NTNU
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Science and Technology

Virtual reality based vision therapy

For stroke patients with homonymous visual
field deficits.

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“How can *virtual reality headsets* be used for *vision therapy*, by stroke patients with *homonymous visual field deficits*?”

A master thesis written by Iselin Kanstad and Martinus Ishoel,
Department of Design, Norwegian University of Science and Technology, june 2017

PREFACE

This master thesis is written at the Department of Design at the Norwegian University of Science and Technology, Spring 2017.

During the fall of 2016, we worked individually on two specialization projects about *skill acquisition from training in virtual reality* and *designing for patient centered communication in the health sector*. This inspired us to contact Attensi AS which works in both these fields. This led to a collaboration between Attensi, Østfold Hospital Trust and us.

Our motivation for writing this thesis has been to gain deeper knowledge about how virtual reality equipment can be utilized for medical purposes and to contribute to give people with visual impairments more options for getting help.

This thesis is meant as a description of our project, and as a reference book on homonymous visual field deficits, vision therapy, and virtual reality, for those who continue to work on this project, and for those who are working in similar fields.

We would like to thank our supervisor Professor Thomas Porathe for invaluable help and insights into this project.

Thanks to our project partners Anne Lise Waal, Stine Tanggaard, Volker Solyga, and Jarl Schjerverud, for the collaboration, help, and support.

Thanks to Kristin Lundberg for contribution and guidance throughout this project.

This project would have been impossible without help from the great people at Hurdal. The contributions from Mahnaz Rashidi, Eva Irene Nordhagen, and Arne Tømta, are sincerely appreciated.

Lastly, thanks to all the people which has participated in tests, interviews and workshops during this project.

We hope you enjoy reading!

I.M.K & M.I

Trondheim, June 9, 2017

ABSTRACT

Background
Homonymous visual field deficits is a condition where parts of the patient's vision are lost. This condition results in a reduced field of view, which can lead to significant problems, such as reduced literacy, mobility, and challenges with activities of daily living. While stroke patients, in general, have many opportunities for rehabilitation, this group have limited options.

Objective
This thesis aims to expand the options these patients have for getting help, by creating an innovative and self-service way for patients to treat their condition, utilizing virtual reality headsets.

Process
The first part of the project is an assessment of vision therapy and patients within the target group. Two weeks was spent at Hurdal, at a course meant for people with visual deficits, to conduct workshops, observations, and interviews with the teachers of the visually impaired and the course participants. This insight was used to create methods for vision therapy, which was used as a foundation and framework for creating a vision therapy prototype. This prototype was designed for the Merge virtual reality goggles and tested with students, lecturers, and patients.

Result
The result from this project is four sub deliveries; suggested equipment for the further work in this project, four methods for vision therapy, a virtual reality prototype for vision therapy and the contents of this thesis.

SAMMENDRAG

Bakgrunn
Ensidig synsfeltutfall er en tilstand hvor deler av en pasients syn er borte. Dette resulterer i et redusert synsfelt, som ofte kan føre til store utfordringer for pasienten, slik som nedsatt leseevne, mobilitet og daglige funksjoner. Mens slagpasienter generelt har et bredt rehabiliterings tilbud, har denne pasientgruppen få muligheter.

Mål
Målet med dette prosjektet er å utvide tilbudet til denne pasientgruppen. Målet er å lage en nytenkende og selvbetjent løsning for pasienter til å behandle sin tilstand, ved ta i bruk virtual reality teknologi.

Prosess
Det første steget i denne prosessen har vært å kartlegge synstrening og pasienter innenfor målgruppen. To uker ble tilbragt sammen med pasienter og synspedagoger på Hurdal, for å utføre workshops, observasjoner, og intervjuer. Denne innsikten har blitt brukt til å lage fire metoder for synstrening, som videre har blitt brukt som bakgrunn og rammeverk for å lage en synstrenings prototype. Denne prototypen har tatt i bruk Merge Virtual Reality Goggles, og har blitt testet på studenter, forelesere og pasienter.

Resultat
Resultatet fra dette prosjektet består av fire delleveringer; foreslått utstyr til videre arbeid med prosjektet, fire metoder for synstrening, en virtual reality prototype for synstrening, og innholdet i denne oppgaven.

TASK DESCRIPTION

NTNU
Norges teknisk-naturvitenskapelige universitet

Fakultet for arkitektur og design
Institutt for design

Masteroppgave for student Iselin M. Kanstad og Martinus Ishoel

VR-basert rehabilitering av synsfeltutfall etter hjerneslag

Virtual reality rehabilitation of patients with hemanopsia/quadrantanopia

I Norge får ca. 15 000 mennesker hjerneslag årlig, som følge opplever opptil 60 prosent av disse synsforstyrrelser. Dette kan påvirke pasientens mobilitet, leseferdigheter, visuell orientering og daglige funksjoner. Spontan bedring av synsfeltdefekten kan forekomme innen de første 2-3 måneder, og forskning har dokumentert at det foreligger rehabiliteringsmuligheter for synsevnen. Synsrehabiliteringen bør starte umiddelbart når pasientens tilstand er stabilisert og kartlegging av synsaffeksjon kan gjennomføres. Kartlegging av synsaffeksjon er i dag en krevende prosess, som er gjennomføres ved bruk av avanserte tester. Testene involverer også flere aktører, der blant øyelege, spesialist i hjerneskade, synspedagog og optiker.

Attensi AS har via Sykehuset Østfold fått innovasjonsmidler fra Helse Sør Øst til forskning på rehabilitering av svekket synsevne etter hjerneslag ved hjelp av VR. Prosjektet er tilknyttet Nevrologisk avdeling på Sykehuset Østfold, og er iverksatt av avdelingsoverlegen på sykehuset.

Oppgavens fokus er selvbetjent rehabilitering av synsforstyrrelser etter slag. Oppgaven vil ta sikte på å undersøke i hvilken grad rimelig VR-utstyr kan brukes som et selvbetjent rehabiliteringsverktøy for slagpasienter. Målet er å gi pasientgruppen bedre kontroll over egen rehabilitering, og å finne løsninger som gjør rehabiliteringsprosessen enklere for pasientene.

Oppgaven vil blant annet omfatte:

- Informasjonsinnhentning, behovskartlegging og analyse
- Idegenerering og konseptutvikling
- Prototyping og testing
- Evaluering og refleksjon

Oppgaven utføres etter "Retningslinjer for masteroppgaver i Industriell design".

Ansvarlig faglærer:	Thomas Porathe, Professor i interasjonsdesign, NTNU
Bedriftskontakt:	Anne Lise Waal, Daglig leder og CTO, Attensi AS
Utleveringsdato:	13. januar 2017
Innleveringsfrist:	9. juni 2017

Trondheim, NTNU, 13. januar 2017

Thomas Porathe
ansvarlig faglærer

for Casper Boks
instituttleder

The nature of the thesis has changed a lot over the course of this project. The path towards the goal has not been straightforward, and many aspects of the task description has changed.

Firstly, this project is no longer about rehabilitation, as there is no clear answer for whether this is possible for patients with HVFDs. Instead, the thesis is about creating a tool which patients can use to better compensate for their impairment.

Secondly, a lot of time has been focused towards vision therapy. While this is not a big part of the project according to the task description, the opposite is true. A significant part of this project has been spent assessing this field.

Lastly, the delivery has turned towards a standalone solution for patients. This gives the user total control over their training, which they can access whenever it suits them. However, how this could be combined with existing options for treatment has not been discussed.

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INTRODUCTION

Chapter 1 | Presenting and defining this thesis

CHAPTER OVERVIEW

Homonymous visual field deficits is a condition often acquired from stroke, which results in a reduced field of view. This condition can lead to significant problems for the patients, such as reduced literacy, mobility, and challenges with activities of daily living. While stroke patients, in general, have many opportunities for rehabilitation, this group have limited options for receiving help.

This master project is part of an early stage innovation project initiated by Østfold Hospital Trust. The aim of this project is to provide these patients with a new and simple way of treating their condition, by utilizing virtual reality technology.

1.1 THE INNOVATION PROJECT

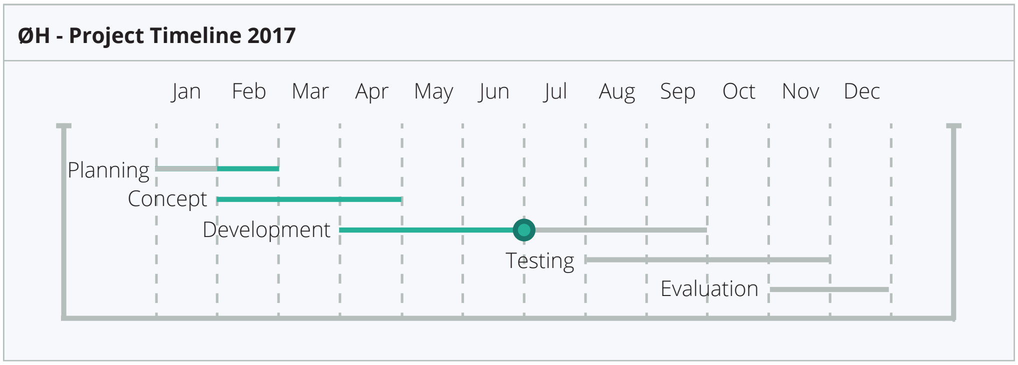

Figure 1.1 | Timeline for the innovation project. Green line marks the contributions of this thesis

This thesis is part of an innovation project initiated by Østfold Hospital Trust(ØH). The goal of this innovation project is to conceptualize and develop a virtual reality application, which can be used by patients with homonymous visual field deficits, to conduct vision therapy. Next, this prototype will be employed in a pilot test, to assess whether the therapy has an effect for the patients. The results of this test will determine whether the innovation project will be continue. For the full project description, see Appendix E.

