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Master's Thesis
Academic Year 2021

Dementia Eyes: Understanding Dementia through Augmented Reality

Keio University
Graduate School of Media Design

Ximing Shen

A Master's Thesis
submitted to Keio University Graduate School of Media Design
in partial fulfillment of the requirements for the degree of
Master of Media Design

Ximing Shen

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Abstract of Master's Thesis of Academic Year 2021

Dementia Eyes: Understanding Dementia through Augmented Reality

Category: Design

Summary

Dementia is a worldwide public health priority which is accelerating as we entered the aging society. While dementia-oriented care service is still an emerging field, the lack of understanding in pathology, the misunderstanding of patient behaviour, and the shortage of skilled labour, make it unconventionally challenging comparing to that for the elderly without cognitive impairment. To make contribution to a better aging society, this research proposes utilizing Extended Reality(XR) to improve professional medical worker's understanding of dementia. We created an Augmented Reality(AR) experience simulating the most common symptoms of Alzheimer's type of dementia based on the known pathology and medical workers' experience with actual patients, which allows users to see the world through a dementia patient's eyes. We tested the AR experience with professional medical workers in the field, and the result advocates for the efficacy of the empathy the experience expects to bring.

Keywords:

dementia care, empathy training, senile dementia, aging population, Extended Reality, Augmented Reality

Keio University Graduate School of Media Design

Ximing Shen

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Last but not least, I am grateful for my family and friends back home. You are the light of my life.

Chapter 1
Introduction

1.1. Dementia and Dementia Care

Dementia is a collective term describing the phenomenon of memory loss, language ability disorder, problem-solving, and other cognitive disabilities due to the damage of brain cells. According to WHO[1], dementia currently affects around 50 million people worldwide, and is estimated to increase by, on average, 10 million new cases every year. As a progressive syndrome which mainly affects the elderly, it has become a global public health challenge since we entered the aging society.

Same as the other healthy elderly, people with senile dementia requires certain level of daily support in the later stage of their life; however, caring for those who have cognitive disabilities could be reasonably challenging: imagine being the caregiver who has to introduce themselves over and over again, tolerate it when patient screams at them, fix damages patients make like messing up toileting, and teach basic tasks like putting on shirts or grabbing their mug repeatedly etc.. Yet if we switch the perspective to the patient, once the first symptom shows, it becomes a one-way trip that only gets worse over time, and eventually become a years-long process for themselves, their families, informal and formal caregivers, and everyone else around them. Hence, the question of how to make the last stage of dementia patient's life quality, which requires the understanding of all parties involved in this never-return journey, has come to the spotlight.

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1 https://www.who.int/news-room/fact-sheets/detail/dementia

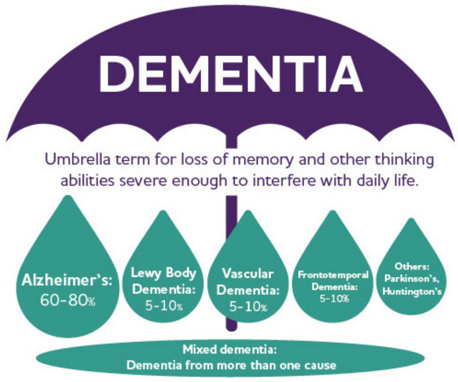


Figure 1.1 Key Facts about Dementia(Source: Alzheimer's Association[2])

1.2. Empathy: A key factor to quality medical experience

Empathy stands for the ability to place oneself in another person's situation, consequently understanding the person's feelings from their perspective. In the field of professional medical care, empathy between those experts and patients has been investigated in many studies in the past decades. We all have the suffering experience of waiting in line for doctor's appointment anxiously in hospital or clinic, because we are waiting for a judgement which might not be good. It is not hard to imagine the situation when a patient being too anxious to describe their illness or talking incoherent things to the doctor, and the doctor gives diagnosis and prescription without explanation, then the patient becomes more anxious. It has been proven that understanding patient's perspectives and the obstacles they are going through is vital to smooth communication between medical professionals and patients – empathy is effective in increasing patients' satisfaction, decreasing anxiety, and is unquestionable important to quality medical experience [1].

2 https://www.alz.org/alzheimers-dementia/what-is-dementia

1.3. Industry's effort on better care service

As the globe is entering the aging society, better the healthcare service has become an urgent need. The industry has put on their efforts to solve the problem by providing new assistive technologies, improving the hospital environment design, and transferring patient's experience etc.. With the surge of new technologies such as Artificial Intelligence, blockchain, and 5G, we have myriad innovative options for improving social welfare now, and it is a good time to slow down our step to think about how they can benefits the mankind, rather than tirelessly exploring fast algorithms. For example, Extended Reality(XR) is described as the experience of real-time interaction between real-world environment and computational information. With the spread of the use of mobile devices and the rapid enhancement of their functionalities, AR applications have already entered many aspects of our life: face filters on social media platforms such as Instagram and Snapchat, Nintendo's mobile game Pokemon Go[3], and Adidas's virtual sneaker try-on App[4]. However, XR shall not be limited to recreational purpose. For example, when astronomy students look up to the sky, an MR application can immediately name all of the visible planet for them; when physicians operate a surgery, an MR application can identify organs wherever they look at, etc.. XR is a powerful tool that is beneficial to our lives, and yet still have many potentials for us to explore.

1.4. Research Goal

Utilizing XR technology, we propose an empathy experience which brings manifested visual phenomenon of senile dementia patients to their caregivers. The goal of this research is to help nurses to understand people with dementia better by perceiving the world through a dementia patient's eyes.

3 https://www.pokemongo.jp/

4 https://footwearnews.com/2019/business/retail/adidas-alphaedge-virtual-try-on-ar-vyking-1202876679/

1.5. Thesis Structure

This thesis consists of 5 chapters.

- Chapter 1 introduces the background of this research.
- Chapter 2 is a literature review chapter of the necessary medical knowledge for this thesis, existing XR practice in the medical spectrum, and existing XR applications for dementia specifically.
- Chapter 3 elaborates on the concept design process of this research and the technical implementation of the visual design.
- Chapter 4 includes the design of roof of concept, a series of user tests, as well as analysis on the result from them.
- Chapter 5 is a conclusion of this research, general discussion and insights for future works.

Chapter 2
Literature Review

2.1. Dementia

Dementia is an umbrella term for any disease that cause significant level of cognitive declination which by pathogenesis, can be categorised into degenerative and non-degenerative disease or disorder. Summarised in a review paper by MD Seth A. Gale, MD Diler Acar, and MD Kirk R. Daffner [2], because it is a heterogeneous syndrome that can be caused by many different reasons jointly, when a person is said to “have dementia”, it is possible that they are diagnosed with certain type of neurodegenerative disease or non-neurodegenerative disease, or both at the same time which might lead to aggravated cognitive impairment. While non-neurodegenerative types of dementia can be due to extrinsic factors such as trauma, nutrition deficiency, or alcohol abuse, neurodegenerative types of dementia are due to intrinsic changes inside the brain and are identified as irreversible.

Without traumatic external factors, most dementia occurring to the elderly are neurodegenerative; among which, the type of dementia that takes the largest proportion is Alzheimer’s Disease(AD), which by estimation, accounts for 60˜80% of total cases according to Alzheimer’s Association’s 2020 yearly fact sheet [3].

AD is a neurodegenerative disease caused by abnormal accumulation of beta-amyloid rich neuritic plaques and neurofibrillary tangles, and can lead to memory loss and other cognitive declination. Other common types of dementia includes Parkinson’s Disease(PD), Lewy Body Disease(LBD), and Cerebrovascular Disease(CD).

Table 1 Examples of Selected Cognitive Impairment/Dementia Syndromes, Divided into Two Broad Categories: Neurodegenerative and Non-neurodegenerative

Neurodegenerative	Non-neurodegenerative
Alzheimer disease	Vascular dementia (multi-infarct dementia, small-vessel ischemic disease, chronic/subacute subdural hematomas, hypoxic/ischemic encephalopathy)
Dementia with Lewy bodies, Parkinson disease dementia	Normal pressure hydrocephalus
Frontotemporal lobar degeneration	Metabolic causes (hypothyroidism, chronic uremia, malnutrition, Cushing syndrome)
Multiple system atrophy	Autoimmune causes (limbic encephalitis, Hashimoto encephalopathy, voltage-gated potassium channel encephalopathy)
Non-Parkinsonian movement disorders (Huntington disease, Wilson disease, Dentatorubral-pallidoluysian atrophy)	Depression, bipolar disorder (historically called "pseudo-dementia")
Alcoholic cognitive impairment/dementia	Neoplastic/paraneoplastic causes (NMDA-receptor and CRMP-5-antibody encephalopathy, brain tumor)
Chronic traumatic encephalopathy	Infectious causes (syphilis, HIV-associated neurocognitive disorder)
Prion disease (Creutzfeldt-Jakob disease, fatal familial insomnia)	Toxic causes (lead, arsenic, organophosphate pesticides)
Dementia related to multiple sclerosis	Vasculitides (primary vasculitis of the central nervous system, Behçet disease, SLE-related)
Motor neuron disease (Amyotrophic lateral sclerosis, Primary lateral sclerosis)	Vitamin deficiency (B12, thiamine, niacin, folic acid)

CRMP = collapsin response-mediator protein; HIV = human immunodeficiency virus; NMDA = *N*-methyl-D-aspartate; SLE = systemic lupus erythmatosus.

Figure 2.1 Examples of Selected Dementia Syndromes(Source: Gale, Acar, and Daffner [2])

2.2. Dementia Care

How much population worldwide is impacted by dementia? According to Alzheimer's Disease International[1], on average every 3 seconds there is one person somewhere in the world diagnosed with dementia. Having been a global health crisis for decades, yet there are still many barriers to dementia care: inequality in different countries or areas inside one country [4, 5], belated diagnosis [6], the demand of a dementia-oriented care system distinguished from the healthy elderly's caring home [7], etc..

Behavioral and Psychological Symptoms of Dementia(BPSD), is a commonly used term in the field of dementia care, which summarizes any forms of inappropriate actions reflecting on internal and/or external triggers that can possibly happened to any dementia patient [8]. Decreasing the level of BPSD has been a major task in all dementia care, regarding the detailed treatment, it can be separated into pharmacological treatment of BPSD, as well as non-pharmacological treatment: Pharmacological treatments are prescribed medicines targeting different types of dementia disease, while non-pharmacological treatments are dementia-

1 https://www.alzint.org/about/dementia-facts-figures/dementia-statistics/

friendly orientation of the environment [5].

