been met with any negative response by any of the care takers or the elderly in anyway. Everyone I met was very open and enthusiastic towards new technologies and were quite excited to try out the VR experience.

My procedures sometimes changed, depending on how close the elderly were sitting together. When they were relatively close to each other, I observed the people surrounding the person with

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[11]https://vr.google.com/daydream/
[12]https://www.motorola.com/nl/products/moto-z
[13]Internal non-published reports.

the VR experience as well, since they were all interested and often started conversations about it with me and others around them. However, I tried to put emphasis on the person undergoing the experience.

The results are quite positive in general. Only a couple of elderly did not enjoy the VR experience and took the VR headset off before the end of the video. Some people described the experience as being nauseating and uncomfortable. A small minority experienced this and I did not encounter situations where this was serious in any way. All other participants had a contrastingly positive experience and enjoyed it intensely. Interestingly, even the elderly that found the experience as uncomfortable, still believed it could be a useful tool, since it is more dynamic than just a folder. For most people it was the first time they experience a virtual reality, but even people that already have had more than one experience were still excited and enthusiastic towards it. "It was quite an experience" was something that was said more than once, together with "how is this even possible?!".

Before the start of any VR video, a horizon is displayed with a text overlay. This text overlay consists of the text: 'video will start in', followed by a numerical countdown of 10 seconds, accompanied by a decreasing bar from two sides. I would always start with whether they can read what is displayed and if not so, I would adjust the VR headset to fit better. Even without reading glasses, the text should be readable, and the goggles simply need some adjusting to display correctly. The enthusiastic reactions often started here with phrases like: 'how is it even possible?!'. Others started counting and did so for all ten seconds. Most elderly found the letters clear and readable, there were however many seniors that struggled reading the letters and preferred a bigger font size. The 10 second countdown was mostly experienced as a good duration as well.

For the elderly in particular, the VR experience of the Amarath Kurhaus[14] at Scheveningen beach was showed first. This is a very famous and old hotel and landmark in The Hague's beach district. I picked this video in order to find out whether the elderly would recognize were they were. Some people did confuse the Kurhaus with a well-known train station in The Hague called Hollands Spoor. They all figured out within the first minute where they actually were, and to be fair, the locations have similar architectural styles.

The video also contained a gentleman in that welcomed the people into the main hall in the Kurhaus, providing some background and historic information. This was not always understood well as a result of poor audio quality, but most elderly did find it positive that there was a host welcoming you in. Some elderly even talked back to the man and replied with "thank you!" or "good day sir". Some elderly were not able to hear him properly and did not understand what was going on. When asking the elderly about this topic after the VR experience, most of them clearly stated that they would prefer to have a guide in the video and more context and info. "It's nice to have people in the videos, that makes it real". One reason for this was that people wanted to learn more about what they saw in the videos: "Having a guide would be nice, I would like to know what I am looking at" and "a guide is great, I would like to know more about Scheveningen." However, the audio quality needs

improvement for this to be useful; "a guide would be nice, if I could hear him properly".

The Kurhaus video was also selected because of its length, which is close to the average of all video's the EldersVR platform currently has. The length is 3 minutes and 15 seconds. The elderly were asked after the video how long they thought the video was. Most of the elderly thought the video took between 4 and 8 minutes and did say it took some time to get used too. When asked whether the length of the video was too long or too short, most people stated that they would prefer longer videos; "it may last as long as possible!", where some people's opinion was that it was long enough. The videos were found to be on the short side, rather than on the long side in general, also taking other longer videos into consideration. The elderly clearly interacted with their perceived environment. Some elderly tried to touch things around them, others replied to the gentleman welcoming them inside of the Kurhaus. Multiple elderly tried to stand up. I had to keep some of them seated, because safety reasons.

After the experience, questions about how the elderly felt in general about the experience and how they feel towards using this in the EldersVR home scenario were asked. On both topics all elderly were very positive. One of the seniors stated that there was no form of information 10 years ago about any of the topics the EldersVR platform provided. The 360° aspect of the experience was very well received: "You can look all the way around you, quite an experience". Others just responded with powerful words such as; "fantastic!" and "beautiful!". Especially for people being mostly at home alone it was suggested to be a useful experience. Almost all the elderly interviewed would use EldersVR to learn something new or to be transported to a different place. Some even asked where a VR headset could be purchased.

Almost everyone was positive towards the idea of using EldersVR in the home setting to decrease social thresholds that the elderly might experience. Many appreciated the initiative: "This is a good initiative, there should be done more for the elderly who cannot do much anymore or are not comfortable doing so." Many agreed that it would help them and that they would use it themselves. Most elderly believed it could improve safety too: "many accidents happen with mobility scooters, it would be useful to have an explanation."

Old memories resurfaced together with long smiles. The energy in the room often changed during and after the watching of a video in VR. Several people that were interviewed had witnessed no one less than the Rolling Stones in the Kurhaus in 1964. Others started talking about the time that the Kurhaus was still a casino. Other videos also made memories resurface and often started meaningful conversations. One person immediately started talking about a sibling, who worked as a diver while experiencing the diving video. Others started talking about holidays they enjoyed in Italy after seeing the gondola tour in Venice.

A reoccurring topic is how much the elderly are interested in the changes in their city, and more specific, their neighborhouds. They would all love to re-experience how their neighborhouds were when growing up. Many described the rapid changes as sucking out the soul and energy of most neighborhoods. They did often not like grandiose architectural changes, in both infrastructure and buildings. "It was all simpler and cozier."