Project plan

The innovation project is planned to last for 12 months, and is separated into five phases; planning, concept development, application development, testing, and evaluation.

The role of this thesis is to contribute in the planning and concept development phase, see Figure 1.1.

Virtual reality

The innovation project aims to investigate whether virtual technology can be used as a new and efficient tool for patients affected by visual field deficits. This is thought to be a technology which is both accessible and user-friendly, which could lead to an increased focus on self-service technology and increase the number of options this group has for getting help.

1.2 PILOT TEST

The objective of this thesis is to lay the groundwork for a pilot test. This pilot test aims to prove that virtual reality headsets can be an effective tool for vision therapy, for patients with HVFDs.

Protoype
The pilot test will utilize a prototype developed by Attensi. This prototype will be created based on the specifications from the planning and concept development phase.

Exection
The test itself will be carried out in collaboration with voluntary patients and Østfold Hospital Trust. The test group will be patients with homonymous hemianopia, and no other visual impairments or impairment that could affect the results of the test. The test group will utilize the prototype for an extended period of time.

Results
The test aims to assess the user's experience with the prototype, and whether the test provides any results in regards to the vision therapy. These results will determine whether the project will continue or be discontinued.

1.3 PROJECT STAKEHOLDERS

Volker Solyga
Neurologist
Manager at the department of Neurology at ØH

Origin of the idea

Jarl Schjerverud
Project manager ØH
Responsible for management and administration.

Project manager

Stine Tanggard
Attensi AS
Responsible for development, verification and testing.

Project manager

Anne Lise Waal
CTO Attensi AS
Responsible for development, verification and testing.

Managing director

HELSE SØR-ØST

Helse Sør-Øst, responsible for the funding of the project.

The authors' role
The authors' role in this innovation project is best described as consultants for Attensi AS. However, there has been a close collaboration with the idea owner Volker Solyga and project manager Jarl Schjerverud, throughout the project.

1.4 THESIS SCOPE

"How can virtual reality headsets be used for vision therapy, by stroke patients with homonymous visual field deficits?"

The project in its entirety will be working towards this problem statement. However, this is statement is very open. To narrow the scope of the project, two research questions are created to guide the project.

The purpose of this thesis is to explore whether virtual reality technology can be used as a viable solution for vision therapy. The aim is to develop a concept for vision therapy, made for patients with homonymous visual field deficits.

The intention of this concept is to lay the groundwork for the innovation project initiated by Østfold Hospital Trust, which can be used to further develop a prototype for the pilot test.

There are two key parts to this groundwork. The first is to define the target user and homonymous visual field deficits, as these will be central throughout the project. The second is to outline methods and principles for vision therapy, to create a foundation for the early virtual reality prototype to be effective.

The purpose of this groundwork is to facilitate for the pilot test to be successful and for a development phase with a focus on the patient's needs.

The goal of this thesis is to explore two **research questions:**

Research Question 1	**Research Question 2**
What should a virtual reality application contain in order to be useful for vision therapy?	How can the application be adapted to the intended users?

1.5 MOTIVATION

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> *After the stroke, I lost parts of my vision, my ability to read and my license. The doctors won't help me, as it is not their responsibility*
>
> Illustrative quote reflecting findings from this thesis

Losing parts of the visual field
Homonymous visual field deficits (HVFD) is the most common visual impairment after stroke. This condition results in a reduced field of view, which can lead to significant problems for the patients.

Few options for getting help
Stroke patients, in general, have many opportunities for rehabilitation. However, patients with visual impairments have limited options. As vision therapy is not part of the public health care system in Norway and is counted as adult education and few municipalities in Norway have available therapists, getting help can be difficult.

Therapy at home
The possibilities for vision therapy at home are limited, and the options that exist often require support from a TVI to be useful for the patient. Additionally, these options are not suitable for all patients, as other impairments from their stroke can obstruct the training.

Virtual Reality
The starting point of the innovation project is that virtual reality can be used as a new and efficient way for patients to conduct vision therapy. Notably, this technology can be cheap, portable and allows for full control of what is displayed in the user's field of view. This could allow for the patient to have greater control over their training and reduce the required equipment for vision therapy.

1.6 STRUCTURE

This thesis is structured in 14 chapters, this section explains how these are connected.

Insight and method creation
Chapter 2, 3, 4 and 5 organize the findings from the insight phase. These define the target group, homonymous visual field deficits and vision therapy, and explore how vision therapy is practised today.

These findings are used to define four methods for vision therapy, which are presented in Chapter 6.

Creating a prototype
Chapter 7, 8 and 9 discuss topics and organize findings relevant for creating a virtual reality application. These elaborate on how virtual reality equipment was selected, what stroke-related challenges are relevant for this project and discuss user interfaces in virtual reality.

These findings are used to create a prototype for vision therapy, which is presented in Chapter 10.

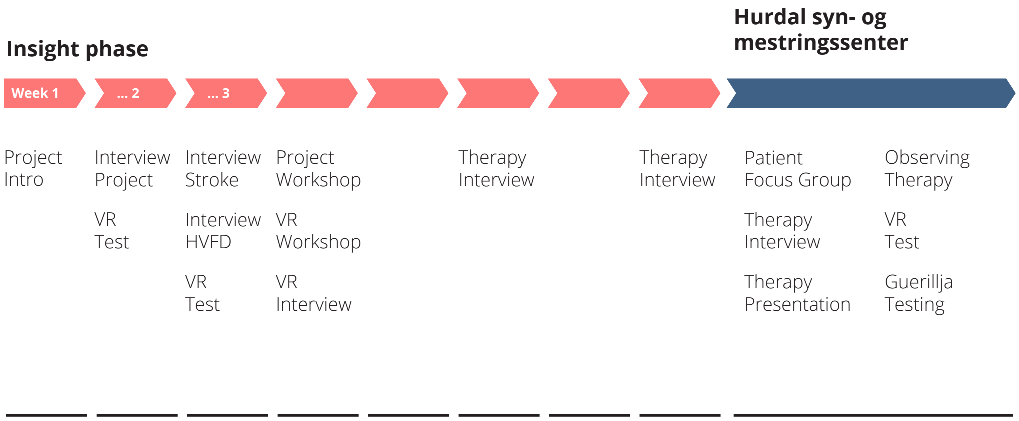
Future work and Delivery
Chapter 11 and 12 discusses how the prototype could be improved. These present results from user tests and explore how to facilitate for motivation and use.

Chapter 13 present the final delivery, and thoughts on how this project should proceed.

Evaluation
Chapter 14 present our reflections on this thesis.

Appendixes
All interviews, workshops, and tests are covered in the appendixes of this thesis. These are referred to throughout the thesis, which is done to avoid redundant writing and to keep the report on point. To see how some of the findings has originated, please read these appendixes, when they are referenced.

1.7 PROCESS



"How can virtual reality headsets be used for vision therapy, by stroke patients with homonymous visual field deficits?"

From the problem statement, there was two terms wich were entirely new to both authors, namely; vision therapy and homonymous visual field deficits. The starting point of this project was, therefore, to get familiar with these topics.

To get a general overview of the project, a literature search on the relevant subjects was conducted. However, the primary source of insight in the early stages of the project has been through workshops and interviews with relevant stakeholders.

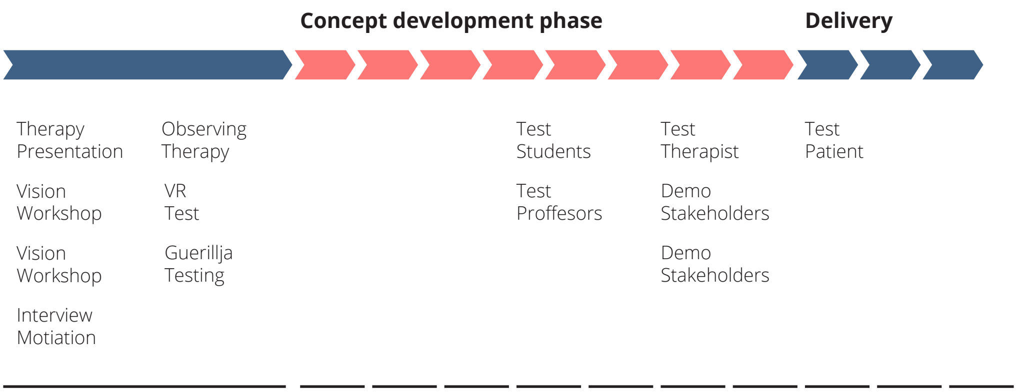
Insight phase

Early in the process, vision therapy was found to be a more complex field than expected. Experts in this field were therefore consulted, which recommended Hurdal Syn- og Mestringssenter as a great source of information.