After years of evolution, non-pharmacological treatment of BPSD has become a special area in interior design, where emphasis on color contrast, easy-to-understand signs, and other cautious elements such as lighting and acoustic performance of the space are included, according to experts at Dementia Services Development Centre, University of Stirling [9].

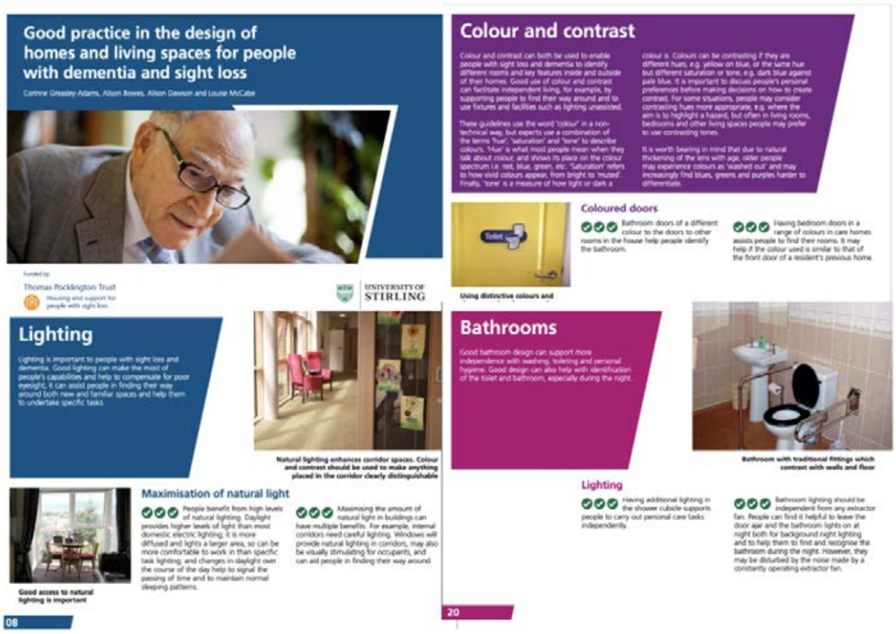


Figure 2.2 Sterling University's dementia design principle (Source: Good practice in the design of homes and living spaces for people with dementia and sight loss[3])

2.3. Empathy

Dementia care is such a delicate process that requires cautious behaviour of nurses in every step, while it is of human nature that people who are free from those

3 https://dementia.stir.ac.uk/system/files/filedepot/12/good_practice_in_the_design_of_homes _and_living_spaces_for_people_living_with_dementia_and_sight_loss_final.pdf

diseases cannot understand how the patient feel, and might be frustrated and do not know how to response when interacting with patients. Nurse's empathy has been validated in multiple clinical practices to be a pivotal factor in care service. In a systematic review by Frans Derksen, Jozien Bensing and Antoine Lagro-Janssen [1], they reflects that empathy has been agreed by different parties involved in the nursing service as "the basis for a humane patient-centred method in general practice and as an important component of professionalism", and patients have an inclination to recommend empathetic physicians they have worked with to others. In the article, empathy is divided into three categories: attitude, competency, and behaviour(see Figure2.3), which are equally important components in empathising with patients. Communication skill, for example, is a usually neglected factor by the general public, while remaining an effective tool in the general practice. Sandra van Dulmen and Atie van den Brink-Muinen [10] conducted one of the earliest studies on patient-physician communication and the corresponding emotional changes; throughout their study, those researchers were able to find out that, via before and after questionnaires, patients indeed experience emotional changes: they reported lower level of anxiety after seeing empathetic doctors, and a hypothesis of the relationship between patient's level of anxiety and physician's empathy, as well as response to patients is illustrated in Figure2.4.

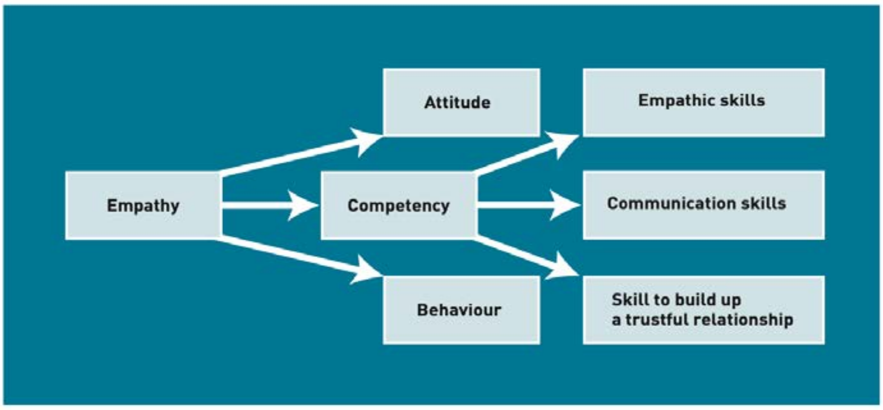


Figure 2.3 Subdivisions of Empathy,(Source: Derksen, Bensing, and Lagro-Janssen [1])

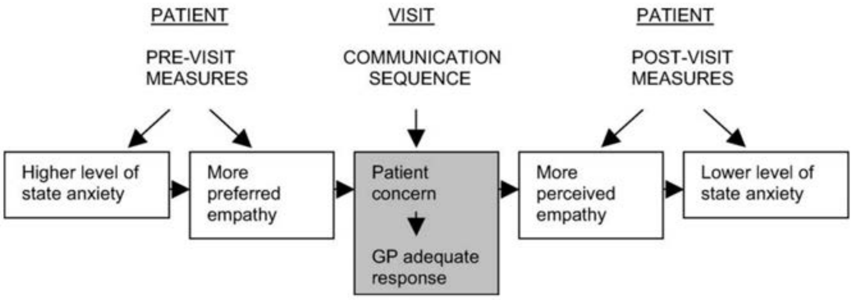


Figure 2.4 Presumed relationship between patient's level of anxiety, preferred and perceived empathy and GPs adequate response to patient's concern (Source: Dulmen and Brink-Muinen [10])

2.4. Extended Reality(XR) and Experience Transfer

To empathize with individuals from other groups in the modern world, Extended Reality(XR) has become a powerful tool. XR is an umbrella term includes Virtual Reality(VR), Augmented Reality(AR), and Mixed Reality(MR), which describes all human-computer-interaction technologies in a real or virtual environment. Comparing to AR which we introduced in the previous chapter, VR stands for the immersive experience of a computer-generated three-dimensional(3D) environment that is fully virtual; while AR, emphasizes on the capability of interactions between the real-world user and the virtual elements(illustrated in Figure2.5).

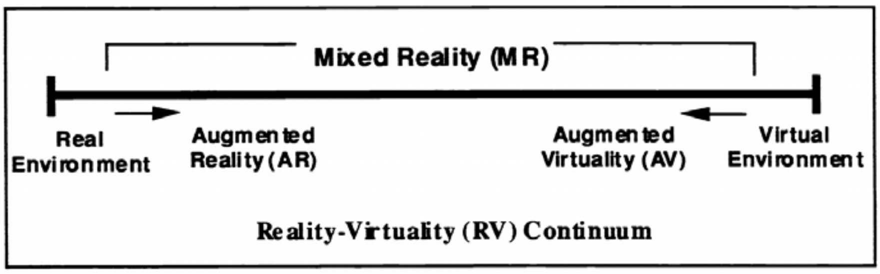


Figure 2.5 Reality-Virtuality(RV) Continuum (Source: Milgram et al. [11])

For example, Royal College of Art graduate Heeju Kim[4]designed an AR and candy toolkit to transfer the experience of autism(demonstrated as Figure 2.6). This toolkit includes an AR headset to interfere the user's vision, a pair of earphones to simulate the oversensitive hearing, and a weird-shaped candy to hinder the ability to talk, aiming for understanding of unclear pronunciation. The design drew attention as it can help designers to understand the importance of inclusive design, and how to improve on the autism spectrum. Although there is no studies regarding the efficacy of this design, it is a pioneer design in the field of small-scale AR tool for inclusive experience transfer.

Figure 2.6 Empathy Bridge for Autism by Heeju Kim, 2017 (Source: Royal College of Art[4]

Another example of experience transfer is Preterna, created by two artists Jeremy Bailey and Kristen D. Schaffer from Toronto[5], an VR experience simulating pregnancy(see Figure2.7 for demonstration). Preterna uses Leap Motion sensors on the VR headset, and allows the user to look down to observe their avatar in the virtual world; the user can also experience rubbing their pregnant belly in the VR experience.

4 https://www.rca.ac.uk/research-innovation/research-centres/helen-hamlyn-centre/helen_hamlyn_student_programme/helen_hamlyn_design_awards/2016/empathy-bridge-autism/

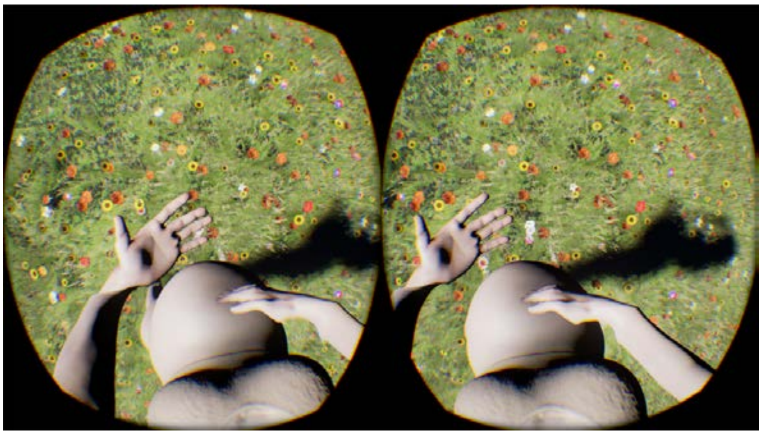


Figure 2.7 Preterna by Bailey and Schaffer, 2016 (Source:Jeremy Bailey and Kristen D. Schaffer[5])

2.5. Mainstream XR applications in the medical field

Inside the XR spectrum, VR specifically , has had its appearance in the medical field for years now. In this session, we will go through some of the representative applications inside the professional world.

2.5.1 XR for medical training

When thinking about possible VR applications outside recreation, medical training–narrowing down to simulated surgical practice–is one of the first things that come to people's mind. Nagoya University established its XR Medical Center in 2013[6], where they focus on applying cutting edge technologies on medical training and surgical practices in a wide range of area including laparoscopy(examples in Figure 2.8), and other categories of surgeries(examples in Figure 2.9).