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[14]https://www.amrathkurhaus.com/

3.5   Support Personnel Perspective

The second key group of stakeholders are the support personnel, of which some are nurses, elderly consultants, caregivers, facility attendees, and volunteers. X-TRA Welzijn deploys many elderly consultants, which are specialized in assisting the elderly. When someone reaches the age of 70, a local elderly consultant schedules a home visit to find out what the specific needs of that person are. The main role of the elderly consultant is to provide information about available possibilities and to support the elderly with a happy life. They help open up channels, such as with the local municipality or with the nearest activity centers. They were also the first to use the EldersVR platform and are still using it. Learning more about their perspective is pivotal for the platform, since they are the ones that have to deliver the product to the target audience. If the platform shows any deficiencies in any way, it could result in the consultants simply not using it all together. To gain insight into this group, a total of 12 semi-structured open-ended interviews were conducted. All these interviews were conducted in their offices or the location where they work most.

All support personnel were positive about the platform and found that it had a positive effect on their clients. "It's user-friendly and it should not be an issue using it." Some leaned more towards the Shared experience and did not feel much for the Home experience; "The elderly are more interested in relaxation and are not keen on Home", "I use Shared rather than Home." While others suggested that they simply do not have time in their busy schedule to use the Shared experience, and only use the platform to help their clients with their struggles. Some support personnel also used it during events, which worked well to draw the attention of senior citizens: "providing something new that activates them, that is what they often say as well!". Their experience also showed that it supported breaking social isolation that some elderly experienced. Being transported outside, sometimes accompanied by loved ones, was really powerful and could make someone's day. This especially when they have been out of social circles for a while.

Two hurdles that were often encountered were poor audio quality and unsharp visuals. When the headset was not seated properly, the visuals were experienced as being poor of quality or unsharp. This is however hard to test, since it could also just be the decreased sight that elderly often have, or the overall lesser quality of VR over real world vision and videos on modern televisions. The visuals often improved when the headband was tightened, unfortunately, not all support personnel knew that this could help. Furthermore, audio was often a nuisance. It was often not loud enough, especially for those with hearing impairment. This group is often lonely, because communication gets increasingly harder. Hearing aids sometimes interfered with the VR headset, which resulted in high pitched tones that were uncomfortable for anyone in the room.

Another topic most support personnel struggled with, was the system, or lack thereof, revolving around the availability of the EldersVR platform. As of now, the set has to be picked up at a separate location, signed for and returned within a specified period of time. It is also often unclear whether there is any availability. This is quite disruptive to some: "Since it has a playful character, it also needs a spontaneous character for it to work naturally." A proper system for the distribution of the platform was suggested, together

with a better means of transportation. Some even indicated that they got the set to borrow in a paper bag, which of course is less than ideal. A colorful and playful case or bag designed especially for the set was suggested by the care takers, not only for convenience purposes, but also in order to create enthusiasm for the elderly.

It was also not clear to many of the support personnel what the platform could do and what it is for. "I have worked here for a year, I know that Stef Beun is working on this project but I did not know that I could use this for the elderly. I do not have this in my system for a home visit." The goal of the platform and how it can be reached is unclear to many. The notion that it is a gimmick, or that is hard to use surfaced multiple times.

Some safety issues were also brought to light by the support personnel, of which some were in line with my personal experience with EldersVR. The elderly tend to stand up during the experience. This can be quite dangerous, since you cannot see the real world around you. They could also move slightly and miss their chair when they try to sit back down again. Nausea and dizziness can also stick around for a while, which can result into falls after the experience. Fear is also something that can be triggered: "I am not going to stand up, because then I will fall into the water." One of the clients could not swim and was shocked when seeing the VR experience of diving under water. It can be a sensitive tool, and some would not send just anyone to someone's home to use it. One care taker did not use it often, because the risks of using VR with this sensitive audience is not well known.

3.6   Teachers and Professionals in the Field

During my research I presented the EldersVR platform at a symposium the ROC mondriaan[15] organized. This symposium theme was the future of MBO education, which nursing is a part of. After a short 10 minute presentation on the topic of the elderly, loneliness and VR, a focus group of 8 people experienced EldersVR live. 7 of the 8 were teachers and there was one principal present.

The first question asked was what their opinions are on the EldersVR platform. All eight were positive and believed this could be very well implemented in the future, not only in the healthcare system, but also as a teaching method. "It was instructive, very interesting practical education and a fun experience. "They especially appreciated the mobile aspect of the system. Not having to carry around heavy and complex equipment, but using the company phone you already have at hand.

Furthermore, I asked this group what they think would be good videos for future use. For the elderly, they suggested activating videos, such as swimming, running, dancing, and climbing. Activities that are hard for fragile elderly, were found very applicable for EldersVR. Besides this, all eight agreed that this could very well be used for teaching purposes. Some sensitive situations are better handled in the field when the future care takers can train with it first. The immersion of virtual reality, together with the simple set up of EldersVR, convinced them that this could be used for many use cases in the teaching environment.

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[15]ROC Mondriaan Symposium

4 RESULTS

Returning to our research questions, we find that VR platforms indeed can decrease the sense of loneliness with the elderly and have an overall positive effect on cognitive and emotional wellbeing. Introducing information and communication technologies to senior citizens can have significant and positive effects. The use of technology by senior citizens increases interpersonal connectivity and organizational involvement and reduces levels of isolation, strengthens social networks, especially for elderly coping with impaired mobility.

For senior citizens the technological revolution can widen the generational gap and create feelings of loneliness, depression, and anxiety. There are however many opportunities for the elderly to find connection online. Despite seniors being hesitant at first, their attitudes do improve the more they learn how to use and interact with technology. Therefore, computer classes for older adults can contribute to social and cognitive aspects of aging.