Hurdal Syn- og Mestringssenter

This resulted in participating in a two-week course in vision therapy, for patients with homonymous visual field deficit. During this stay, workshops and interviews were conducted with both patients and experts in vision therapy. In addition to 15 hours of observation of vision therapy sessions. At the same time, the virtual reality equipment was tested, and four methods for vision therapy was created.

While the insight phase of this project was both rewarding and educational,



it lasted for almost ten weeks, about half of the project period. However, it provided a solid foundation for the rest of the project, which was shared with the stakeholders in the innovation project.

Concept development phase
The groundwork acquired at Hurdal Syn- og Mestringssenter, was then used in a concept development phase. During this phase, a further assessment of designing for virtual reality was conducted. This was used along with the methods and principles for vision therapy to create an early virtual reality prototype.

This prototype was tested on students, professors and stakeholders, in addition to a TVI. This provided positive results, with much room for improvements. The last test of the prototype was with a patient, in collaboration with a TVI.

Delivery
The last phase of this project has been used to prepare the delivery to the innovation project stakeholders, which will continue the project.

Evaluation
While this project has been challenging, the process has been fairly straightforward and has in general been directed towards the problem statement. Eventhough the progress has been slower than anticipated, the project has ended with a result the authors think will be appreciated by the target group.

DEFINING THE TARGET GROUP

Chapter 2 | Presenting and defining the target group

CHAPTER OVERVIEW

Stroke patients with visual field deficits are a diverse group. It is necessary to narrow down and define this group, as this would allow for the insight phase of the project to be both more accurate and efficient.

Content
This chapter starts by presenting for which groups HVFDs are most common. Then the target group is narrowed down, by defining both age span and which subgroups are most relevant.

Result
The results from this chapter is a defined target group. A summary of this group is presented at the end of the chapter.

2.1 STROKE PATIENTS WITH HVFDs

Focus on STROKE PATIENTS

Stroke is the leading cause of HVFDs (69.7%), followed by traumatic head injury (13.6%) and tumors (11.3%) [1]. Therefore, the primary focus of this thesis is patients suffering from HVFDs as a result of a stroke.

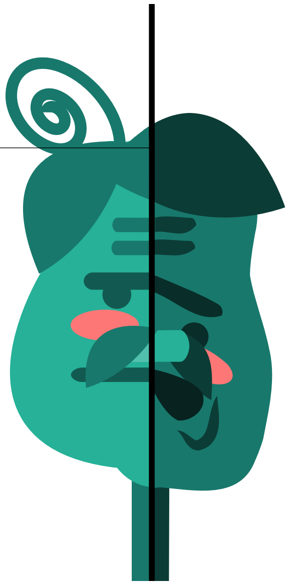


Figure 2.1 | Stroke patient

Stroke patients in Norway

Visual impairments are common as a result of stroke, where approximately 20-60% of patients gets visual field deficits[2]. As 15 000 people in Norway experience a stroke every year[3], this implies that up to 9000 people get visual field deficit, every year.

HVFD as the primary deficit

This project will focus on those patients who has HVFDs as their primary impairment after stroke. This is because of rehabilitation of other conditions, e.g. paralysis or severe cognitive impairment, often takes priority over HVFDs. Patients with less severe impairments will, therefore, more likely benefit from this project.

2.2 TRAUMATIC BRAIN INJURY AND TUMORS

Brain injuries and tumors

HVFDs can be acquired from traumatic brain injuries and tumors [1].

Figure 2.2 | Tumor illustration

Brain injuries and tumors
Patients suffering from traumatic brain injuries and tumors, often suffer from the same symptoms as stroke patients, as the resulting brain damaged can be similar. As brain injuries and tumors are not connected to age in the same way as stroke, patients within this group will often be in a younger age segment than patients acquiring HVFDs from stroke.

These patients will be relevant for this project, and will be included in observations and testing. However, they will not be the main focus of the assignment, as HVFDs are more frequently acquired from stroke.

2.3 LIMITED OPTIONS FOR HELP

From the two initial interviews, see Appendix C.3 and C.4, and the task description for the innovation project, it was found that the options that stroke patients with HVFD have for getting help are limited. One reason for this is that vision therapy is not supported by the Norwegian health care system but is instead counted as adult education.

Patients living at home

Teachers of students with visual impairments (TVIs) and speech therapists are rare in Norway. Few municipalities have available TVIs, and many of the TVIs have private practices. Patients often have to travel far to get help, or do not have the possibility to get help at all. A solution that enables patients to conduct therapy at home could be a possible solution to this problem. The focus of this thesis is, therefore, patients living at home.

After being treated in the stroke unit at the hospital, a patient is either sent home, to a rehabilitation facility or a nursing home [4], see Figure 2.3. As this project targets stroke patients who live at home, group 1 and 2 are most relevant.

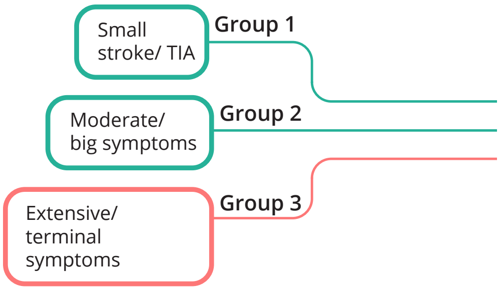
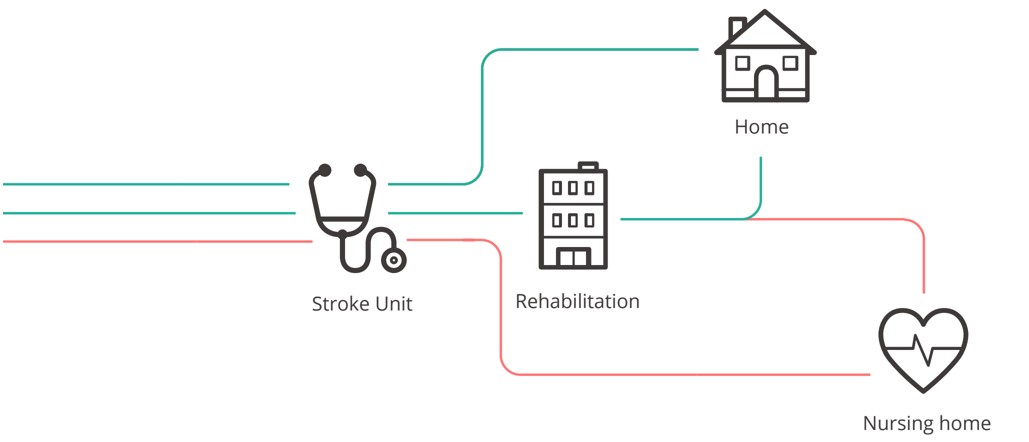


Figure 2.3 | Stroke journey

Group 1 Sent directly Home

The patients in group 1 are sent home after treatment in the stroke unit. This group covers patients who have had a small stroke or a transient ischemic attack. They have a fast recovery and no need for further treatment in a rehabilitation facility. According to the Norwegian Health directory, most stroke patients returns home after treatment in the stroke unit at the hospital [5].



Group 2 Sent to a Rehabilitation

The patients in Group 2 are sent to a rehabilitation facility for further recovery after treatment at the stroke unit. This group consists of patients who have moderate to big symptoms post stroke, and include all patients who are not sent directly home or to a nursing home. It is ,therefore, a huge variation between patient within this group, related to how they are affected by the stroke.

Group 3 Sent to a Nursing Home

The patients in group 3 require care in a nursing home after treatment at the stroke unit. This group consists of patients who have extensive symptoms and patients who are terminally ill, with impairments such as patients massive brain damage, unconsciousness or severe dementia pre-stroke. These are evaluated as unable to benefit from rehabilitation.

2.4 PATIENTS OF WORKING AGE

In this project, the target group is defined as patients within working age. There are several reasons for this choice.

As our focus is on home rehabilitation, it is natural to focus on younger patients, as these have a faster recovery and are more likely to end up at home. Younger patients do also have to live longer with their HVFD, as well as the possibility of benefiting from rehabilitation decreases with age.

The society benefits more from rehabilitation of patients from within working age, as these has a bigger chance of returning to work. Additionally, these patients will usually require support and aids for a longer period of time.

2.5 TARGET GROUP SUMMARY

This is a summary of **the target group in this project:**

Stroke patient

HVFD as primary impariment

Within working age: 18 - 70 years old

Lives at home

Target Group
Further on in this thesis, the target group will be used as a guide in the insight phase, to ensure that the concept presented solves their needs. These target users are those who are believed to have the biggest potential of benefitting from easier access to vision therapy.