Another VR goggle approach for laparoscopy is the novel LAP Mentor VR by 3D Systems[7](see Figure 2.10), which provides a fully immersive virtual operation

5 https://canadianart.ca/reviews/vr-and-the-failure-of-self-help-technology/

6 https://www.med.nagoya-u.ac.jp/edu/nucsc/tools/

(a) CAE LapVR

(b) LAP X3

Figure 2.8 VR laparoscopic simulators available in XR Medical Center, Nagoya University(Source: Nagoya University, XR Medical Center[6])

(a) TEMPO Middle Ear Surgery Simulator

(b) EYESI Intraocular surgery simulator

Figure 2.9 Various VR surgery simulators available in XR Medical Center, Nagoya University (Source: Nagoya University, XR Medical Center[6])

room environment for the medical trainee. It is believed to be an approach close to reality and can help future medical workers to prepare for the stressful operation room environment in advance.

Figure 2.10 LAP Mentor VR (Source: 3D System[7])

Not only is XR already used in clinical medical training, but also is it entering classrooms now. Inside the TEE Innovations Lab at University of California San Francisco, Dr. Derek Harmon and Dr. Kimberly Topp conducted a project to enhance anatomy education via bringing students into an immersive environment where they can see, as well as interact with a 3D anatomical structure from head to toe(see Figure 2.11).

Figure 2.11 UCSF TEE Innovations Lab: VR for Anatomy(Source:Baker [12])

7 https://www.3dsystems.com/healthcare/lap-mentor-vr

2.5.2 XR in clinical practice

Comparing to its widely adoption in the education field, XR's application in actual clinical practice is still new. In 2016, Stanford University opens its Neurosurgical Simulation and Virtual Reality Center, which is one of the pioneer centers that applies patient-specific 3D anatomic model into an immersive virtual environment for physicians to better scheme the surgical approaches beforehand(see Figure 2.12). Another pilot clinical practice is a VR exposure therapy treatment for fear of flying by Amihai Gottlieb and fellows from Center of Advanced Technologies in Rehabilitation, Sheba Medical Center, Ramat Gan, Israel in 2020 [13]. In this study, they proved the efficacy of the VR treatment in treating fear of flying.

Figure 2.12 Stanford Neurosurgical Simulation and Virtual Reality Center(Source: [14])

2.5.3 XR for the elderly

For the general elderly, XR also has a variety of applications. For example, the Positive Aging project that Embodied Media conducted with Mediva Inc.(see Figure2.13), which created collective memories for elderly and conducted workshops to help them increase intimacy. On the commercial side, Japanese company

MediVR launched its VR self-exercise training device aiming to design an "entertainment with hidden healthcare agenda" for the elderly(see Figure2.14).

Figure 2.13 Embodied Media x Mediva: Positive Aging Project (Source: Embodied Media[9])

Figure 2.14 MediVR(Source: MediVR[10]

9 http://embodiedmedia.org/

10 https://www.medivr.jp/

2.6. XR for dementia

As a public health priority affecting 50 million people worldwide[11], emerging technologies have entered this field aiming to improve social welfare and life standard. In this section, we will cover some exiting XR applications in the dementia field specifically.

2.6.1 XR for patient

A potential application for patients with dementia is early assessment. Vitae VR is a UK company using VR to assess cognitive function. They developed a tool called VStore which through asking the user to perform tasks in a virtual game, assess their cognitive level. The product is now under clinical trials at King's College Hospital, London(see Figure2.15 for demonstration).

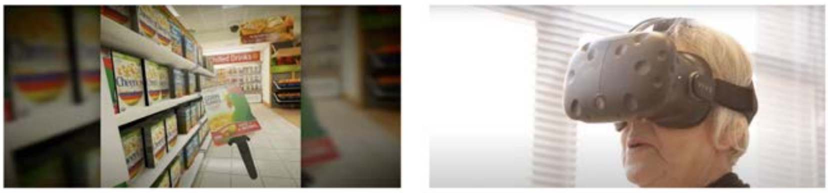


Figure 2.15 Vitae VR's VStore Tool(Source: Vitae[12])

In academia, the potentials of using VR for cognitive training for the elderly has also been studied. In 2014, Rebeca I. García-Betances and her fellows [15] conducted a study on utilizing VR for cognitive rehabilitation and concluded that "VR-based cognitive rehabilitation systems are capable of achieving the expected training goals for people affected by age-related cognitive impairments".

11 https://www.who.int/news-room/fact-sheets/detail/dementia

12 https://www.vitaevr.com/

2.6.2 XR for non-patient

For non-patient's potential XR application related to dementia, there are also many possibilities. A preventive approach is cognitive training for people with high risks of AD: a pilot study published by Glen M.Doniger et al. in 2018 [16].The study aims to evaluate whether a VR-based training tool(shown in Figure2.16) can be an effective cognitive training tool for middle-aged adults at high risk of AD. Although a full-scale study and the result is not included in the pilot study paper, XR's potential in cognitive training has continuously been exploring by researchers worldwide.

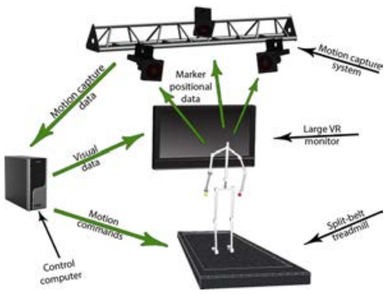


Figure 2.16 VR Training Setup (Source: Doniger et al. [16])

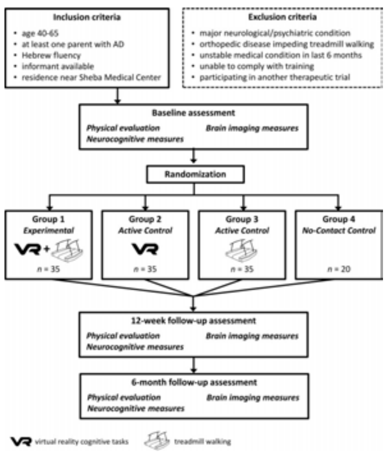


Figure 2.17 Long-term Study Design (Source: Doniger et al. [16])

At the same time, empathy for dementia falls under another category in this area; many products and researches have come out in the past few years. One of the most representative product is the Virtual Reality Empathy Platform in the UK(see Figure 2.18), which can bring immersive experience of a dementia filter. In the relevant academic area, many studies are also done. A pilot study on the effectiveness of Through the D'mentia Lens (TDL), a VR tool for informal caregivers to empathise dementia was conducted by Eva M. Wijma aet al. [17]; 35 informal caregivers participated in their pilot study, and they received promising results which led to their conclusion that TDL is feasible.

Figure 2.18 Virtual Reality Empathy Platform(Source: VR EP[13])

2.7. Summary

In this chapter, we walked through some fundamental knowledge about dementia, dementia care, together with the significance of nurse empathy in caring service. We also covered many research and commercial products leveraging XR techonologies in the medical field, especially its tremendous potential in cognitive training. Throughout the process, we can now understand the potential of XR in empathy training, and how it may eventually lead to benefits in caring service and social welfare. Currently, VR is the most explored type of XR in the medical field; while the prevalence of commercial products leveraging on VR technology for empathy

13 http://vr-ep.com/

has been going on, there is limited amount of research paper studying about the efficacy of them.

Consequently, we decided the goal of this research to be establishing a new system to help medical workers to empathise dementia.

Chapter 3
Concept Design

3.1. Designing an XR experience to understand dementia

Tackling the problem of lack of understanding of dementia patient's true feeling even in professional medical staff, the idea of an XR experience simulating dementia emerged. XR is such a powerful tool for creating virtual experience – the capability of bringing user to an interactive virtual environment, makes it a promising way in transferring dementia experience to the non-patients. For doctors, nurses, family members, and all other people who have daily interactions with patients,understanding and empathy is a solution for everyone's better life together.

Since this proposal is part of the 認知症共生社会に向けた製品・サービスの効果検証事業[1] ("Project to Verify the Effectiveness of Products and Services for a Society with Dementia") initiated by the Ministry of Economy, Trade and Industry(METI), and has been a collaborative project between Embodied Media and Mediva Inc.[2] – a reputable Japanese healthcare and consulting company, in the long term, we aim to launch the XR system as part of a general dementia nursing training program inside hospitals all over Japan, contributing to a dementia-friendly society.

1 https://www.jri.co.jp/service/special/content11/corner113/project2020/

2 Mediva, Company website: https://mediva.co.jp/

3.2. Concept Design Process

3.2.1 Initial Proposal: VR Role Playing and AR with Wearable Devices

Interview

Dementia care is an extensive topic which the younger generation is usually not familiar with, via last chapter we have had a rough image of the current obstacles in dementia care such as, yet to solve the problem down to earth, talking to actual nurses and understand their need is necessary. Therefore, through our collaborator Mediva, we were able to arrange an interview with a nurse who has years of experience caring for dementia patients, Mr. Hirano. The translated transcript is attached below(original transcript in Japanese available in Appendix):

- interviewee: Mr. Hirano
  A nurse at the National Cancer Center East Hospital for 13 years.
  Until two years ago, he was working directly on the ward. He was introduced to us by Dr. Ogawa and accepted today's interview. Usual work: Management and consultation where it is difficult for the general ward staff.
  work in a team with a psychiatrist and a clinical psychologist.
  directly involved with the patients and take a leadership position for the ward nurses.

1. Q. When training new nurses from the training period, what do you keep in mind for dementia patients who require special care?
   A. Basic human communication.
   e.g. greetings. Choose words and explain according to cognitive functions. Refrain from using technical terms. Communicate in plain language. Make sure to do things like informed consent. The nurse should introduce himself/herself and then state the matter in a straightforward manner. When nurses touch the patient's body, they should explain each item before touching it.

2. Q. What do you find difficult about working with dementia patients?
   A. When I am dealing with BPSD (behavioral and psychological symptoms of dementia). To the point where I cannot protect the patient's safety. I want to go home. Unable to consent to medical treatment. I don't want to stay in bed. I fall down. For example, desire to go home, refusal of treatment, inability to rest in bed, removal of route, etc.
   Episodes Many patients are elderly. Also, those with many diseases. They have pancreatic cancer and Parkinson's, pneumonia, and are at high risk of falling. High risk of delirium. It is difficult to administer medication to the patient's mental health, but the patient is in pain mentally and management is difficult. The patient walked out of the room with the route still connected, overcoming the nurse's stillness. The patient's safety could not be protected.

3. Q. As a researcher, what are the tools that can be used for physical assessment and management of patients?
   A. e.x. Checklist made by Dr. Ogawa
   In accordance with the reduced cognitive function.
   It is difficult to teach at once in group education when work is busy, so it is good if it can be done with a tool.
   Communication with young nurses
   Use VR to visually communicate with simulated patients.
   This is to observe the situation and simulate what kind of perspective a patient with cognitive decline would have. Explaining to new nurses with words does not get the point across. It would be nice to be able to understand delirium as well.