Virtual reality environments have shown to stimulate the practice of communicative and cognitive skills and offer a means for senior citizens to experience various scenes in an individual and safe way. VR has proven to be significant for one of the biggest issues senior citizens face: social isolation and loneliness. VR has also demonstrated to be an effective treatment of memory deficits with the elderly. VR memory training may improve memory function by enhancing focused attention, improve general cognitive functioning, and verbal memory. VR scenery was also found to stimulate autobiographical and episodic memory. Exercise platforms using virtual reality are also methods for improving cognitive function, muscle strength, and balance of senior citizens. Creating a strong virtual presence can shift attitude towards exercise with the elderly, increasing the benefits even more.

A good example is the Butler platform, which uses natural environments in VR for therapeutic ends. The use of natural environments stands out in VR platforms, since it is found to be stress reducing and that it can improve cognitive functions. A platform such as Butler can help reduce the technology gap, for the improvement of mental health, the prevention of depression, and the facilitation of protective activities. In turn, this can improve social networks, exercising emotional capabilities, learning new communication skills, strengthening the desire to keep learning, and promoting curiosity through the developing of new skills.

Furthermore, virtual reality is not proposed to be the solution to solve loneliness within this population, but rather as an opportunity for interaction. In turn, this has a decreasing effect, since social experiences and interactions have been suggested to improve health and decrease mortality. VR platforms enable senior citizens to feel a sense of connection, a social role and belonging in society. Furthermore, in line with Ahmed and colleagues, results point out that "virtual reality is a viable option to meet the needs of elderly suffering from loneliness" [5].

What is more, these results are strongly supported by the results of the interviews, which also point out that senior citizens can benefit from the EldersVR platform. Not only the elderly, but also support personnel believe that this platform has a great impact on this sensitive audience. Seniors respond positively in general and observations also show a that seniors enjoy the experience. It starts

healthy conversations when used in groups, but can also have a relieving effect when used individually.

The elderly and the people assisting them experience virtual reality as being a rather interesting and exciting tool. Both EldersVR Shared and Home have benefits for different use cases, where specific audiences prefer the one over the other. People that have used the platform believe that it is a good tool to use to both relax and transport the elderly into new environments, as well as decreasing social thresholds senior citizens might have. VR can be experienced as intense, frightful, and nauseating, but the strong majority has a positive attitude towards it. Most studies support this notion and find the elderly to respond well to virtual realities. During the interviews, the elderly often got used to VR fairly quickly and were comfortable enough to look around within the first minute.

Also teachers and professionals in the field found the platform interesting and useful. Not only for the elderly, but also for students. The videos provided in the EldersVR Home experience can just as well be informative for students. They saw potential into the platform and showed great interest.

The type of new content preferred by senior citizens and care takers was dominantly nostalgic content and content on places that are hard to reach for this audience. Seniors would love to experience how it all was before and simultaneously see the differences in their neighborhoods and living areas. Suggestions for video content from care takers varied but did also overlap with the needs the elderly proposed. They would prefer to have content that reminds them of the past, such as filming Prinsjesdag[16]. Another big theme was things the elderly simply cannot do anymore, because of immobility or old age, such as ice-skating and going to famous Dutch attractions such as the Keukenhof[17]. "Senior citizens are interested what happens outside of The Hague, since they cannot get there anymore." One strongly reacquiring topic for EldersVR home was "Begeleiden en Rijden", or BER[18] for short. A local initiative run by volunteers that pick up senior citizens for appointments at for example the hair dresser, hospital appointment, or for doing groceries. Finally, music was a popular topic as well. Visiting a concert is often not accessible to fragile senior citizens. Studies on VR and the elderly have suggested the use of natural scenery, such parks and gardens, since environments of nature provided in VR have found to reduce stress and improve cognitive functions.

The length and format of the VR experiences are preferred to be between 5 and 8 minutes, with better visual and audio quality. Using VR extensively with the elderly was found to create feelings of discomfort and result in a decrease in willingness to participate with the elderly. Thus, VR platforms should be provided within a safe environment, starting with shorter sessions, preferably in groups.

The length of the videos of the EldersVR platform were experienced as being too short at 3.15 minutes. A video of 5 to 8 minutes was preferred overall. Moreover, the text on the loading screen was of proper length and often readable but could benefit by an increase in font size. The visual quality of EldersVR was equally experienced

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[16]https://en.wikipedia.org/wiki/Prinsjesdag
[17]https://keukenhof.nl/en/
[18]https://www.stichtingmooi.nl/vrijwilligers/begeleiden-en-rijden

as being positive and negative, while the audio was dominantly perceived as being of poor quality. When the smartphones would not be positioned properly, the visuals decrease significantly. This is in line with the three main hurdles encountered by support personnel: poor audio and visual quality, as well as the process of obtaining the VR set. The latter is not made more accessible due to the fact of how it is transported. There is no proper case or protective bag provided for the set. It was also often unclear what the platform could do and where it could be deployed for.

There were also some safety concerns, such as elderly that would stand up with the desire to walk. This could be quite troublesome, since the real world is not visible with a VR headset. Nausea could linger around after a VR experience, which can also result into falls with this fragile target audience. It could also be an intense experience that could inspire fear. Care takers sometimes had the sense that there is a lack in protocol for sensitive cases.