HOMONYMOUS VISUAL FIELD DEFICITS

Chapter 3 | Presenting the condition and related challenges

CHAPTER OVERVIEW

The target group of this project has now been defined. This chapter aims to elaborate on homonymous visual field deficits(HVFDs) and challenges connected to this condition.

Content
This chapter goes through how HVFDs are experienced, what it is, and subgroups of this condition. The most common challenges for patients with this condition are also discussed.

Result
The results from this chapter is an overview of HVFD and difficulties common to the target group. A summary of these findings is presented at the end of the chapter.

3.1 EXPERIENCING HVFD

Figure 3.1 | Normal Vision to the left vision with HVFD to the right

Seeing with a HVFD

People with regular vision rarely reflect on their vision, as they can see everything like normal and the world is experienced as a whole. However, this is also true for many patients with HVFDs.

Figure 3.1 shows how the world could look for a person with normal vision. The Figure also show how the same world can look through the eyes of a patient with a right- sided HVFD. For the patient, the world seems relatively normal, but they are not detecting several objects to the right side of their vision. This is because the right side of the vision is blind, and the brain patches the image together, making it seem like a whole.

3.2 VISUAL EXPLORATION

Having a HFVD makes visual exploration difficult, as parts of the environment no longer are visible to the patient. Patients with HVFD often collide with objects, e.g. tables and chairs on their affected side. Navigation and orientation are therefore often challenging.

Crowded places can be challenging
Traveling in crowded places, such as in a busy street can be especially stressful, as there is a lot of sensory stimuli, see Appendix C.10. In such places, there are often many people, lights, sounds, motion and several other disturbances that can result in a high cognitive load for the patient.

3.3 ABOUT THE CONDITION

Among the visual field deficits, homonymous visual field deficits (HVFDs) are by far the most common [3, 6]. This section elaborates on this condition.

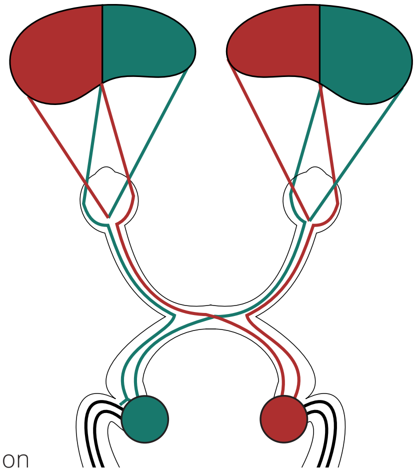
Homonymous visual field deficits

Homonymous visual field deficits (HVFDs) is visual field loss to the same side of both eyes.The result is that all or parts of the information from the ipsilateral nasal field of view and contralateral temporal field of view are lost on the side where the lesion is located, see Figure 3.2. The result of this is that parts of vision is lost to either the left or right.

Depending on the location of the lesions, which can be in the optic tract, occipital lobe, parietal lobe or the temporal lobe, different parts of the visual field can be affected [7].

For this condition, there is nothing wrong with the eyes themselves, but rather parts of the brain which are no longer able to receive information from the eyes [8].

Red | Lesion located to the right, loss of vision to the left

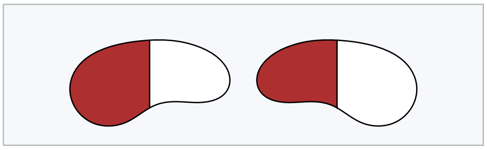


Green | Lesion located to the left, loss of vision to the right

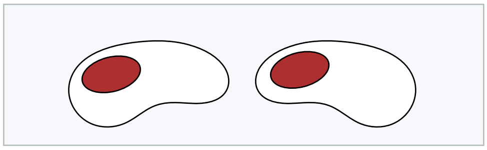
Figure 3.2 | HVFD illustration

3.4 SUBGROUPS

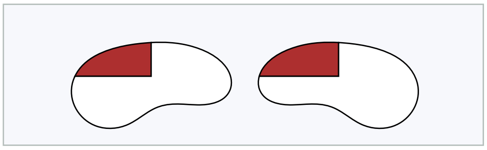
The condition can be divided into three main subgroups based on how much of the visual field is lost. These subgroups are presented in this section.



Homonymous hemianopia
Homonymous hemianopia is a complete HVFD, were half of the visual field is lost, to either the right or left side of the vertical midline.



Homonymous scotoma
Homonymous scotoma is harder to define than the previous subgroups. For this condition, smaller parts of the visual field are lost, in the same part of both eyes.



Homonymous quadrantanopia
Homonymous quadrantanopia is the most common type of incomplete HVFD. For this condition, upper or lower quarter of the visual field, on either left or right side is lost.

Figure 3.3 | Left-sided Homonymous visual field deficits

3.5 READING DIFFICULTIES

Reading difficulties are common among the target group in this project. This section elaborates on the difficulties this group can experience when reading.

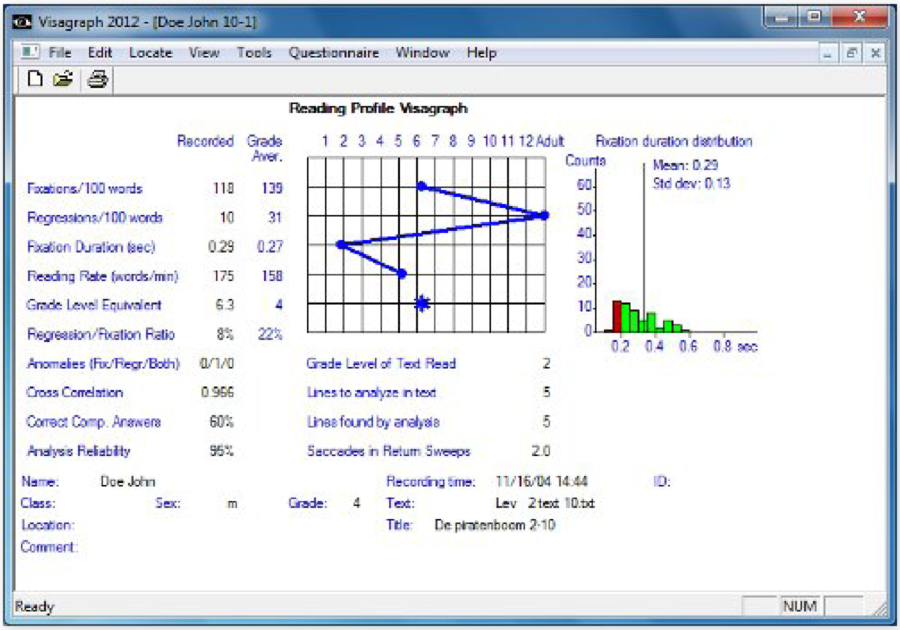


Figure 3.3 | Example of a Readalyzer analysis

Reading disorders
Hemianopic dyslexia is a term used to describe reading disorders caused by a visual field loss [9]. Patients with hemianopic dyslexia struggle with finding syllables and words. Reading is experienced as being slow, tedious and fatiguing. Eye-movement recordings show that patients with HVFD have severely altered eye-movement patterns and that both their reading and visual exploration performance are impaired [10].

Reading with a HVFD
Tests from Readalyzer a program which is used to assess reading techniques, see Figure 3.3, gave a good visual indication of how it is to read with a HFVD. Readalyzer is a program that registers eye movements when reading a text. Recordings from HVFD patients show many of the struggles these patients have with reading.

Patients with left-sided visual field loss often have problems with finding the beginning of a new line, whereas those with right-sided visual field loss struggle with in moving the eyes smoothly along a line of text.

Other observations were: Starting mid-sentence, re-reading words, jumping back and forth in a sentence, jumping between sentences, in addition to having severely impaired reading speeds. This is consistent with the article [10], which found that HVFD patients have an increased number of fixations, a higher percentage of fixation repetitions as well as prolonged fixation durations. In addition, they also have considerable shorter saccades, and they make more forward-directed saccades than normal readers.

Accommodation techniques
Patients with HVFD often use several accommodation techniques, to compensate for their reading difficulties. Examples of these techniques are guessing of words, trying to find meaningful completions of partially seen words, and omitting small words or prefixes and suffixes[10]. This became evident during the input test of HVFD patients, see Appendix D.2, where patients read parts of the instructions and made up the rest. The instruction on the screen said “press right button” and the patient read out loud “right button press”, as he had overseen the first word in the sentence.

3.6 DRIVING DIFFICULTIES

Vision plays an important role when driving, as it is the most crucial source of information input. Therefore, patients with HVFD in Norway loose their drivers licence. Driving with a HVFD requires the driver to find compensatory techniques in order to perceive all necessary information [11]. Loosing the drivers licence can lead to social isolation, depression and decreased quality of life [11]. Being able to drive is an important factor for living independently, and an essential way of transportation in industrialized countries.