4. Q. Which perspective is needed?
   A. Both perspectives are needed. I feel how nurses respond from the perspective of dementia patients. Understand how the dementia patient's comments are conveyed from the nurse's perspective.
   If two VRs are linked, it would be more effective to create a nurse role and

a patient role.

5. Q. Is there anything that you yourself were not taught, but you learned through practice in the field?
A. In terms of knowledge, I didn't have much knowledge on how to control symptoms from a pharmaceutical perspective.
Regarding communication. I was in a cancer center, so I was behind the curve in terms of dementia. When BPSD (behavioral and psychological symptoms of dementia) appeared, we used "sedatives". There were no role models.

6. Q. What do you want to teach when you give input during training and training programs?
A. Dr. Ogawa's educational program has helped me to handle delirium rather well. I would like to learn more about what to do when the patient is not delirious but has dementia. When a patient has delirium, we try to use anti-delirium drugs, but in reality, the patient may have dementia. There is a reason why dementia patients behave the way they do, so it may be possible to control their symptoms without using drugs.

7. Q. Should we avoid administering drugs?
A. Of course, it's not a general yes. However, it would be good to be able to identify the symptoms of dementia, rather than just going one way: "He's saying something I don't understand -¿ delirium.
Delirium is a disorder of consciousness. There is a large diurnal variation. The way we live our lives these days and the way we spend our time outside the hospital also have an impact.

8. Q. What is the importance of nurses' involvement in the prevention part?
A. It is common for both delirium and dementia to control the physical symptoms well. Prevent dehydration, constipation, and pain. Preventing

the small things.
Communication. Share the current treatment and how to proceed with the treatment. Reality Orientation. Have them regain disorientation through daily interactions.

9. Q. Change the way you communicate from “noticing”. How will you be able to do the noticing part?
   A. Can you properly assess (evaluate) the patient’s physical condition? Can you read the blood data?
   Always think about what you are doing. Understand why the patient is doing what they are doing. Understand the patient from the interaction with the patient. It should be done while explaining one by one.
   e.x. “I’ll take off your diaper.” Touching the body immediately can cause anxiety and BPSD (behavioral and psychological symptoms of dementia). Lack of explanation and words can lead to anxiety and rejection.
   Intravenous drips also need to be considered “wide” in nature. IVs do not absolutely have to be given at this time. It is good to be able to respond to the patient’s pace.
   Drip infusion also has to be considered “wide” in nature. It is not absolutely necessary to give an IV at this time. It is good to be able to adapt to the patient’s pace.

10. Ms. Hirano: Can you imagine? When a patient’s executive function is down, even if you say, “Let’s go to the bathroom,” they don’t know in which order to do it. It’s confusing. As a medical professional, I would say, Disorientation and administer the medicine. This causes confusion.
    It is difficult to grasp the situation. If a stranger suddenly comes and says, “Let’s go somewhere,” anyone would be scared. In addition, adults they don’t know gather around them. They become more sensitive. As a medical professional, I would have to give a sedative. The anxiety is heightened.

11. Q:What are some examples of successful communication?

A. The route is deflected and fixed so as not to be in the patient's view. (upper arm to neck). I also connect it to clothing. I try to adjust the environment strictly. There are things that can be prevented by the method of root fixation and environmental adjustments.
e.x. A small woman with cognitive decline but able to move her body. When she is able to move, it may be safer not to use the air mattress, but considering the risk of bedsore, she dared to use the air mattress even though there was a risk of falling. When using the air mattress, the bed fence is used, so the patient cannot get in and out of the bed freely. She fell over the fence. If she had been able to get in and out of the bed freely without a fence, there is a possibility that she would not have fallen. We need to think about each person's line of sight.

Mr.Hirano has been working in the National Cancer Center East Hospital for 13 years, and he is the head of the nurse training program in the hospital now; he is working with psychiatrists and clinical psychologists mainly on consultation for medical workers inside the hospital, and because of this job, he has witnessed plenty daily struggles nurses had from dealing with patients. During the interview, he told us that one of the problems many nurses have encountered is the frustration and feeling of failure. Because some patients keep on losing short-term memories, they do not know where they are, they feel insecure that a stranger would give them unknown pills and touch their body, which leads to stress on the caregivers too. Meanwhile, when a dementia patient accidentally fall down or hurt themselves, the caregiver would feel guilty because they failed to take their own responsibility of securing the patient's safety.

Then we asked, from a medical care consultation professional's perspective, what is important in dementia-oriented care service training and how it can be improved, he replied that communication with patients is a pivotal point. When it comes to medical care, we often think about task assistance, equipment checking and the level of medical knowledge needed, while underestimating the importance of communication, but to many people's surprise, good communication skill is much more powerful in lowering the level of BPSD, and specialized communication technique is required for dementia care, according to Mr.Hirano.

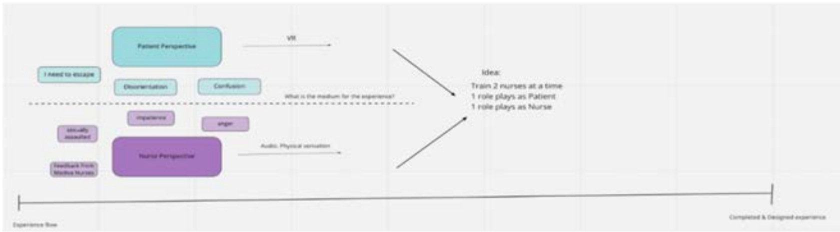


Figure 3.1 Initial Proposal 1: VR Content Proposal

Consequently, he further advised, it shall be a powerful tool for new nursing trainees if there is an equipment, such as VR, that can simulate both the patient and the nurse's perspective. Even if nurses are already educated on dementia, they cannot really understand the patient's perspective, and it will be even better if symptoms of delirium can be recreated.

Initial Ideation

Based on the feedback, we proposed the idea of two sub-projects: a VR role play game along with an AR experience with wearable devices(refer to Figure 3.1 and Figure 3.2). The VR role play game will include frames of two perspectives: one from nurse and the other from patient. This VR game should strengthen the communication between these two parties, and it is expected to be separated into a good communication mode as well as a bad communication mode. The specific conversation content in this game shall be carefully designed to enlighten the user of the difference of level in BPSD triggering between good and bad communication.

The AR experience, on the other hand, focuses on recreating the most common symptoms of dementia with a head mounted display(HMD) and multiple wearable devices. The HMD is expected to realize visual symptoms, while wearable device including haptic gloves and shoe soles are expected to interfere with user's behaviours.

Feedback

After discussing with Mediva, the VR role play idea was removed due to the fact that time lag has been acknowledged to be an inevitable challenge when two

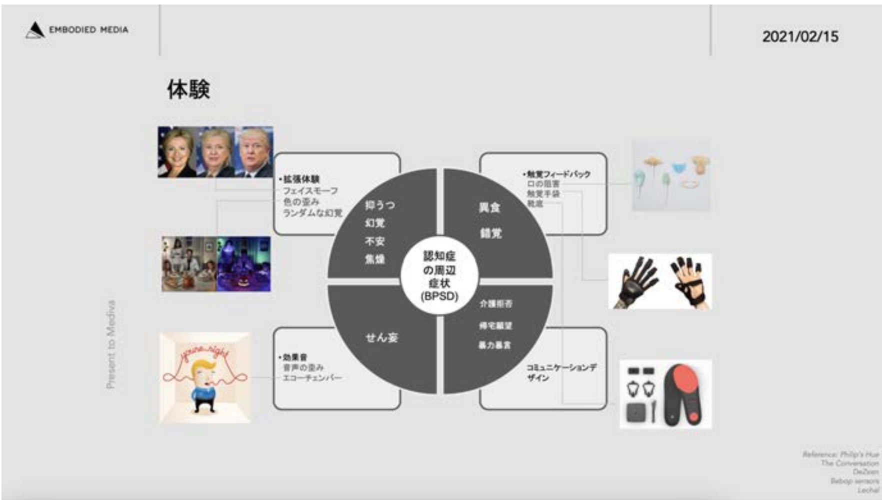


Figure 3.2 Initial Proposal 2: AR with Wearable Devices

users are involved in one game simultaneously – imaging if they are not moving simultaneously, even a one-second-mismatch will decrease the user's experience inside this immersive environment.

Meanwhile, since the long-term goal of this project includes large-scale implementation inside actual hospitals, the first priority in hardware selection is the convenience to use for instructors and easiness to mass production. In this case, haptic devices' application are limited since it is relatively hard to roll out production while challenging for instructors coming from non-technical background, as a result all of the haptic devices are decided to be removed, while only the request for audio interference remained.

HMD, however, remained the best choice for all visual effects; regarding the specific brand and model, several options are proposed as shown in Figure 3.3; we also invited Mediva to take part in the Varjo XR-3[3] preview session in May 2021(Figure 3.4), the Varjo HMD is mainly for research and industry use, although the high image quality was impressive, the cables, requirement for same-time professional operations and bigger budget made us believe that it is not the best choice for orll-out production.

3 Varjo-XR 3 is a high-quality MR HMD mainly for research and industry use: https://varjo.com/products/xr-3/

Figure 3.3 Initial Proposal: Hardware System Design

3.2.2 Second proposal 1: VR Movie

Based on the feedback and feasibility of hardware, the second proposal emerged, which is also separated into two sub-projects: a non-interactive VR movie and an AR experience.

In the VR experience, a few scenarios from dementia patient's perspective will be prerecorded and implemented into an Oculus Quest 2 HMD[4]; the user is then asked to wear the HMD and lie down on the bed to watch the movies. This experience, aligned with the previous VR proposal, will focus on the communication between the patient and the nurse. Scenarios are segmented by sites patients go to everyday(i.g. bedroom, aisle, toilet), and inside each scenario, two versions of the story(good and bad communication) shall be recorded; the user is expected to try out both versions to experience and understand different communication styles.