Finally, the results also point out that it is preferred to have a clear dialogue with a real person. Lonely seniors were more socially responsive to a virtual environment with a social embodied agent involved, which suggests that having contact with even a virtual person can have an impact on the sense of loneliness. Seniors responded very positively to the host in the Kurhaus video, even greeting him and waving back. The elderly also indicated that they appreciated guidance and context in the EldersVR content, preferably by a guide. Loneliness could also be caused due to shyness, where virtual reality is considered as being an easier path to get in touch with others. Providing a real person in VR can therefor be beneficial.

In figure 2 a word cloud consisting of the most frequent words in the interviews is provided.

Figure 2: NVivo Word Frequency Query

5 CONCLUSIONS

To conclude, the elderly population is increasing strongly and struggles with loneliness amongst other things. there are over one million elderly in the Netherlands alone that feel the sense of loneliness and disconnection with society. This study provided an overview of literature about the elderly and virtual reality, as well as a case study on the virtual reality platform called EldersVR. The case study contains 30 extensive semi-structured open-ended interviews with both the elderly as other key stakeholders. Results show that VR platforms indeed can decrease the sense of loneliness with the elderly and have an overall positive effect on cognitive and emotional wellbeing. The elderly and the people assisting them experience virtual reality as being a rather interesting and exciting tool. The type of new content preferred by senior citizens and care takers was dominantly nostalgic content and content on places that are hard to reach for this audience. The length and format of the VR experiences are preferred to be between 5 and 8 minutes, with better visual and audio quality. Results also point out that it is preferred to have a clear dialogue with a real person.

The EldersVR platform has room for improvement on some topics. One major theme not discussed is culturally sensitive videos. According to elderly consultants, there are many immigrants in the Netherlands struggling with similar social threshold, possibly even more so because of language and other cultural barriers. Hack the Planet currently is investigating the possibilities of comparing the Grand Bazaar[19] in Istanbul with the Haagse Markt[20] in The Hague.

Audio quality was experienced to be rather poor but could be solved relatively easy with the introduction of a separate and more capable audio source, such as a Bluetooth speaker. Even a smaller speaker, such as the JBL GO[21], could prove helpful for seniors with impaired hearing and improve the experience overal.

Besides, the setup with the Google Daydream View and smartphones can be experiences as cumbersome. The smartphone in the VR headset has to be positioned properly for a positive result, which is not always the case. Therefore, new and feasible options, such as the Oculus Go[22] should be investigated for future versions of the platform. Mainly because it boasts a more streamlined design with the screen built in and fine-tuned for that particular design. The current method feels more like a DIY solution, where a slight shift can decrease visual quality.

What is more, at this point, videos and updates have to be added and executed manually and cannot be done online. It would be very convenient for both the end users as for the development team to send out updates automatically and for content to be downloaded from the cloud. This will also prevent encountered cases of support personnel not having the latest version of the EldersVR platform.

Finally, the platform would also strongly benefit from clearer protocols, guidelines, and a centralized method of operation. As of now, support personnel is experiencing trouble obtaining the platform itself, as well as with knowing what and when to use it for. Providing clear information about it, in for example a short course or just on the intranet would be helpful. Guidelines on risks and safety would also be helpful. It could also be useful to add

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[19]http://www.kapalicarsi.com.tr/
[20]url https://dehaagsemarkt.nl/
[21]Example Bluetooth Speaker: JBL GO
[22]https://www.oculus.com/go/

an availability section to the EldersVR master app, where support personnel have a clear overview of whether a set is available or in use. Having a container, such as a bag or case, specifically designed for the used VR headset, will make transportation easier too.

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REFERENCES

[1] 1 miljoen ouderen in Nederland eenzaam nationaal ouderen fonds. https://www.ouderenfonds.nl/activiteiten/eenzaamheid. Accessed: 2019-03-15.

[2] Actieprogramma gericht op het bestrijden van eenzaamheid gemeente rotterdam. https://www.rotterdam.nl/wonen-leven/voor-mekaar/actieprogramma_eenzaamheid_voor_mekaar.pdf. Accessed: 2019-03-15.

[3] Bevolkingspiramide cbs. https://www.cbs.nl/nl-nl/visualisaties/bevolkingspiramide. Accessed: 2019-03-15.

[4] Gezondheidsmonitor Volwassenen en Ouderen, GGD'en, CBS en RIVM, howpublished = https://bronnen.zorggegevens.nl/bron?naam=gezondheidsmonitor-volwassenen-en-ouderen%2c-ggd%e2%80%99en%2c-cbs-en-rivm, note = Accessed: 2019-03-15.

[5] Ahmed, B., Eklundh, J., Hellström, S., Lindvall, J., Yenkong, E., and Hellstén, T. Could virtual reality be a solution for loneliness among elderly?

[6] Antunes, T. P. C., de Oliveira, A. S. B., Crocetta, T. B., de Lima Antão, J. Y. F., de Almeida Barbosa, R. T., Guarnieri, R., Massetti, T., de Mello Monteiro, C. B., and de Abreu, L. C. Computer classes and games in virtual reality environment to reduce loneliness among students of an elderly reference center: Study protocol for a randomised cross-over design. Medicine 96, 10 (2017).

[7] Bell, C. S., Fain, E., Daub, J., Warren, S. H., Howell, S. H., Southard, K. S., Sellers, C., and Shadoin, H. Effects of nintendo wii on quality of life, social relationships, and confidence to prevent falls. Physical & Occupational Therapy in Geriatrics 29, 3 (2011), 213–221.

[8] Benoit, M., Guerchouche, R., Petit, P.-D., Chapoulie, E., Manera, V., Chaurasia, G., Drettakis, G., and Robert, P. Is it possible to use highly realistic virtual reality in the elderly? a feasibility study with image-based rendering. Neuropsychiatric disease and treatment 11 (2015), 557.