Driving is an important motivation

Driving is a huge motivational factor for conducting vision therapy, see Appendix C.11. During vision therapy several patients refer to driving during exercises, and driving is used as a motivational factor for conducting vision therapy .

Regaining the drivers licence after being diagnosed with a HFVD rarely happens. When at Hurdal, only one patient was metnioned to regain their licence during the past 7 years. A TVI stated that only around five patients yearly in Norway got their licence back, which surprised a neurologist, stating that the number had to be way to high. In addition, the requirements for dispensation has become stricter over the years, and the possibility of regaining the licence is therefor even lower.

> *To be able to drive again is very important to me, I want to improve the other stuff to, but that can wait.*
>
> Patient at Hurdal

Different goals create a barrier

A TVI at Hurdal stated that the unrealistic goal of regaining the licence, creates a barrier between the TVI and the patient. The TVI wants to enable the patient to manage everyday life in a better way, while the patient is solely focused on regaining the drivers licence. In other words, the Patient's goal and the TVI's goal does not align. This misalignment often causes frustration. Especially, when a patient performs well during vision therapy exercises, it can be difficult for the patient to understand that these results is not taken into consideration when a dispensation is considered. Patients and TVIs often have different views on the patient's capabilities. While a patient often get the impression that their skills haven not been evaluated correctly, the TVI have the impression that the patient is not qualified to drive.

A TVI at Hurdal stated that luckily he is not the one that chooses whether a patient regains their licence or not, see Appendix C.11 for full interviw.

Accepting that driving is not an option

The article, *Car driving performance in hemianopia*, recommends that people with HVFD should be allowed to demonstrate their driving skills in a valid driving assessment, on the condition of positive evaluations of visual and (neuro)psychological functioning [11]. Claiming that patient's who are judged as unfit to drive through such a careful test protocol, will be more accepting and compliant with the final decision.

> *It would be beneficial to let him try a car game, to show that it is not safe for him to drive.*
>
> TVI at Hurdal

In order to regain the drivers licence patients first have to pass a visual awareness test at the ergotheratpist. The test is very strict, and one of the TVIs stated that if everyone had to take this test, many would not have their drivers licence today. The test can be especially difficult for patients with aphasia, as they often have problems with understanding instructions and language. One patient stated that he felt that he got tested in linguistic skills rather than visual. He felt neglected by the test responsible, who according to him showed no understanding of his other stroke related difficulties. It should be noted that patients with aphasia are allowed to drive.

As the goal of regaining the drivers licence diminishes, many patients loose their motivation to continue vision therapy.

3.7 AWARENESS OF THE DEFICIT

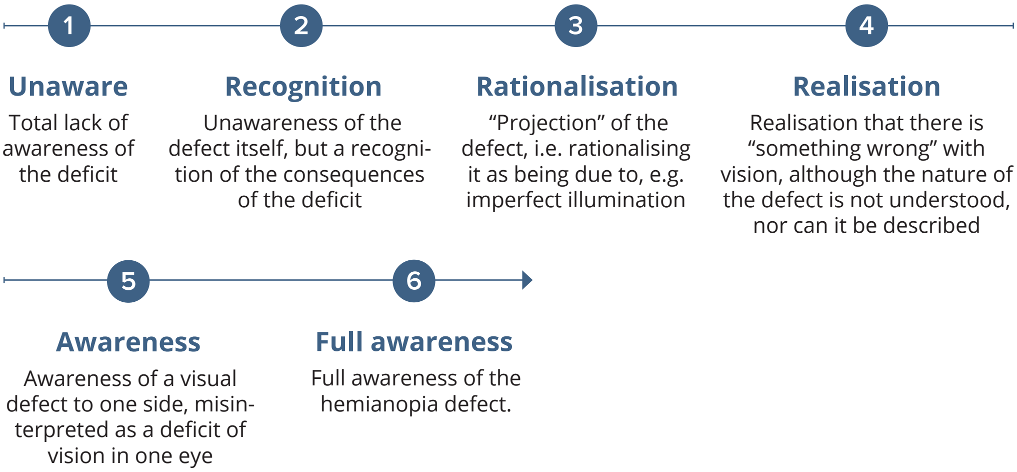


Figure 3.4 | Six degrees of awareness, Zihl [12]

Zihl [12] states that patients with HVFD are not always aware of their visual defect. He identifies six degrees of awareness, as seen in Figure 3.4. A visual field deficit can be difficult to detect, as both the patient and health personnel can be unaware that something is wrong with the patient, see Appendix C.10 for more information. It often takes time before patients get fully aware of their HVFD, and some never become aware at all. Becoming aware usually starts with a recognition of the consequences, such as colliding with objects, and not finding things.

A patient's version of becoming aware
This subsection presents how one of the patient's at Hurdal experienced going from unawareness to awareness. See Appendix C.16 for the full interview.

It had taken about 9-10 months before I realized that something was wrong with my vision. It was strange walking around not knowing what was wrong. I remember seeing a rabbit running, thinking "Oh, how cute!", then I looked to the right "Oh, shit! There is a fucking fox chasing it!".

Before I got to my first course here at Hurdal, I thought that I could see everything. But after attending the course, I realized that I could not see shit. Now I think about it all the time, it's like a virus in the back of my head. I think about it when I am out fishing, at the mall, and in the store. It can be frustrating realizing something is wrong, without knowing what it is.

The patient said that he had to live with a visual deficit, noticing that something was off, without anyone telling him what was wrong. The TVI Arne Tømta states that many misunderstand their impairments, thinking that their vision is better than it really is, or believing that they are blind in only one eye.

Creating awareness

The courses at Hurdal gives patients an awareness of the extent of their visual field loss. Methods where patients have to keep their eyes and head still, illustrates to which extent a patient is affected. A method called UFO, see Appendix F.7, can be used as an illustrative example. Figure 3.5, shows the UFO results from a person with regular vision. If a patient with left sided hemianopia conducts this exercise, without moving their head or eyes, it will be evident from the results that something is wrong with the patient's left field of view, see Figure 3.6.

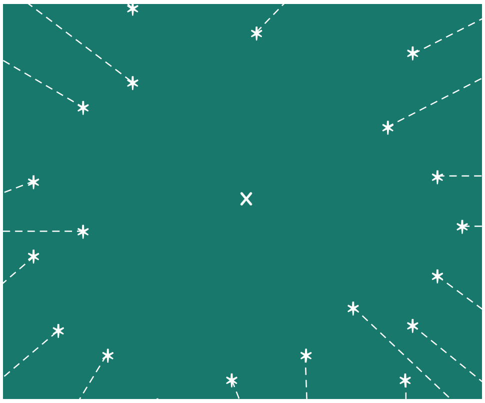


Figure 3.5 | Reproduction of UFO result

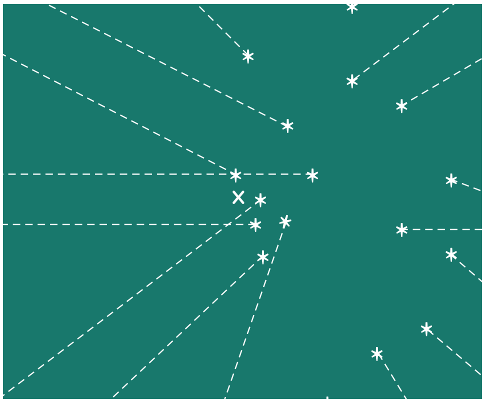


Figure 3.6 | Reproduction of UFO result with left sided HVFD

3.8 HOMONYMOUS VISUAL FIELD DEFICITS SUMMARY

Homonymous visual field deficits is a frequently seen as an imparienent as a result of stroke. This is a summary of **this condition and common challages for these patients:**

Experiencing HVFDs

For some patients with HVFD, the world is experienced as being whole. This is because the brain patches the parts of the visual field that is affected, while the patients, in reality, are blind to one side.

The Condition

For HVFDs, there are nothing wrong with the eyes themselves. However, the brain is not able to receive parts of the signal from the eyes, resulting in these parts of the vision being lost.

Sub Groups

HVFDs consists of three subgroups. Hemianopia, where half of the vision is lost, quadrantanopia, where a quarter of the vision is being lost, and scotoma, where smaller parts of the vision are lost.

Reading difficulties

Reading skills are often severely impaired from HVFDs. Patients struggle with everything from finding the new line to reading longs words. Ineffective compensation techniques are often seen in these patients.

Driving difficulties

Patients with HVFDs are not allowed to drive, with few exceptions. This is by many experienced as a big loss.

Awareness

There are a various amount of awareness of the HVFD among patients. Some are completely unaware that there is something wrong with their vision, whereas other has a complete understanding of what is wrong with their vision and what this involves.

DEFINING VISION THERAPY

Chapter 4 | Presenting and defining vision therapy

CHAPTER OVERVIEW

An insight into HVFDs has now been provided. This chapter aims to give an overview of how this condition can be treated and to cover the basic principles and methods involved in vision therapy.