4 Oculus Quest 2 is a wireless commercial VR goggle prevalent in the VR community: https://www.oculus.com/blog/introducing-oculus-quest-2-the-next-generation-of-all-in-one-vr-gaming/

Figure 3.4 Varjo XR-3 Preview Session with Mediva in Chiyoda

VR Prototype

To transfer the dementia experience to a non-patient user, this project is required to be as realistic as possible, thus Embodied Media and Mediva agreed on the fact that the content of the VR sub-project, when implemented in the actual nurse training, the movies should be acted, recorded and post-produced by professional

Figure 3.5 Second Proposal: Hardware System Design

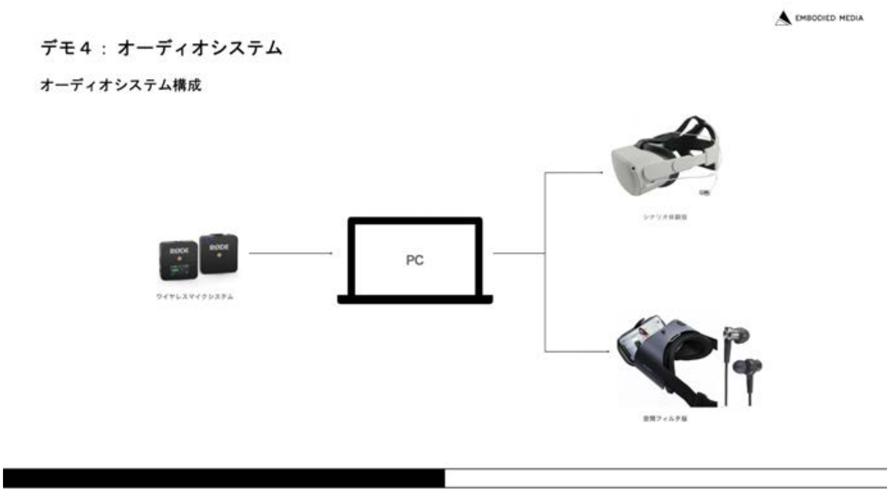


Figure 3.6 Second Proposal: Audio Design

(a) (b)

Figure 3.7 Second Proposal: VR Content Illustrations (a) Scenario 1 (b) Scenario 2

production companies. Therefore, we only built up a dirty prototype of the VR experience, acted by KMD students, to demonstrate how the VR experience will look and feel like.

Based on this agreement, scenario(a) illustrated in Figure3.7 was recorded with a RECOH THETA Z1 [5], where the content was later post-produced in Unity and exported to Oculus Quest 2.

Figure 3.8 Second Proposal: VR Content

5 RECOH THETA Z1 is a commercial 360 Degree Camera: https://theta360.com/en/about/theta/z1.html

Feedback

With 5 Mediva staff and more than 15 doctors and nurses, the VR prototype as well as the AR prototype were tested on the same day, after the AR prototype trial. After lying down on the bed, wearing the headset, and experiencing the VR, users generally responded that the VR experience is not as impressive as the AR one, attributing to the fact that it is lack of actual interactions.

Since the goal of the whole project is to understand dementia patient's feeling while the method is not restricted; after careful discussion, the VR experience was removed, and the communication emphasis is now considered to be added to the process of the AR experience.

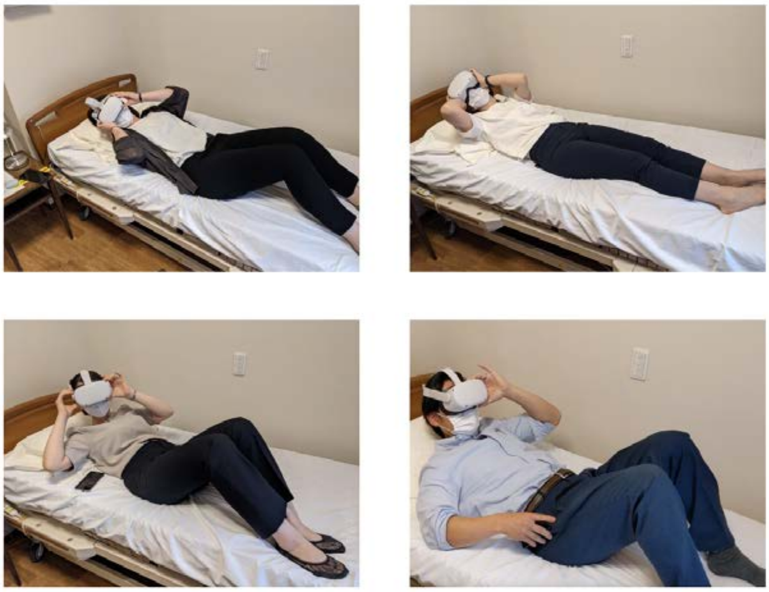


Figure 3.9 Second Proposal: VR Trial with Mediva

3.2.3 Second Proposal 2: AR Experience with iPhone HMD

Alongside the VR movie proposal, an iPhone-based AR experience is proposed as shown in Figure 3.5. The idea of the AR sub-project is to create a real-time dementia experience to allow non-patients to physically experience dementia. We understand the fact that dementia is a neurological syndrome and most of the symptoms happen inside the brain. While visual and hearing symptoms are usually not directly caused by dementia, they do happen to up to 60% of the AD dementia patients [18,19], also according to a study conducted by Ji-sun Paik et al. in 2020 [20], visual impairment is positively related to the risk of dementia, hence we put forward the hypothesis that recreating these symptoms will be powerful for nurses to understand dementia.

AR Prototype ver 1

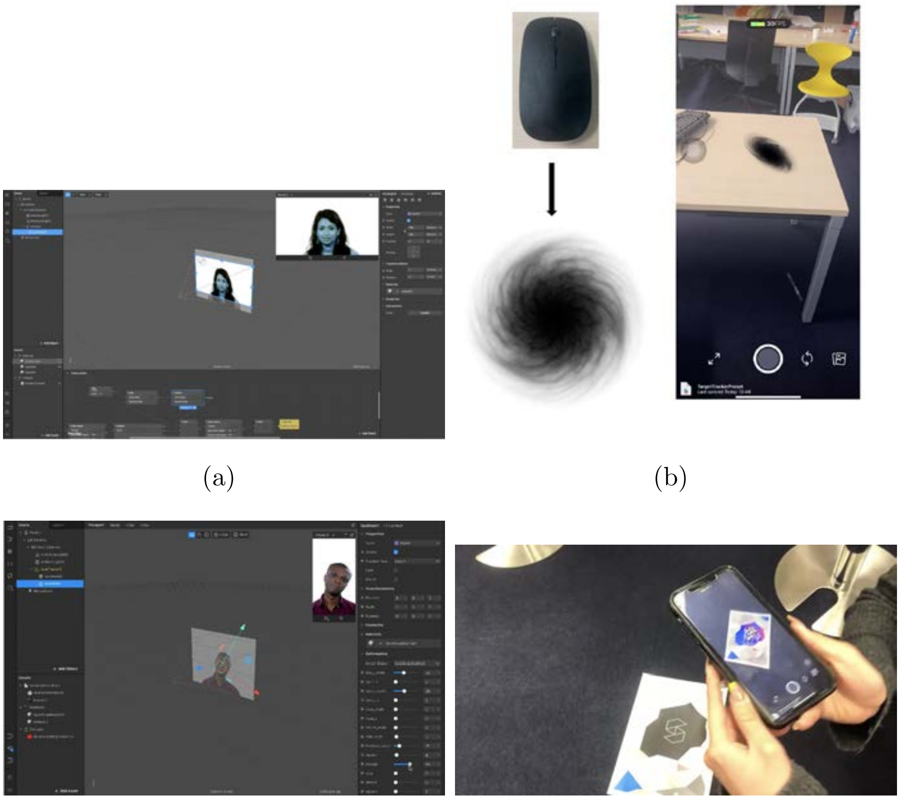
Based on the past brainstorming sessions and Mediva's decades of experience in the medical field, we came up with the following symptoms to realize as listed in Table 3.1, and from here the first AR prototype, which is done in Spark AR, is presented.

Spark AR[6] is a powerful AR software commonly used for face and environment filters on Instagram.As a toolkit easy to get started, it is an adequate method for a fast dirty prototype. In this version, the feasibility of effects No.1, No.2, No.3, No.4 and No.9 were checked(others remained challenging), and the project was able to export to an iPhone smoothly; meanwhile, three major problems were encountered:

- the possible mismatch between object detected and the layer of AR effect that will be putting onto the object
- 0.1 second estimated time lag for AR effect to appear
- the number of trackable face and object inside one project is limited

While the first problem is an inevitable challenge depending on the user's head position when wearing the device, one possible method to solve the second problem is pre-scanning the whole environment as well as all of the objects already set up for recognition before any user is involved, since the problem happens because the phone application need that 0.1 second for object recognition. However, for

6 https://sparkar.facebook.com/ar-studio/



(a) (b)

(c) (d)

Figure 3.10 Second Proposal: AR Prototype ver 1 (a) Color and Contrast (b) Black Hole (c) Impaired Facial Recognition (d) Object Tracking Example a large-scale training tool aiming to be implemented in several hospitals, it is nearly impossible to pre-scan the environment every time before use, at the same time, the third problem is due to the software's default setting; on account of the problems listed above, we decided to shift to the professional game engine Unity[7] for further software developments.

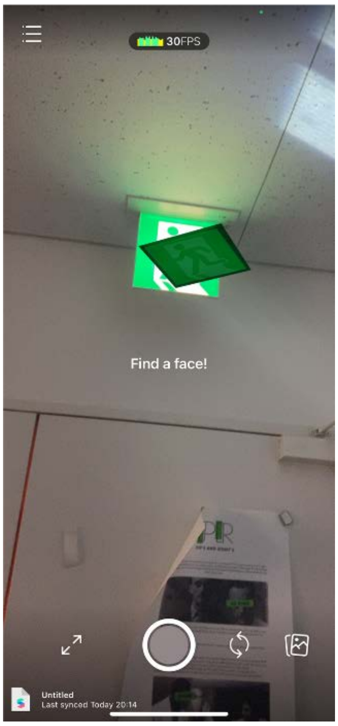


Figure 3.11 Second Proposal: AR Prototype ver 1 Failure Demo

AR Prototype ver 2

For the second version, inside Unity, Apple ARKit's functionality is used for all AR effects includes plane tracking and object tracking, what needs to be noticed is that Apple does not authorize the face tracking function on the front-facing camera for app development, while Android's ARCore deactivate the function on both front-facing and rear-facing camera on a phone. Considering that "impaired

7 https://unity.com/

facial recognition" only happens to LBD which accounts for 5~10% of the dementia population[8], "impaired facial recognition" was removed from the Effects To Achieve list.

In this version, effects are still done following the Effects To Achieve list in Figure 3.1; here item 1 and 2 were achieved by placing a UI canvas in front of the AR camera; item 3 was achieved by first using plane detection - placing a glare figure on any plane detected, then switched to object detection - placing a glare figure on a pre-identified lamp. During the process of glare effect's enhancement, we noticed that a key factor to realistic AR effect following this route would be the quality of the material: the higher the quality of the material, the more transparent its edges are, the more realistic the effect will eventually look like. However, the problem of mismatching between actual and virtual object is not compensated yet; meanwhile, during the build-and-test cycle, it was noticed that if the user suddenly looks at the object from the side, at some angles the virtual object will look like flat(see Figure 3.10), which, also considering from the aesthetic perspective, is not very realistic.