[9] Blit-Cohen, E., and Litwin, H. Elder participation in cyberspace: A qualitative analysis of israeli retirees. Journal of Aging Studies 18, 4 (2004), 385–398.

[10] Botella, C., Etchemendy, E., Castilla, D., Baños, R. M., García-Palacios, A., Quero, S., Alcaniz, M., and Lozano, J. A. An e-health system for the elderly (butler project): A pilot study on acceptance and satisfaction. CyberPsychology & Behavior 12, 3 (2009), 255–262.

[11] Bruun-Pedersen, J. R., Serafin, S., and Kofoed, L. B. Simulating nature for elderly users-a design approach for recreational virtual environments. In 2015 IEEE International Conference on Computer and Information Technology; Ubiquitous Computing and Communications; Dependable, Autonomic and Secure Computing; Pervasive Intelligence and Computing (2015), IEEE, pp. 1566–1571.

[12] Burdea, G. C., and Coiffet, P. Virtual reality technology. John Wiley & Sons, 2003.

[13] Cody, M. J., Dunn, D., Hoppin, S., and Wendt, P. Silver surfers: Training and evaluating internet use among older adult learners. Communication education 48, 4 (1999), 269–286.

[14] Corriveau Lecavalier, N., Ouellet, É., Boller, B., and Belleville, S. Use of immersive virtual reality to assess episodic memory: A validation study in older adults. Neuropsychological rehabilitation (2018), 1–19.

[15] Day, J. C. National population projections. Methodology 301 (2011), 457–2422.

[16] De Bruin, E., Schoene, D., Pichierri, G., and Smith, S. T. Einsatz der virtuellen realität für das training der motorischen kontrolle bei älteren. einige theoretische überlegungen. Zeitschrift fur Gerontologie und Geriatrie 43, 4 (2010), 229–234.

[17] De Bruin, E., Schoene, D., Pichierri, G., and Smith, S. T. Use of virtual reality technique for the training of motor control in the elderly. Zeitschrift für Gerontologie und Geriatrie 43, 4 (2010), 229–234.

[18] Demiris, G., Rantz, M. J., Aud, M. A., Marek, K. D., Tyrer, H. W., Skubic, M., and Hussam, A. A. Older adults' attitudes towards and perceptions of 'smart home' technologies: a pilot study. Medical informatics and the Internet in medicine 29, 2 (2004), 87–94.

[19] Denissen, E. Ouderen en nieuwe technologie in huis: bondgenoten of vijanden? Master's thesis, University of Twente, 2006.

[20] Depledge, M. H., Stone, R. J., and Bird, W. Can natural and virtual environments be used to promote improved human health and wellbeing?, 2011.

[21] Diemer, J., Pauli, P., and Mühlberger, A. Virtual reality in psychotherapy. International Encyclopedia of the Social Behavioral Sciences (2015), 138–146.

[22] Etchemendy, E., Baños, R. M., Botella, C., Castilla, D., Alcañíz, M., Rasal, P., and Farfallini, L. An e-health platform for the elderly population: The butler system. Computers & Education 56, 1 (2011), 275–279.

[23] Garcia-Betances, R. I., Jiménez-Mixco, V., Arredondo, M. T., and Cabrera-Umpiérrez, M. F. Using virtual reality for cognitive training of the elderly. American Journal of Alzheimer's Disease & Other Dementias® 30, 1 (2015), 49–54.

[24] González, A., Ramírez, M. P., and Viadel, V. Attitudes of the elderly toward information and communications technologies. Educational Gerontology 38, 9 (2012), 585–594.

[25] Hammick, J. K., and Lee, M. J. Do shy people feel less communication apprehension online? the effects of virtual reality on the relationship between personality characteristics and communication outcomes. Computers in Human Behavior 33 (2014), 302–310.

[26] Hughes, S., Warren-Norton, K., Spadafora, P., and Tsotsos, L. Supporting optimal aging through the innovative use of virtual reality technology. Multimodal Technologies and Interaction 1, 4 (2017), 23.

[27] Jebara, N., Orriols, E., Zaoui, M., Berthoz, A., and Piolino, P. Effects of enactment in episodic memory: a pilot virtual reality study with young and elderly adults. Frontiers in aging neuroscience 6 (2014), 338.

[28] Kahlbaugh, P. E., Sperandio, A. J., Carlson, A. L., and Hauselt, J. Effects of playing wii on well-being in the elderly: Physical activity, loneliness, and mood. Activities, Adaptation & Aging 35, 4 (2011), 331–344.

[29] Karavidas, M., Lim, N. K., and Katsikas, S. L. The effects of computers on older adult users. Computers in human behavior 21, 5 (2005), 697–711.

[30] Khademi, M., Hondori, H. M., Dodakian, L., Cramer, S., and Lopes, C. V. Comparing "pick and place" task in spatial augmented reality versus non-immersive virtual reality for rehabilitation setting. In 2013 35th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC) (2013), IEEE, pp. 4613–4616.

[31] Kim, A., Darakjian, N., and Finley, J. M. Walking in fully immersive virtual environments: an evaluation of potential adverse effects in older adults and individuals with parkinson's disease. Journal of neuroengineering and rehabilitation 14, 1 (2017), 16.

[32] Lange, B., Requejo, P., Flynn, S. M., Rizzo, A., Valero-Cuevas, F., Baker, L., and Winstein, C. The potential of virtual reality and gaming to assist successful aging with disability. Physical Medicine and Rehabilitation Clinics 21, 2 (2010), 339–356.