Content
This chapter goes through our assessment of vision therapy. First, four principles of vision therapy are presented. Then eye movements and visual skills relevant for this project are discussed. Last, categories of vision therapy methods are presented.

Result
The results from this chapter is an insight into vision therapy, and topics relevant to this field. A summary of these findings is presented at the end of the chapter.

4.1 ABOUT VISION THERAPY

Treatment
Currently, there does not exist adequate documentation for the Norwegian Directorate of Health to provide a recommended a method for treating HVFDs [13]. However, there are three main options for getting this condition treated [14], these are; widening your field of view with optical aids, visual restoration therapy (VRT), and Compensatory visual field training (CVT). This project focuses on vision therapy in terms of CVT, which has proven to have a positive effect for people suffering from HVFDs [7,15,16,17]. CVT will in this thesis be referred to as vision therapy.

What is vision therapy?
Vision therapy is about teaching patients with HVFD, techniques for improving their visual skills and abilities. The aim of vision therapy is training patients to move their eyes more efficiently, by practicing vision exercises and procedures, using the eye-brain connections that are involved in vision [18]. The goal of this therapy is to better the lives of people suffering from a visual impairment, through improvements and corrections of behaviors derived from these impairments.

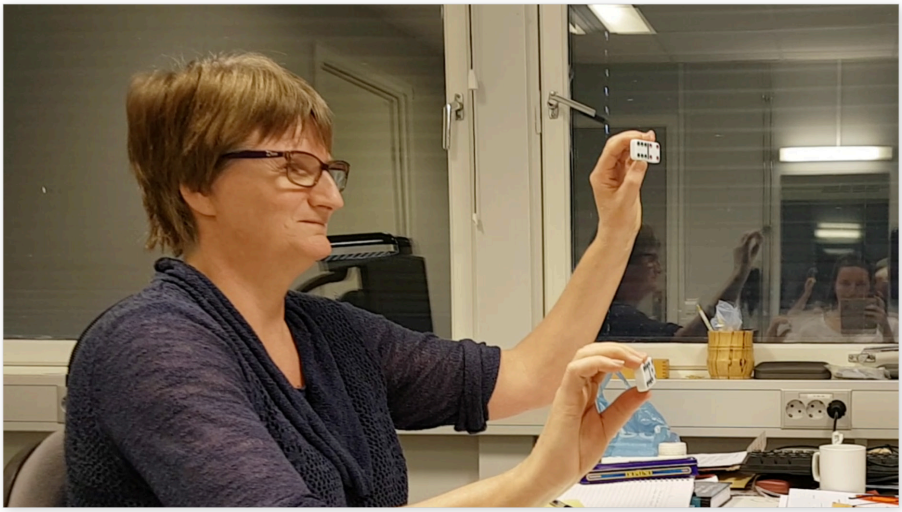


Figure 4.1 | Image from observing a vision therapy session

TVIs
Vision therapy is usually performed under the supervision of a teacher of students with visual impairments (TVI). TVIs are specialized teachers who provide services to people suffering from visual impairments.

Insight
Vision therapy is not a new domain. Still, it has few conventions and standards. For this reason, defining and assessing this field was difficult. A preliminary literature review and interviews with TVIs resulted in few answers for how this practice is conducted, see Appendix C.8 and C.9. For this reason, observations of vision therapy were conducted, see Appendix E. Additionally were, interviews, and workshops were used to map vision therapy.

This chapter covers the findings from this groundwork, which was used to define principles and categories for vision therapy.

4.2 FOUR PRINCIPLES

To understand the fundamentals of vision therapy, observations were conducted at Hurdal syn- og mestrings-senter (HSMS). Based on this insight, four principles for vision therapy emerged. These were validated with help from two TVIs, see Appendix C.14 and C.15.

The idea behind these principles is that if a patient masters these all principles, the patient should be able to compensate for his HVFD successfully. This section explains these principles.

PRINCIPLE 1

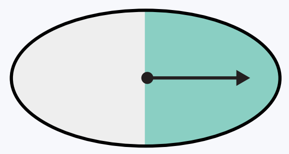


Figure 4.2 | Vision therapy principle 1

PRINCIPLE 2

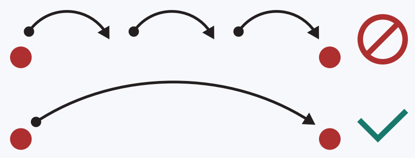


Figure 4.3 | Vision therapy principle 2

Explore the Affected Visual Field

The first principle is to explore the parts of the visual field that are affected. This sounds self-evident but is not apparent to all patients with HVFDs. Many are most concerned about using the intact visual field and ignores, to some extent, their affected side. The idea behind this principle is for the patient to get an overview of their surroundings.

Precise Saccades and Fewer Fixations

A side effect often associated with HVFDs is shorter saccades and a higher frequency of fixations during visual search, which are often more prominent towards the affected side. This makes visual search slower and more tedious. The second principle is, therefore, to increase saccade lengths and precision, and reduce the frequency of fixations during a search tasks.

PRINCIPLE 3

Figure 4.4 | Vision therapy principle 3

PRINCIPLE 4

Figure 4.5 | Vision therapy principle 4

Avoid using Head Movements

Using head movements to compensate for HVFDs are common amongst patients with HVFD. The techniques that are adapted are often both slower and more stressful than techniques that uses the eyes. Frequent and unnatural head movements can also lead to both strains and poor head positions. The third principle is, therefore, to avoid head movements, when this is not natural or necessary.

Awareness of the Visual Defect

Patients have various degrees of awareness of their HVFD. Some have full awareness of their defect, while others have a total lack of awareness, as seen in Section 3.7. While most patients naturally acquire techniques for compensating for their HVFD, an increased awareness will help patients gain an understanding of how to compensate more efficiently. The fourth principle is, therefore, to enlighten patients about their HVFD and how it affects their vision.

4.3 EYE MOVEMENTS

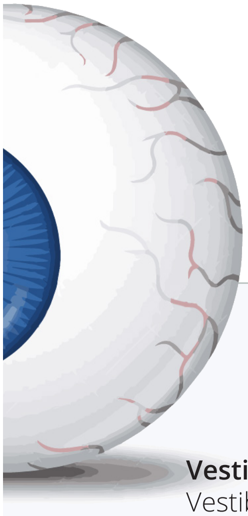
Eye movements are central in vision therapy, as they are the basis for how people use their eyes. This section covers four basic types of eye movements, defined by Purves et al. [19]. These are saccadic, smooth pursuit, vergence, and vestibulo-ocular movements. Their relevance for this project will also be discussed.

Saccadic Movements
Saccadic movements are eye movements used during a search task [20]. These movements are rapid and ballistic, with the purpose of changing the eyes fixation point. Being ballistic means that once a saccade is initiated, the eyes does not stop moving until the end point is reached. Saccadic movements are constantly executed at a subconscious level, but can also be executed deliberately.

Saccades are central in this project as many vision therapy methods for HVFDs are based on improving these movements. Saccadic movements will, therefore, be in relevant for this project.

Smooth Pursuit Movements
Smooth pursuit movements are used to lock onto an object of interest, to track it. These movements are, contrary to saccadic movements, both slow and always deliberately controlled. However, smooth pursuit movements can be difficult to perform, and can often result in small and frequent saccades instead.

Patients who only suffer from HVFDs, should, in theory, have little problems with these eye movements. However, many vision therapy methods are based on training these particular eye movements. Smooth pursuit movements are, therefore, relevant for this project.



Vestibulo-Ocular Movements

Vestibulo-ocular movements are in many ways similar to smooth pursuit movements. However, these movements are used to automatically compensate for head movements while keeping the eyes locked onto an object of interest.

As of now, we have not seen any method or research using these movements for vision therapy. While it could be interesting to see how these movements compare to smooth pursuit movements, these will not be dicussed in this project.

Vergence Movements

Vergence movements, also called convergent movements, are used to align the eyes when fixating on objects at different distances. These movements can be both saccadic and smooth. Contrary to other types of eye movements, the eyes travel in opposite directions during these movements.

Vergence movements are often a relevant for vision therapy methods, as they are closely linked to oculomotor control. While these eye movements are relevant for some vision therapy methods, they will not be emphasized in this project.

4.4 VISUAL SKILLS

Visual skills are the abilities a person can perform using their vision. The Optometric Extension Program Foundation provides a list with seven visual skills[21], which are simplified in Table 4.1.

These skills are the basis for most vision therapy methods, where most methods are based on improving one or more of these skills.

Skill A The ability to follow a moving object
Skill B The ability to aim the eyes on a series of stationary objects
Skill C The ability to change focus
Skill D The ability to team two eyes together
Skill E The ability to see over a large area
Skill F The ability to see and recognize in a short look
Skill G The ability to see in depth

Table 4.1 | Visual skills [21]

Relevant visual skills
This project, which focuses on patients HVFD, therefore, not all visual skills are equally relevant. Skill C, D, and G are closely linked to oculomotor control, which can often be seen together with HVFDs. However, oculomotor dysfunction often makes HVFD adapted training more difficult[22]. As for this reason, it is expected that these skills are adequate for patients participating in this project. Additionally, skill F is also often linked to other impairments than HVFDs and will not be discussed in this project.