While looking for materials for item no.6(light reflection on the floor looking like a puddle), the possibility of sharing material between item no.3(glare) and no.6 was noticed; after diving into the list, it is further noticed that item no.2(reduced perception of light) and item no.7(dark corner) can be possibly related, and if these two "dark lighting effects" are related, is it possible that the black hole visual phenomenon, which has been reported by many nurses taking care of dementia patients, is also related to the other two? Keeping this discovery in mind, we asked a new question: why do these visual phenomena happen to patients?

We started to look into the pathology behind common non-cerebral symptoms behind dementia, and soon found evidence from a review paper by Pratik S. Chougule, Raymond P. Najjar and fellows [21]:"Alzheimer's Disease-related neurodegeneration affects both the parasympathetic and the sympathetic arms of the PLR (cholinergic and noradrenergic theory), combined with additional alterations of the afferent limb, involving the melanopsin expressing retinal ganglion cells (mRGCs), subserving the pupillary light response."; since slowed pupillary

8 https://www.alz.org/alzheimers-dementia/what-is-dementia

Figure 3.12 Second Proposal: AR Prototype ver 2 Perception of Color

Figure 3.13 Second Proposal: AR Prototype ver 2 Same glare from different angles

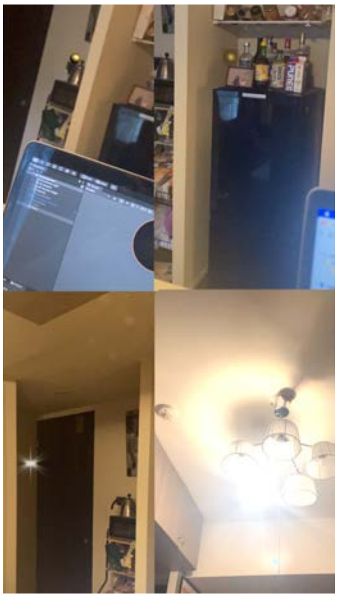


Figure 3.14 Second Proposal: AR Prototype ver 2 Glare Evolution

light response means slowed down adaptation to darkness and brightness with light changing, from here a new hypothesis came out: some of different known phenomena dementia patients described happened because of the same pathological cause.

Based on this hypothesis, we decided to build a new prototype based on the pathology behind dementia, hence this AR Prototype ver 2 was removed before any reviews.

AR Prototype ver 3

Bearing in mind the goal of an easy-to-replicate AR application of general dementia experience, in this version, we decided to focus on AD, the most common type of dementia. The common symptoms that were able to realized are listed below.

1. Delayed Pupillary Light Response
   As mentioned above in the previous session, we already found evidence that pathologically, AD-related neurodegeneration has an effect on the pupillary light response [21]; visually this phenomenon can be interpreted as the decreased speed of darkness and lightness adaptation. Imagine on a sunny

(a) Dark (b) Bright

Figure 3.15 Second Proposal: AR Prototype ver 3 Delayed Pupillary Light Response

day, when a dementia patient suddenly enters a dark room from the outdoor, because their pupils cannot adjust in time, the amount of light input entering their eyes can be very limited; vice versa, when walking from indoor to a comparatively bright outdoor environment, because pupils fail to shrink without delay, the amount of light input entering their eyes can make it overwhelming for those patients.

2. Vision Field Defects
As Paolo Brusini from Santa Maria della Misericordia Hospital [22] pointed out that the age coefficients used in many existing vision field devices underestimated the sensibility change due to age in the elderly, vision field defects is a common health issue for them. Although vision field defects have myriads of forms from different pathological causes, it has been proved by MD Patino and her fellows from Keck School of Medicine, University of Southern California [23] that "both central and peripheral vision loss are independently associated with increased risk for falls and falls with injury in a dose-response manner", and thus we believe that vision field defects is a noticeable phenomenon for this AR experience. Peripheral vision refers to the field of vision outside our central viewpoint, which accounts for the ma-

Figure 3.16 Second Proposal: AR Prototype ver 3 Peripheral Vision Loss

jority of our field of vision, and the loss of peripheral vision was visualised in this prototype(see Figure 3.16).

3. Decrease in Color Sensitivity
   Decrease in color vision is a well-known problem in the aging society: the yellowing of the lens can cause reduction in sensitivity of selective colors such as red and pink, or yellow and blue; evidence that patients with AD have difficulty distinguishing between blue and green has been found by PhD Cronin-Golomb and her fellows in a study published in 1991 [18]. With the science backing, an effect of decrease in color sensitivity of blue effect was created(see Figure 3.17).

4. Impaired Depth Perception
   Depth perception can be explained as the visual ability to identify distance with objects as well as the capability of three-dimensional perception; disorder occur to visuospatial function is due to focal cortical lesions that involves the parietal and temporal lobes, which is associated with decreased glucose metabolism in the posterior cerebral cortex–a major reason for cognitive declination [24]. One of the phenomena common in depth perception

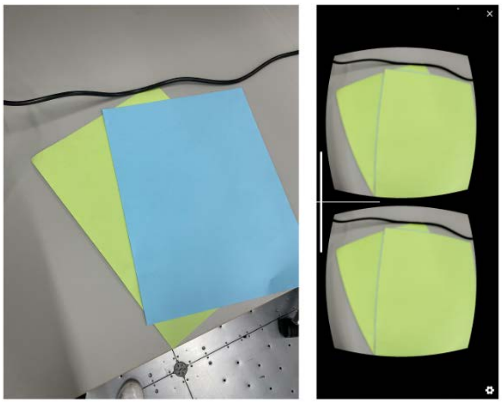


Figure 3.17 Second Proposal: AR Prototype ver 3 Decrease in Color Sensitivity

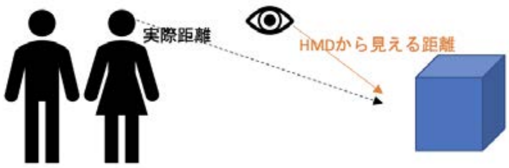


Figure 3.18 Second Proposal: AR Prototype ver 3 Impaired Depth Perception Illustration

impaired individual is “grabbing the air”: for instance, when a dementia patient wants to grab a mug on the table, because they will mistake the distance between their arm and the mug, the person will fail to grab the mug and instead, it will look like they are just moving their arms. This symptom was successfully achieved by leveraging the disadvantage of HMD.

5. Decreased Visual Acuity
   Visual acuity refers to the ability of identifying shapes and details of what an individual can see, the declination in visual acuity will cause myopia and/or presbyopia which people are familiar with. It has been proven by Neil S. Gittings and James L. Fozard [25] in their study that visual acuity decreases by aging regardless of visual pathology; since most neurodegener-

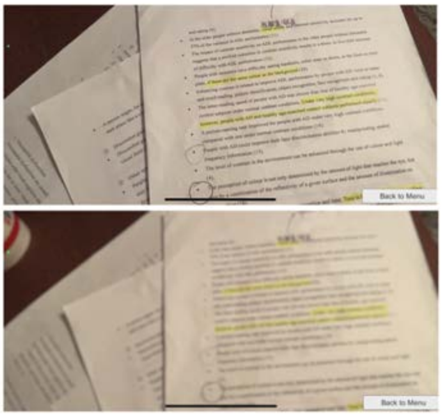


Figure 3.19 Second Proposal: AR Prototype ver 3 Visual Acuity

ative dementia patients belong to the aging population, a decreased visual acuity effect was added to the experience.

6. Visual Motion Sensitivity
   Visual motion sensitivity, in a nutshell, describes the nauseous feeling an individual might experience when what they see does not match with how their body simultaneously feels, which is a common issue happens often to new comers to video game or VR HMDs, as well as dementia patients, as a previous study shows – according to Gary L. Trick and Scott E. Silverman's paper [26] on the reputable journal Neurology, motion thresholds related to visual motion sensitivity increase significantly for patients of senile dementia of Alzheimer's type comparing to the healthy elderly. Leveraging on HMD's nature of bringing certain people motion sickness, this symptom is naturally achieved; while we want to make it controllable, a layer of motion blurring was added as well.

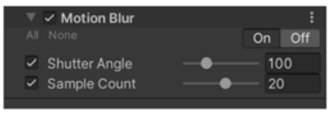


Figure 3.20 Second Proposal: AR Prototype ver 3 Visual Sensitivity to Motion

A combined AR prototype of 6 symptoms was tested with Mediva's medical professionals, and they were able to understand the reason why we shifted from creating the prototype based on the original list(referred to Table3.1) to the pathology-based prototype ver 3, while visuals on current version of the prototype is considered to be too strong, the idea of an adjustable version of AR prototype ver 3 was raised.

AR Prototype ver 4

Based on the feedback on the previous proposal, we decided to brush up the AR experience by doing the following:

- Remove manual vision motion sensitivity element;
- Create an UI to control all of the elements;
- Add a remote control for the prototype;
- Add the audio element(refer to item no.11 on Table3.1;

Selective auditory hearing was later removed due to the fact that it creates too much chaos.

Table 3.1 Second Proposal: AR Effects to Realize

AR Effects to Realize			
Sensory System	Item No.	Item	Description
Vision	1	Color and Contrast	Reduced perception of colour differences; Reduced contrast between two adjacent areas makes it difficult to distinguish items from the surrounding environment ie wall or floor.
Vision	2	Perception of light	Reduced perception of light. For example, the normal lighting level may look darker.
Vision	3	Glare	Glare from uncontrolled lighting.
Vision	4	A black mat looks like a hole	Avoidance of "dark mats, tiles or even lines on the floor"* because "they visually misinterpret the blackness as a drop-off, the so-called visual cliff."*
Vision	5	High contrast between two adjacent areas looks like a step	People misjudge two contrasted surfaces as a step.
Vision	6	Light reflection on the floor looks like a puddle	Shiny flooring can reflect light from natural daylight or artificial lighting. This can be misjudged as a puddle.
Vision	7	Dark corner	A dark corner looks like somebody is hiding and increases people's anxiety.
Vision	8	Narrow filed of vision	The narrow range of attention focus; Some older people may develop visual restriction.
Vision	9	Impaired facial recognition	Unable to remember people's faces,
unable to match names	faces.		
Vision	10	Mirror reflection	Images of oneself in the mirror differ from one's perception
Hearing	11	Reduced selective hearing	Unable to select sounds – background noises can disrupt or make one's attention away.