[33] Larson, E. B., Feigon, M., Gagliardo, P., and Dvorkin, A. Y. Virtual reality and cognitive rehabilitation: a review of current outcome research. NeuroRehabilitation 34, 4 (2014), 759–772.

[34] Lee, K. M., Jung, Y., Kim, J., and Kim, S. R. Are physically embodied social agents better than disembodied social agents?: The effects of physical embodiment, tactile interaction, and people's loneliness in human–robot interaction. International journal of human-computer studies 64, 10 (2006), 962–973.

[35] Lin, C.-S., Jeng, M.-Y., and Yeh, T.-M. The elderly perceived meanings and values of virtual reality leisure activities: A means-end chain approach. International journal of environmental research and public health 15, 4 (2018), 663.

[36] Lutz, W., Sanderson, W., and Scherbov, S. The coming acceleration of global population ageing. Nature 451, 7179 (2008), 716.

[37] McCallum, S., and Boletsis, C. Augmented reality & gesture-based architecture in games for the elderly. Studies in health technology and informatics 189 (2013), 139–144.

[38] Milgram, P., and Kishino, F. A taxonomy of mixed reality visual displays. IEICE TRANSACTIONS on Information and Systems 77, 12 (1994), 1321–1329.

[39] Miller, K. J., Adair, B. S., Pearce, A. J., Said, C. M., Ozanne, E., and Morris, M. M. Effectiveness and feasibility of virtual reality and gaming system use at home by older adults for enabling physical activity to improve health-related domains: a systematic review. Age and ageing 43, 2 (2013), 188–195.

[40] Optale, G., Urgesi, C., Busato, V., Marin, S., Piron, L., Priftis, K., Gamberini, L., Capodieci, S., and Bordin, A. Controlling memory impairment in elderly adults using virtual reality memory training: a randomized controlled pilot study. Neurorehabilitation and neural repair 24, 4 (2010), 348–357.

[41] Organization, W. H. Oral health surveys: basic methods. World Health Organization, 2013.

[42] Park, E.-C., Kim, S.-G., and Lee, C.-W. The effects of virtual reality game exercise on balance and gait of the elderly. Journal of physical therapy science 27, 4 (2015), 1157–1159.

[43] Park, J., and Yim, J. A new approach to improve cognition, muscle strength, and postural balance in community-dwelling elderly with a 3-d virtual reality kayak program. The Tohoku journal of experimental medicine 238, 1 (2016), 1–8.

[44] Peng, W., Crouse, J. C., and Lin, J.-H. Using active video games for physical activity promotion: a systematic review of the current state of research. Health

education & behavior 40, 2 (2013), 171–192.

[45] Repetto, C., Serino, S., Macedonia, M., and Riva, G. Virtual reality as an embodied tool to enhance episodic memory in elderly. *Frontiers in psychology 7* (2016), 1839.

[46] Saldaña, J. *The coding manual for qualitative researchers*. Sage, 2015.

[47] Sanchez-Vives, M. V., and Slater, M. From presence to consciousness through virtual reality. *Nature Reviews Neuroscience 6*, 4 (2005), 332.

[48] Shin, J.-H., Park, S. B., and Jang, S. H. Effects of game-based virtual reality on health-related quality of life in chronic stroke patients: A randomized, controlled study. *Computers in biology and medicine 63* (2015), 92–98.

[49] Siegers, J. Mark r. rosenzweig and oded stark (eds.), handbook of population and family economics. *European Journal of Population/Revue européenne de Démographie 15*, 3 (1999), 305–307.

[50] Slattery, P., and Langerock, N. Blurring art and science: Synthetical moments on the borders. *Curriculum Inquiry 32*, 3 (2002), 349–356.

[51] Steuer, J. Defining virtual reality: Dimensions determining telepresence. *Journal of communication 42*, 4 (1992), 73–93.

[52] Tilvis, R., Routasalo, P., Karppinen, H., Strandberg, T., Kautiainen, H., and Pitkala, K. Social isolation, social activity and loneliness as survival indicators in old age; a nationwide survey with a 7-year follow-up. *European Geriatric Medicine 3*, 1 (2012), 18–22.

[53] Tse, M. M., Choi, K. C., and Leung, R. S. E-health for older people: the use of technology in health promotion. *CyberPsychology & Behavior 11*, 4 (2008), 475–479.

[54] Van De Watering, M. The impact of computer technology on the elderly. *Retrieved June 29*, 2008 (2005), 12.

[55] Wellman, B., Frank, K., et al. Network capital in a multi-level world: Getting support from personal communities. *Social capital: Theory and research* (2001), 233–273.

[56] Whiting, L. S. Semi-structured interviews: guidance for novice researchers. *Nursing Standard 22*, 23 (2008), 35–41.

[57] Wiederhold, B., and Riva, G. Earth of wellbeing: a place to live positive emotions. *Annual Review of Cybertherapy and Telemedicine: Advanced Technologies in the Behavioral, Social and Neurosciences. 2012 181* (2012), 310.