Skill A and Skill B are closely related to smooth pursuit and saccadic movements respectively. Whereas Skill E, the ability to see over a large area, is closely linked to the initial goal of vision therapy for patients with HVFDs, as parts of their visual field are lost. The relevant skills are listed to the right, and will from this point be referred to as Skill 1, Skill 2 and Skill 3.

In this project, these are the most **relevant visual skills:**

Skill 1	Skill 2
The ability to follow a moving object	The ability to aim the eyes on a series of stationary objects

Skill 3
The ability to see over a large area

4.5 CATEGORIES

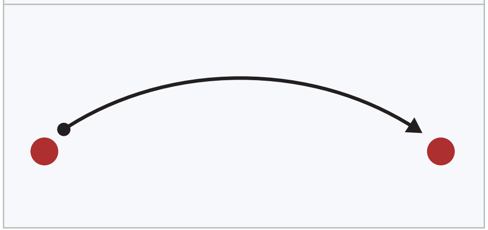
There is no recipe for how vision therapy is conducted. It was, therefore, necessary to get an accurate understanding of this field, for the later stages of this project. Several approaches were made, to find suitable methods for the target user.

Firstly, a literature review was conducted, see Appendix F.1, F.2, and F.3. This was done in an effort to get an overview of this field, but granted few results.

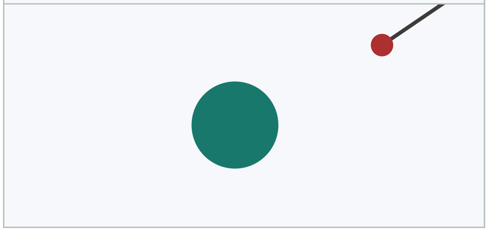
Secondly, interviews about vision therapy were conducted with two TVIs, see Appendix C.14 and C.15. These revealed that vision therapy is complex and that method are usually adapted to every individual user. This meant that the ground work in this project had to be more thorough than first expected.

Lastly, the methods that were seen during observations at HSMS, was used for a more thorough assessment. The methods that were used can be seen in Appendix F.4 to F.19. By sorting these methods based on their purpose, four fundamental categories started to emerge. These categories are presented in this section.

CATEGORY 1: SACCADE



CATEGORY 2: DETECT



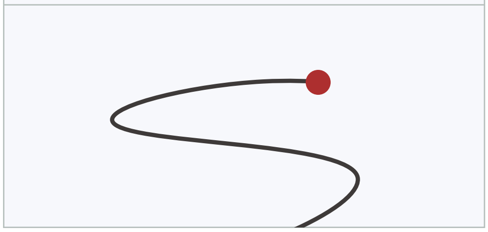
Saccade is a category of methods which trains the patient's saccadic eye movement, hence the name. The goal is for the patient to learn how to perform efficient and precise saccades. These methods are linked to skill 2, which is related to reading and other tasks that require rapid and precise eye movements.

Most of the methods in this category use two or more fixed objects, where the patient is asked to either fixate on the objects in a specific order or to locate one specific object among the others. One or more of the object changes and the patient is asked to recognize the change quickly. The length of the saccades varies between methods.

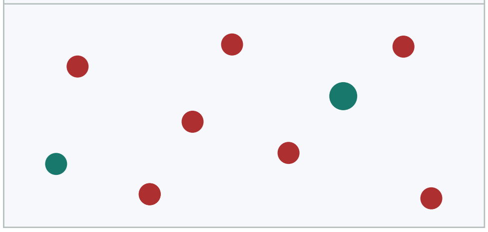
Detect is a category of methods which are based on detecting new and relevant visual stimuli as quickly as possible. This category of methods is linked to skill 3, which aims to train the patient's visual awareness and overview of their visual field.

There exist several variants of methods in this category, both in terms of how they are executed and how cognitively demanding they are to the user. Some methods require the user to fixate on one specific point during the exercise, while others allow for using the eyes to roam freely. Another variable is how relevant visual stimuli appears, which could enter from outside the visual field or appear from somewhere inside the visual field. Some of the methods also require the user to recognize specific properties of the visual stimuli, such as orientation, while others only require just the discovery.

CATEGORY 3: FOLLOW



CATEGORY 4: SEARCH



Follow is a category of methods, where the main objective is to follow an object using smooth pursuit movements. This category is closely linked to skill 1, which is defined as "The ability to follow a moving object". These methods are used to practice oculomotor control and are often used as a warm-up exercise, to prepare the patient for vision therapy.

Methods in this category can be used to make the patient familiar with looking into the affected visual field, and can also be used to treat problems such as double vision, eye flickering, unnatural saccades, and eyes sliding out. By practicing smooth pursuit eye movements, these problems can be reduced. Most methods in this category make use of the full visual field, where some emphasize the affected side.

Search covers vision therapy methods used for training visual search. These methods are used to train both short and long saccadic movements, in order to teach the patients efficient ways to find and sort out relevant information. The goal is to improve the patient's ability to get an overview and systematically scan scenes, improving both Skill 2 and 3.

These methods often use computer generated scenes, where a given number of relevant information and distractors are placed randomly. The goal of these exercises is for the patient to improve their ability to find relevant information.

4.6 SEARCH STRATEGIES

One of the TVIs at HSMS based many of the methods on search strategies, which can be considered to be the fifth category of methods. This section will briefly explain search strategies.

Search strategies are strategies used to search and scan with the eyes efficiently. The principle behind this category of methods is that if you train your eyes to move structured in specific patterns you will successfully compensate for your HVFD.

Search strategies can be used to get an overview of a new environment, to find things that are missing or to learn how to read with a HVFD. An example is when you are in an unfamiliar or difficult environment, for instance at an airport, you use search strategies in order to get an overview of the surroundings.

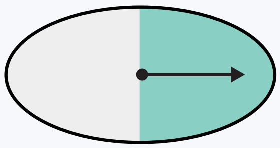
At HSMS three different search strategies were taught to patients. The goal of practicing search strategies is that the eyes automate these movements, and help compensate for the HVFD.

While this could be used as a fifth category in this project, search strategies will not be pursued, as the TVIs had different opinions on their relevance in vision therapy.

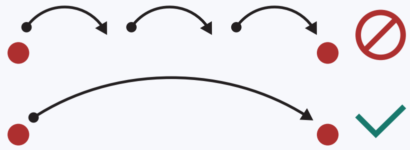
4.7 VISION THERAPY SUMMARY

The assesment of vision therapy found **four fundamental principles:**

Explore the affected visual field



Precise saccades and fewer fixations



Avoid using head movements

Awareness of the visual deficit

The eyes can perform **four basic eye movements:**

Saccadic movements

Changing fixation point from one place to another

Smooth pursuit movements

Tracking a moving object

Vestibulo-ocular movements

Fixateing on a still object while moving your head

Vergence movements

Aligning the eyes when fixating on objects at different distances.

HVFDs often lead to problems with these **three visual skills:**

Visual skill 1

The ability to follow a moving object

Visual skill 2

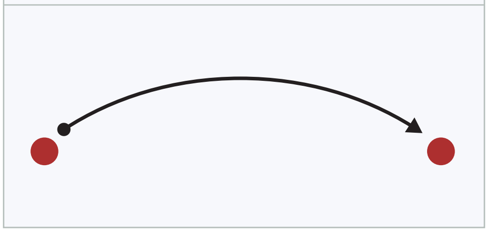
The ability to aim the eyes on a series of stationary objects

Visual skill 3

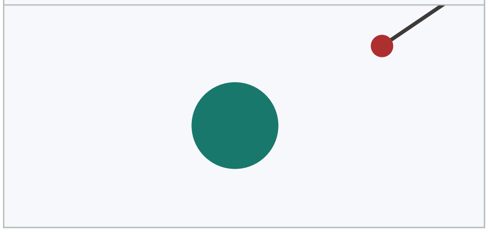
The ability to see over a large area

Methods used in vision therapy can be separated into **four main categories:**

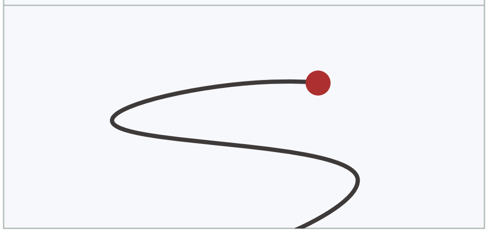
Saccade



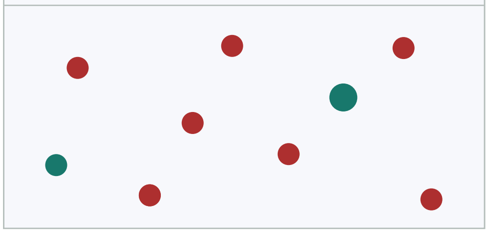
Detect



Follow



Search



VISION THERAPY IN PRACTISE

Chapter 5 | Presenting findings from vision therapy observations

CHAPTER OVERVIEW

The fundamentals of vision therapy have now been covered. This chapter aims to provide insight into how vision therapy is carried out in practice, and it is experienced by patients.