Chapter 4
Proof of Concept

4.1. Pilot Test

Because of the fact that implementation stage of the project started during the state of emergency, a pilot test in a mock hospital is set up inside the Takeshiba Moonshot Laboratory. The purpose of the pilot test is to eliminate all potential risks and brush up the prototype for a first time before testing inside a professional setting during the pandemic, which therefore guarantee a later safe and prompt user test in the actual hospital setting; Consequently, the current setup is intentionally designed to maximize the visibility of the experience. The users we tested in this pilot test are 4 professional medical consultants from the healthcare consulting company Mediva. During the test, tasks were not performed in the order below, and each user was asked to perform a different combination of tasks because the space is limited, while all others were standing inside the space to observe the one that is under the test; thus it is likely that the later ones would have an advantage in task performing since them have observed multiple times. In response to this possible bias, the order of tasks was mixed.

4.1.1 Experience Design 1

To let the users maximally understand the experience, users are asked to perform certain tasks that are separated into two categories: cognition-based(CB) and behaviour-based(BB). Some of the CB tasks are modified from published studies conducted on actual dementia patients for research purpose in the past, and the user is asked to identify an object, then perform a simple action with the object including pointing it out, or grabbing the physical object; while for the BB task, the user is asked to walk around freely with the HMD on, and we observe their

Figure 4.1 Pilot Test Task 1: tissue box

behaviour. The user is allowed to to not give answers to the questions they are asked, or refuse to perform the tasks they are asked to perform.

Task 1: Tissue Box

The first CB task is to identify the color of the two tissue boxes as shown Figure4.1, and pick up a piece of tissue from the blue box. The purpose of this task is to understand the difficulty of dementia patients in distinguishing blue from green.

Task 2: Hand-drawn vs. Printed Objects

The second task is to identify the hand-drawn objects from a piece of paper(see Figure4.2). There are four objects on the same piece of paper: two triangles and two squares. The triangle and the square on the left side are printed, the two on the right side are hand-drawn. The user is allowed to pick up the paper and observe the figures as they wish.This task is modified from a study on LBD patients [27], the original purpose was to understand how much the individual's visual acuity is impacted by the disease. Here we let the users know that they are

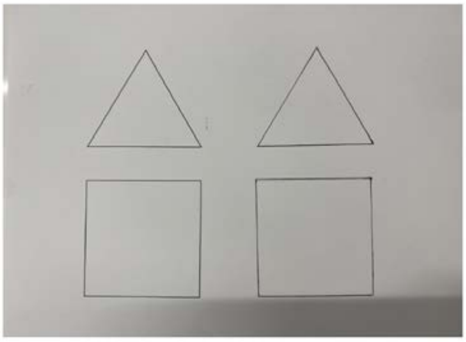


Figure 4.2 Pilot Test Task 2: choosing the figures that are hand-drawn

going through a test designed for actual dementia patients, and the purpose is to let the user understand "this is what actual dementia patient see when they go through vision tests".

Task 3: Book Cover Reading

The third task is to read the title of a given book out loud. The user is allowed to pick up the book and put it under a separate reading light like many senile dementia patients. The purpose of this task is to let the user understand the difficulty of reading for aging dementia individuals.

Task 4: Toilet selection

The fifth task is to identify the right toilet sign for the user and sit down on the "toilet seat" accordingly. In this task, we put stickers and colored papers on the floor to simulate the signs on the hospital floor(referred to figure4.4), the blue stickers and paper lead to a "female toilet" while the green stickers and paper lead to a "male toilet". The detailed setup of the mock toilet seat is shown on Figure4.5, there is another a wooden toilet sign attached to whiteboard behind the "toilet seat", the user is allowed to touch the wooden sign to help themselves to make decisions.

Figure 4.3 Pilot Test Task 3: Example of Books

Task 5: Pick up a pair of scissors

The fifth task is to pick up a pair of scissors from a first-aid box. First-aid box is a common object inside hospital, and we designed this task to let the user understand the difficulty in picking up normal objects for dementia patients.

Task 6: Pick up a marker pen

The sixth task is to identify the objects inside a containing box and pick up the objects. In this task, there are two pens inside the containing box, one is black and the other is blue. The containing box is intentionally put under a very dark light. The user is allowed to approach the box in any way they want. The task is designed to show the desired black hole effect (item no.4 from Table3.1), and to understand how hard it is to perform a normal task while seeing the black hole.

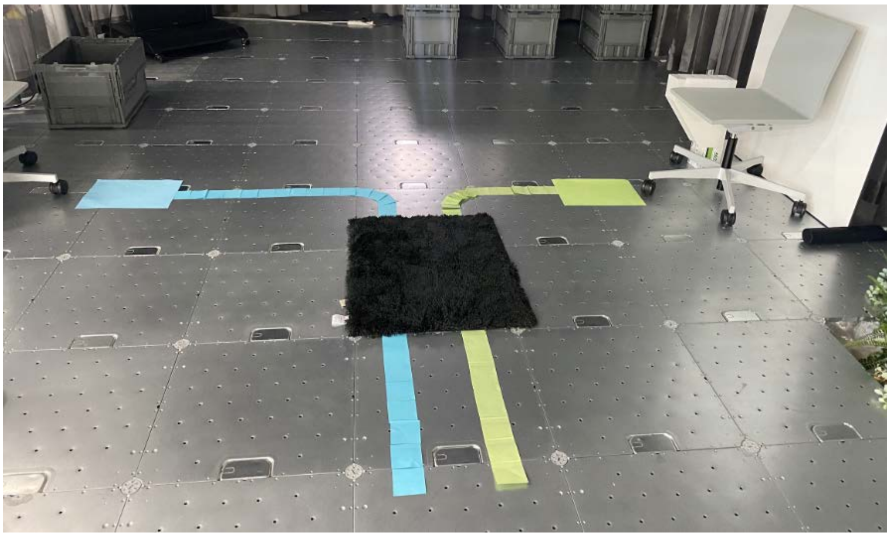


Figure 4.4 Pilot Test Task 5: toilet selection layout

Figure 4.5 Pilot Test Task 5: toilet selection

4.1.2 Results, Feedback, and Analysis

The 4 medical experts from Mediva all fall under the age group of 20 60 years old, one is male and three are females, and none of them have known precedential ocular or neurological disease. All 4 of them performed task 1, among which three failed to identify the blue tissue box, and one refused to answer. For task 2, all 4 of them answered correctly, but it took on average more than 30 seconds to make the decision, and all users got very close to the piece of paper to observe, reflecting certain level of difficulty in performing the task. Three of the users were asked to perform task 3, one was able to read what was written on the magazine cover, one user could only identify one character on the magazine, and one user failed the task. All users were asked to perform task 4, which is the most time-consuming task; and all participants only observed the toilet seat on the right-hand side, replied with "I cannot see the sign" and slowly sat down on it. Two of them were asked to perform task 5 and they both succeeded. All four participants were asked to perform task 6, and three of them had to kneel on the ground to try to touch the marker pens inside the box.

In this pilot test, tasks are designed to deliberately interfere with the user's behaviour, which we believe should help to transfer the experience of dementia and lead to understanding; therefore, results are not evaluated by the responsive behaviour users made itself, but their verbal as well as behavioural feedback. Before putting on the HMD, users were suspicious of the idea of shifting the effects from phenomenon-based(i.e. AR Prototype ver 1 and 2) to the symptoms-based Prototype ver 3; after trying out the whole experience, all users started to understand that comparing to individual object swaps(e.g. black hole object replacement, glare object replacement etc.), visual symptoms in dementia is a continuous experience and variety of visual phenomena are described based on different individual's Interpretation. The users also understood that task performing is helpful in delivering the dementia experience, and started to explore the possibility of more tasks that can be done in actual hospital settings. They found that, for example, under the AR application, when placing a white trash bin next to a whiteboard, it becomes challenging to identify the boundary lines between the two. We then offered them another possible way to show the augmented brightness effect: shining a torchlight on a metal watch; through the AR application, it became impossible

Figure 4.6 Pilot Test

to see anything but a large flashing point. After the test, users all agreed on the current prototype, only asked to decrease the level of motion sickness as much as possible, and offered to design the environment for the next test. From the users response, we believe that they were able to understand the experience of senile dementia patients.

4.2. Field Test

The first field test was conducted in Matsubara Urban Clinic in Setagaya, Tokyo, with the 4 Mediva medical experts,11 nurses and 5 doctors from the clinic, using a semi-finished version of the AR prototype under the third proposal. This is the first test we conducted with current nurses and doctors working in the professional field. Similar to the pilot test, a few tasks were prepared; yet this time, users were asked to perform all tasks in the same order, and no people is allowed in the room except for the cameraman, and a short interview was done after each experience.

4.2.1 Experience Design 2

The experience design in the pilot test was slightly modified to mold into the environment setting of the Matsubara Urban Clinic, the experience is designed to start in the aisle of the clinic, then walk into the room, and then come out to the aisle; the tasks are performed in the following order:

Task 1: Sitting on a chair

After putting on the HMD in the aisle, the user will be asked to walk along the aisle for one meter estimated, find a chair next to a sliding door and sit down(see Figure4.7). This is the only task among this experience, that requires the user to complete alone; the rest are conducted under the help of a mock nurse(also the task instructor).

Figure 4.7 Field Test Task 1: Sitting on a chair

Task 2: Turning on the Light

After successfully sitting on the chair, the user is asked to stand up with the help of the instructor. The instructor would assist the user to walk into the room, and then ask them to find the toilet and turn on the light inside the toilet.

Task 3: Mock Toileting Behaviour

After entering the toilet room safely, the user is asked to sit down on the toilet seat, and then press the flushing button; the instructor is accompanied with the user inside the room to ensure safety.

Figure 4.8 Field Test 1 Task 2: Turning on the Light inside Toilet

Figure 4.9 Field Test Task 3: Mock Toileting Behaviour

Task 4: Tissue Box

After a successful "toileting", the instructor will escort the user outside the toilet room, and enter the main room where two tissue boxes are lying on a desk. For this task, the same tissue boxes from the pilot test were used; however, users are only asked what colors they can see instead of taking out tissue papers. Upon here, all of the tasks are completed, the instructor will accompany the user back to the aisle, the user can then take off the HMD.

Figure 4.10 Field Test Task 4: Tissue Box

4.2.2 Results, Feedback and Analysis

On the behavioural side, more than half of the users were only able to sit on half of the chair for task 1. All of the participants were able to complete task 2 and 3, but time-consuming comparing to usual toileting behaviour. Regarding task 4, besides the confusion between blue and green, users reported seeing different colors including red, orange, yellow. Most of the users, although have been working in the clinic for years, after completing the experience and taking off the HMD, looked back into the room to confirm what is inside. One medical worker, who has never been to the clinic, was extremely panicked after putting on the HMD. She reported that she could not see the person one meter away in front of her, she thought there was a clock on the ceiling which was actually the fire alarm, and she stated she was shocked by the strong light when performing task 2. One medical worker gave up immediately after failing task 1 because motion sensitivity was too strong for her. Several medical workers were able to perform task 2 smoothly

Figure 4.11 Field Test 1: Medical workers experiencing the AR prototype

because they are very familiar with the clinic environment. One user was able to perform all of the tasks smoothly, the individual is extremely familiar with the clinic surrounding, he also has preliminary ocular issues which makes him extra careful. At the same time, his hobby is playing drone with VR HMD controls.