[58] Zyda, M. From visual simulation to virtual reality to games. *Computer 38*, 9 (2005), 25–32.
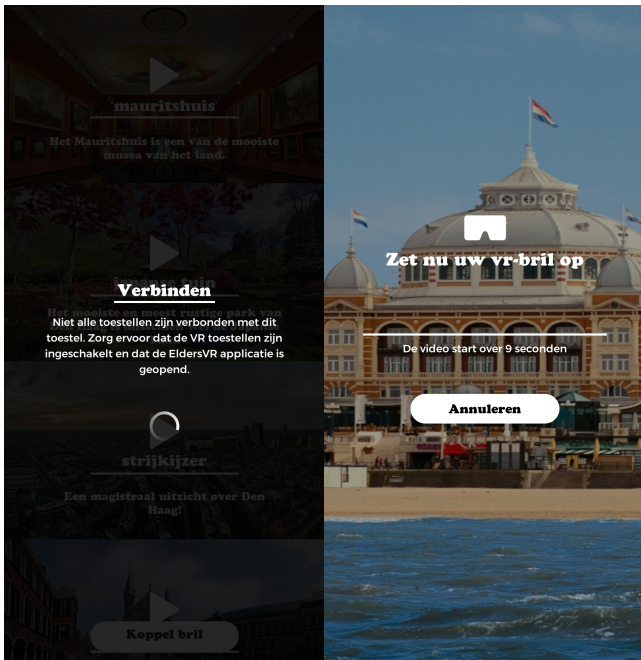
6 APPENDIX

6.1 System Description Screenshots

Figure 3: Screenshots EldersVR Vertical
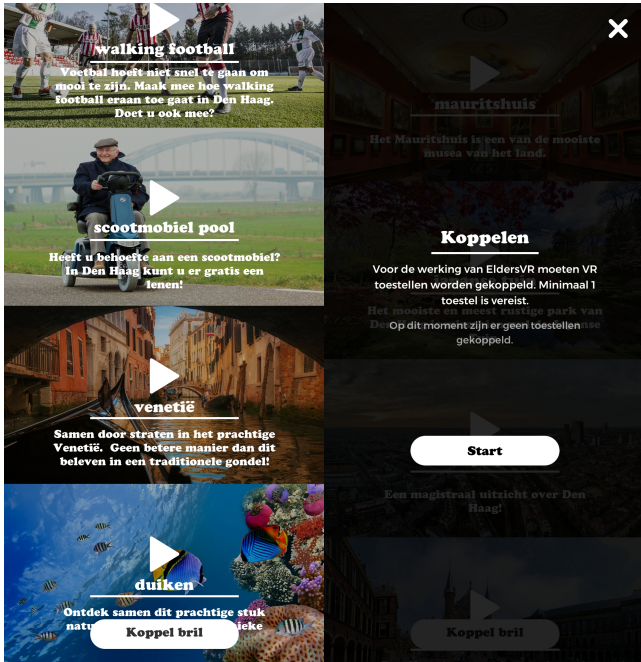
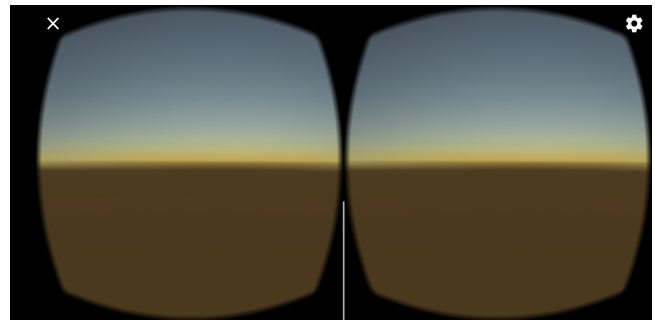(a) Home Screen   (b) Master Pairing

(c) Master Connecting   (d) Master Loading

Figure 4: Screenshots EldersVR Horizontal

(a) Slave Connecting.

(b) Horizon (idle)

(c) Slave Loading

(d) Master Video

6.2 Questions semi-structured open-ended interviews

Vragen

1. Kan je de tekst goed lezen? (aftel scherm op horizon)
2. Hoe lang denkt u dat het filmpje duurde? (Kurhaus = 3.15m)
3. Wat vond u van de lengte?
4. Wat was u ervaring in het algemeen?
5. Wat vond u van de meneer die u welkom heette?
6. Vond u de tekst fijner of heeft u liever een gids die u informeert?
7. Uitleg Home Wat vindt u van dit initiatief?

6.3 NVivo Interview Results Hierarchy Chart

reacties
- Positieve reacties
- Negatieve reacties
  - neutraal

gids of tekst
- gids
  - tekst
  - neutraal

Tekst leesbaarheid
- wel
  - niet
  - twijfel

Mening algemeen
- positief
- negatief
  - misselijkheid - duiziligheid
  - neutraal

wachttijd 10 seconden
- goed
  - te lang
  - te kort

Lengte filmpje schatting
- sterk boven
  - ongeveer 3.15

Home mening
- positief
- negatief

Lengte filmpje mening
- te kort
- goed
  - te lang

verwelkoming host
- positief
- negatief
  - neutraal

gewenning
- snel

beeldkwaliteit
- positief
- negatief

geluidskwaliteit
- negatief
- po...

Toestemmingsformulier
EldersVR Onderzoek

UNIVERSITEIT VAN AMSTERDAM

Naam van het onderzoeksproject	EldersVR impact onderzoek
Doel van het onderzoek	Dit onderzoek wordt geleid door Yahya Algehaili. U bent van harte uitgenodigd om deel te nemen aan dit onderzoek. Het doel van dit onderzoek is de impact te meten van het platform, zodat deze verbeterd kan worden.
Gang van zaken tijdens het onderzoek	U neemt deel aan een interview waarin aan u vragen zullen worden gesteld over EldersVR. Een voorbeeld van een typische vraag die u zal worden gesteld: "wat vind u van het getoonde filmpje?".

Voorafgaand worden enkele achtergrondgegevens gevraagd, zoals uw leeftijd. Van het interview kunnen audio en/of video opnames gemaakt worden, zodat het gesprek later kan worden uitgewerkt
Dit transcript wordt vervolgens anoniem gebruikt in het verdere onderzoek.

Potentiële risico's en ongemakken
Er zijn **geen** fysieke, juridische of economische risico's verbonden aan uw deelname aan deze studie. U hoeft **geen** vragen te beantwoorden die u niet wilt beantwoorden. Uw deelname is vrijwillig en u kunt uw deelname op elk gewenst moment stoppen.

Vergoeding
U ontvangt voor deelname aan dit onderzoek geen vergoeding . Door deel te nemen aan dit onderzoek zult u meer inzicht krijgen in het platform. Het bredere doel van dit onderzoek is: het verbeteren van het EldersVR platform.

Vertrouwelijkheid van gegevens
Uw privacy is en blijft maximaal beschermd. Er wordt op geen enkele wijze vertrouwelijke informatie of persoonsgegevens van of over u naar buiten gebracht, waardoor iemand u zal kunnen herkennen.

Voordat onze onderzoeksgegevens naar buiten gebracht worden, worden uw gegevens **anoniem** gemaakt: geanonimiseerd. Enkele eenvoudige voorbeelden hiervan:

- uw naam wordt vervangen door anonieme, op zichzelf betekenisloze combinatie van getallen.

- uw leeftijd zelf wordt niet verwerkt, maar in een categorie geplaatst. Bijvoorbeeld: leeftijd: tussen 18-25 jaar / tussen 25-35 jaar etc.

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Vrijwilligheid   Deelname aan dit onderzoek is geheel vrijwillig. Je kunt als deelnemer jouw medewerking aan het onderzoek te allen tijde stoppen, of weigeren dat jouw gegevens voor het onderzoek mogen worden gebruikt, zonder opgaaf van redenen.

Dit betekent dat als je voorafgaand aan het onderzoek besluit om af te zien van deelname aan dit onderzoek, dit dit op geen enkele wijze gevolgen voor jou zal hebben. Tevens kun je tot 5 werkdagen (bedenktijd) na het interview alsnog de toestemming intrekken die je hebt gegeven om gebruik te maken van jouw gegevens.

Als u tijdens het onderzoek, na de bedenktijd van 5 werkdagen, besluit om uw medewerking te staken, zal dat eveneens op geen enkele wijze gevolgen voor je hebben. Echter: de gegevens die u hebt verstrekt tot aan het moment waarop uw deelname stopt, zal in het onderzoek gebruikt worden, inclusief de bescherming van uw privacy zoals hierboven beschreven. Er worden uiteraard geen nieuwe gegevens verzameld of gebruikt.

Als u besluit om te stoppen met deelname aan het onderzoek, of als u vragen of klachten heeft, of uw bezorgdheid kenbaar wilt maken, of een vorm van schade of ongemak vanwege het onderzoek, neemt u dan aub contact op met de onderzoeksleider:

yahya@q42.nl

0681900581

Toestemingsformulier

EldersVR onderzoek

Toestemmingsverklaring

Met uw ondertekening van dit document geeft aan dat u minstens 18 jaar oud bent; dat u goed bent geïnformeerd over het onderzoek, de manier waarop de onderzoeksgegevens worden verzameld, gebruikt en behandeld en welke eventuele risico's u zou kunnen lopen door te participeren in dit onderzoek.

Indien u vragen had, geeft u bij ondertekening aan dat u deze vragen heeft kunnen stellen en dat deze vragen helder en duidelijk zijn beantwoord. U geeft aan dat u vrijwillig akkoord gaat met uw deelname aan dit onderzoek. U ontvangt een kopie van dit ondertekende toestemmingsformulier.

Ik ga akkoord met deelname aan een onderzoeksproject geleid door Yahya Algehaili. Het doel van dit document is om de voorwaarden van mijn deelname aan het project vast te leggen.

1. Ik kreeg voldoende informatie over dit onderzoeksproject. Het doel van mijn deelname als een geïnterviewde in dit project is voor mij helder uitgelegd en ik weet wat dit voor mij betekent.

2. Mijn deelname als geïnterviewde in dit project is vrijwillig. Er is geen expliciete of impliciete dwang voor mij om aan dit onderzoek deel te nemen.

3. Mijn deelname houdt in dat ik word geïnterviewd door Yahya Algehaili. Ik geef de onderzoeker toestemming om tijdens het interview opnames (geluid / beeld) te maken en schriftelijke notities te nemen. Het is mij duidelijk dat, als ik toch bezwaar heb met een of meer punten zoals hierboven benoemd, ik op elk moment mijn deelname, zonder opgaaf van reden, kan stoppen.

4. Ik heb het recht om vragen niet te beantwoorden. Als ik me tijdens het interview ongemakkelijk voel, heb ik het recht om mijn deelname aan het interview te stoppen.

5. Ik heb van de onderzoeksleider de uitdrukkelijke garantie gekregen dat de onderzoeksleider er zorg voor draagt dat ik niet ben te identificeren in door het onderzoek naar buiten gebrachte gegevens, rapporten of artikelen. Mijn privacy is gewaarborgd als deelnemer aan dit onderzoek.

6. Ik heb dit formulier gelezen en begrepen. Al mijn vragen zijn naar mijn tevredenheid beantwoord en ik ben vrijwillig akkoord met deelname aan dit onderzoek. Ook heb ik een ondertekende kopie ontvangen van dit toestemmingsformulier.

Datum:

Naam onderzoeker   Naam participant

_____   _____

Handtekening   Handtekening

_____   _____