Throughout the interview session after the experience, some valuable feedback and thoughts from the medical workers were collected.

- One medical worker, after finishing the whole experience, told us that she can now understand why dementia patients behave in certain ways, while with the strength of the AR effects we put on they doubted whether it is really that strong in reality; still she recommended all of the nurses lining up to try the experience. She also said that from her perspective, blurring and depth perception are the two most impactful effects in interfering with user behaviours.

- One medical worker said she can now understand when they –nurses–need to be extra patient and slow to match the speed dementia patient walk while escorting them, and why they should not hurry the patient to walk faster.

- One medical worker considered to improve the way she treats patients.

- One medical worker stated that she can now understand why case of the

Figure 4.12 Field Test 1: Medical workers conducting task 1

elderly falling down in the toilet room often happen; also she was very insecure when she was asked to perform task 2, and once the light was on she was able to calm down; meanwhile, she felt somehow safe because the instructor was much taller than her.

- One medical worker agreed that this experience is powerful for non-patients and indeed helped him to understand the patients better, but since patients are living with the symptoms for times, he believed that they should have somehow been used to these symptoms, therefore it would not be as impactful to them.

- One medical worker claimed that he was able to feel the depth perception was unrealistic, because he is familiar with the hospital setting, when he saw the visuals were amplified, he felt weird.

- The only participant that was able to perform the tasks smoothly – the person who has eye disease and plays drones– told us that, the AR experience is somehow similar to what he actually sees.

- Common feedback include dizziness; mistaking light reflection as puddle; and thinking the wood in the outside garden scary.

Figure 4.13 Field Test 1: Medical workers being interviewed after the test

From the behavioural result and verbal feedback, as well as the two extreme users in this test(i.e. the user that has never been to the clinic before, and the user that is extremely familiar with the clinic), it can be concluded that, the more familiar with the surrounding, the less impactful the AR experience is to the user. Therefore, the experience can potentially be very useful for new nurse training. Nonetheless, all effects inside the current prototype are at their max value, as many users doubted, it is powerful, yet it might be extreme comparing to dementia patients actually see and feel. While we have not yet been able to evaluate how realistic it is on the dementia experience transfer side, since many medical workers reported that they understand why they shouldn't do things such as hurrying the patient, and some of them believe that they should improve the way they treat patients, we can conclude that this AR prototype proposal is, to some degree, bringing empathy to nurses.

4.3. Discussion

The results of the two tests have demonstrated that the AR proposal is indicative, to lead to non-patients to empathise with dementia patients. While the effects are too strong and made some users doubt whether it intentionally exacerbated. Meanwhile, the experience setup design for both test were meant to maximise the AR prototype, the current system as a whole is indeed, very strong. In the future, a more balanced AR model should be expected, while the environmental setup shall be closer to normal hospital setting. More tasks related to actual dementia diagnosis can also be added.

Chapter 5
Conclusion

In this research, we provide an easy-to-replicate AR-based senile dementia experience for nurse empathy. The AR prototype generated from the concept design has gone through a pilot study and a field test, with positive results. We are preparing for a second field test in a clinic in early July, followed by a large-scale hospital experiment. For research purpose,we found out that there are two directions for XR-based experience transfer: how realistic the experience is; and whether the experience can effectively raise empathy, and we are actively delving into the second. Downstream studies on this research could be more on the social effects: how much nurses behaviour changes after the experience, and how much patient BPSD is decreased.

Nonetheless, dementia is such a broad spectrum in this system we only created the most common visual and hearing symptoms of AD. While AD is indeed the most common type of dementia, the feeling PD, LBD and other dementia patients should be equally valued. We expect to see a more inclusive dementia experience design in the future for those patients too. We also believe that, not only medical workers, but also patient families and informal caregivers should have the opportunity to try this type of experience to understand their loved ones. We hope this work will be of support of a future where dementia patients can be understood by the general public.

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Appendices

A. Mediva × KMD Interview Original Transcript in Japanese

interviewee: 平野さん（男性）
国立がん研究センター東病院 看護師 13年目。
緩和ケア2年目。2年前までは病棟で直接勤務していた。小川先生からの紹介で、本日のインタビューを受けてくれた。
普段の仕事：一般病棟のスタッフでは難しいところをマネジメント、コンサルテーションを受けている。
精神科のお医者様と臨床心理士さんとチームを組んで働いている。
直接患者様と関わりながら、病棟看護師さんの指導的立ち位置をしている。

Q.研修期間から新人の看護師さんを育てるにあたって、認知症患者さんへは特別な関わりが必要になると思うが、何を心掛けている？
A.基本的な人としてのコミュニケーション。
e.g. 挨拶。認知機能に合わせて言葉を選ぶ、説明するなど。専門用語を控える。平易な言葉で伝える。インフォームドコンセントのようなことをしっかりと行う。看護師は自己紹介をしてから、用件を端的に伝えるようにする。看護師が患者の体に触れる時は、ひとつひとつ説明をしてから触れるようにする。

Q.認知症患者さんとの関わりで困難に感じるところ
A.BPSD (behavioral and psychological symptoms of dementia)の対応をしている時。患者さんの安全を守れないところまで。おうちに帰りたい。医学的な

治療に同意が得られない。ベッドにいたくない→転倒してしまう。例えば、帰宅願望、治療の拒否、ベッドで安静にできない、ルート抜去など。
エピソード　高齢の方が多い。また、疾患が多い方。膵臓癌とパーキンソン、肺炎を併発、転倒のリスクが高い。せん妄のリスクが高い。精神へのお薬の投与もしづらく、しかし本人は精神的に辛い、マネジメントがむずかしい。看護師の静止を振り切って、ルートをつないだまま歩き出してしまった。患者の安全が守れなかった。

Q.研究として患者さんの身体的なアセスメントとマネジメントをしっかりとれるようなツール
A.e.x. 小川先生が作ったチェックリスト
低下した認知機能に合わせて業務が忙しいと集合教育で一度に教えることが難しいので、ツールでできると良い。
若手の看護師さんとのコミュニケーション
VRで視覚的に模擬の患者さんとのコミュニケーションをとる
様子を観察したり、認知機能が落ちた患者さんがどういう視点を持っているのかを模擬体験するもの。新人看護師に、言葉で説明しても伝わらない。せん妄もわかるようになったらいいかも。

Q.視点どちらが必要？
A.両方の視点が必要。認知症患者の視点から看護師の対応を感じる。看護師の視点から認知症患者の発言がどう伝わっているか理解する。
2台のVR連動していたら、看護師役と患者役を作るなどできると、教育効果が高そう。

Q.平野さんご自身が教わらなかったけれど、現場の実践を通して学んだことはありますか？
A.知識の面で言うと、薬剤的な症状のコントロールの仕方の知識が少なかった。
コミュニケーションに関して。がんセンターだったので、「認知症」に対して遅れていた。できていなかったし、自分もコミュニケーションの持つ効果に半信半疑であった。BPSDが出た場合、「鎮静剤」を使ったりしていた。ロールモデルがいなかった。

Q.トレーニングや研修をする中で、インプットする時に教えたいこと
A.小川先生の教育プログラムでせん妄の対応は割とよくなっている。患者がせん妄でなく認知症であったときの対応はもっと教えてあげたい。せん妄となると抗せん妄薬を使おうとなるが、実際は認知症だったりする。認知症患者の行動には理由があるので、実際には薬剤を使わなくても症状のコントロールができることがある。

Q.薬を投与することは避けるべき？
A.もちろん一概にはYESとは言えない。でもよくわからないことを言っている→せん妄　の一方通行ではなく、認知症症状を見極められるとよい。
せん妄は意識障害。日内変動が大きい。最近の生活のし方、病院の外での過ごし方も影響がある。

Q.予防のところで看護師さんの関わりは何が大事？
A.身体症状をしっかりコントロールするのは、せん妄でも認知症でも共通。
脱水の予防、便秘の予防、痛みが出ていないか。小さいところを予防する。
コミュニケーション。現状の治療内容を共有したり、どのように治療を進めるのか共有したり。リアリティオリエンテーションを行う。日常の関わりから見当識を取り戻してもらう。

Q.「気づく」からコミュニケーションのやり方を変える。気付きのところはどうできるようになる？
A.患者さんの身体状況をきちんとアセスメント(評価)できるか。採血データで読めるか。
常に考えながら関わる。なぜなのかきちんと把握する。患者とのやり取りから患者を理解する。本来一つ一つ説明しながらしなくてはいけない。
e.x.「おむつ外しますね」ですぐに体に触れると、不安になってしまい、BPSDを引き起こす。説明と言葉が足りないと不安感や拒否につながる。
点滴も本来は「幅」を考慮しないといけない。点滴も絶対にこの時間にしないといけないというわけではない。患者のペースに合わせて対応できると良い。

Akane:看護師さんの対応ひとつで、恐怖心が変わる。
平野さん: イメージできるか。患者さんの実行機能が下がっているところに「トイレいきましょうね」と言っても、どの順番でやればいいのかわからない。混乱する。医療者としては「意識障害？」と薬を投与する。すれ違いが起きる。
状況把握が難しい。いきなり知らない人がきて「どこかいきましょう」と言われたらそれは誰でも怖い。しかも知らない大人が集まってくる。より過敏になっていく。医療者としては鎮静剤を打つことになってしまう。不安感があおられる。

Q.コミュニケーションの成功例は？
A.患者さんの視界に入らないように、ルートをそわせて固定している。(上腕から首)。衣類とも繋げている。環境調整を厳密にやるようにしている。ルート固定の方法と環境調整で防げることがある。
e.x.認知機能が低下しているが体は動かせる小柄な女性。体動ができるときはエアマットを使わない方が安全な場合もあるが、褥瘡のリスクを考え、転落のリスクがあるにも関わらずあえてエアマットを使った。エアマット使用の場合はベッド柵を使用するので自由にベッドから出入りできない。柵を乗り越えて落ちてしまった。もし仮にエアマットをやめて、通常のベッドにして柵なしで自由にベッドの乗り降りができていたら転倒しなかった可能性はある。その人それぞれの導線を考えなければいけない。