Content

This chapter goes through insights into vision therapy, which has been acquired from observation, interviews, a focus group and experiencing it first hand. This chapter covers the main findings from this insight.

Result

The results from this chapter are various aspects about vision therapy in practice, these are summarized at the end of the chapter.

5.1 INSIGHT INTO VISION THERAPY

This section aims to elaborate on how insight into vision therapy was obtained.

Observations
During the stay at HSMS, see Appendix E, around 15 hours were spent observing vision therapy. The goal of the observations was to understand how vision therapy worked in practice and resulted in an overview of how vision therapy is performed.

Experiencing vision therapy
In order to get first-hand knowledge of how it is experienced to attend a vision therapy session, some of the methods were tested along with the TVIs. Both computer-based and manual exercises were tested. The resulted in an insight into how vision therapy is experienced from a patient's point of view.

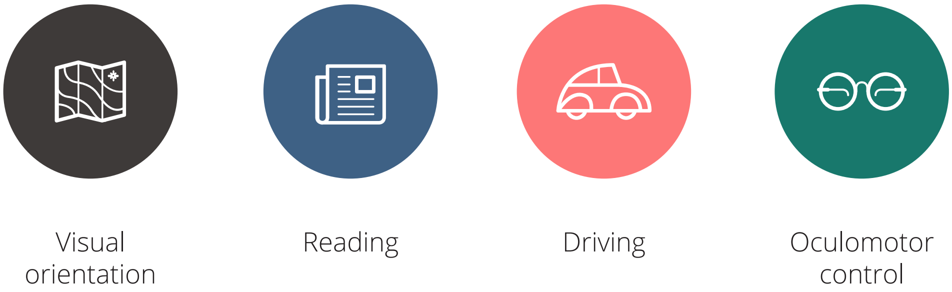
Focus group
At HSMS a 1-hour focus group was held with 6 patients, see Appendix C.12. The goal of this exercise was to get an overview of the patient's preferences, and an understanding of what is important to them concerning vision therapy. Several topics were discussed, with a focus on what they prefer and did not prefer. The topics discussed were: existing methods, vision therapy, the merge, and training at home. The focus group resulted in an overview of the patient's preferences.

Interviews
A total of 5 interviews was conducted with TVIs, in addition to small unstructured interviews before and after every observed vision therapy sessions. The goal of these interviews was to find what important in vision therapy and what is important to the patients.

The course attendants were also interviewed during the course. Most of the interviews were unstructured conversations with topics related to vision therapy. The resulted in an understanding of their preferences in vision therapy sessions, and a better insight into how a session is experienced.

5.2 FOCUS AREAS

Observed **focus areas:**



Sessions often have one focus area
During the observations of vision therapy, one of the findings was that the sessions often had one focus area. The ones that were seen were reading, driving, oculomotor control and visual orientation. These were based on both the patient's personal preferences and the TVI's opinion on which areas had a potential for improvement.

One of the patients had a desire to get better at reading, in order to read the papers and use computers more efficiently. During the training sessions for this patient, the TVI used reading exercises extensively to help with this goal. Some of the other patients had a desire to get their drivers license back, and trained using methods which could be linked to skills related to driving.

5.3 ADAPTED TO THE PATIENT

Figure 5.1 | Patient playing UFO at HSMS

From the observations at HSMS, see Appendix E, it was evident that vision therapy is adapted to fit each individual user. This confirms our findings from previous interviews, see Appendix C.8 and C.9. This section elaborates on why and how vision therapy is adapted to each patient.

Level of skill

The patients level of skill are very different. Some of the patients had attended the vision therapy course previously and has mastered different methods to various extents. This means that the TVIs often adjusts the difficulty of the training methods to fit each patient's skill level.

Different impairments

Patients suffer from different impairments, as a result of their stroke, which means that every patient finds different tasks difficult. An example of this was seen during the exercise UFO, see Figure 5.1, where some users struggled to use the computer mouse because of paralysis affecting one of their arms.

Different visual impairments
Other visual impairments also affect vision therapy. An example is patients who suffer from poor oculomotor control, who has greater difficulties reading and experience more fatigue than those who do not. During therapy, the TVIs adjusted the therapy to compensate for the patient's other visual impairments.

Fatigue and strain
The patients experienced different levels of fatigue and strain during vision therapy. Some became tired rapidly, while others were able to continue training for an extended amount of time. The TVIs had to accommodate for this, by letting the patients who were fatigued take adequate breaks. This had a great impact on the training session, as the patients with greater endurance were able to carry out more training than those who got tired more rapidly.

Personal preferences
The TVIs took the patients personal preferences into account when planning a training session. Examples of a personal preference which was observed were the fondness of computers for training. Some patients were eager to use computer programs, whereas other did not like computers in general. The TVIs took this into consideration and often avoided extended use of computers if this was requested by the patients. It was also evident that the pace of the sessions varied between patients. Some patients were more eager than others, and completed exercises at a rapid pace, while others were more slow and hesitant. However, not all of the patients were equally enthusiastic, which required the TVI to keep a slower pace throughout the session.

5.4 DIFFERENCES BETWEEN THE TVIs

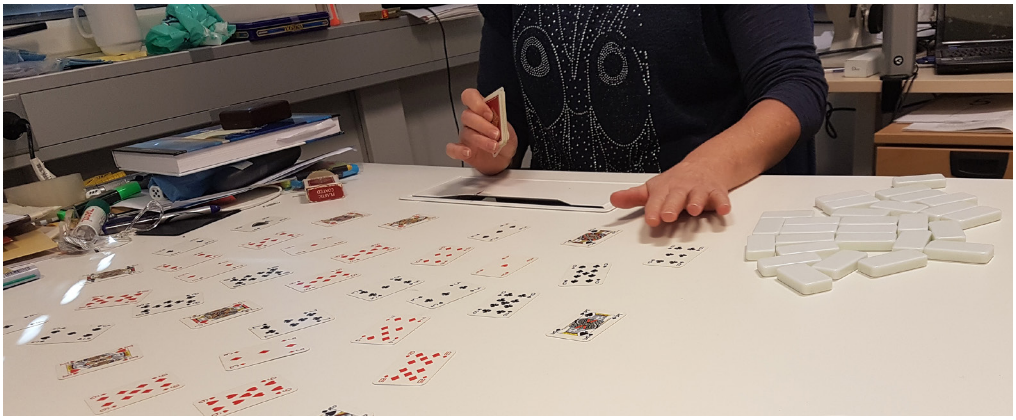


Figure 5.2 | TVI conducting card exercise at HSMS

One interesting finding from the observations at HSMS was the difference between how the TVIs carried out their training sessions.

Different choice of methods

The TVIs at Hurdal had their own set of preferred methods, and therefore the sessions were very different based on which TVI were responsible. In vision therapy today there is a lack of standardization, and there exists a vast number of methods to choose from. In addition, TVIs often experiment with making and testing their own methods. The difference in methods was emphasized by the different equipment the TVIs used during sessions. One of them mainly relied upon equipment specifically designed for vision therapy, whereas the other mainly used everyday items such as dominos or cards. The different emphasis on computer training also had an impact on why the sessions were so different.

Different emphasis on digital training

The amount of training that was done with a computer varied between the TVIs. One of the TVIs, used computer programs for most of the training, whereas the other used a more analog approach, see Figure 5.2. In what way this had an effect on the training, is hard to evaluate. However, this difference resulted in two different ways of assessing a patient's skill. Since the computer programs provided results, in terms of numbers and scores, the TVI had the opportunity to use these as a basis of assessment. The other TVI had to evaluate the patient based on a personal assessment.

Different amount of talking

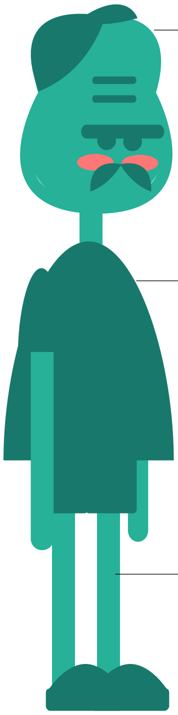
The two TVIs spent various amounts of time talking to every patient. This was partially the patient's choice, but also because the emphasis on conversation seemed to be different between the TVIs. The conversations were related to the patient's impairments and on the vision therapy session. During some of the sessions, the majority of the time was spent talking, while other times almost no time was devoted to conversations.

5.5 VISION THERAPY IS INTENSIVE

One distinct observation which was seen over and over again was that vision therapy is intensive and tiresome. Almost without exception, the patients were fatigued when the sessions were over. This was also noticeable during training, both from the patient's body language and their comments.

During training sessions, several incidents happened as a result of fatigue. However, the TVIs said that the patients generally improve in terms of endurance during the two weeks of the course.

During training sessions several incidents happened as a result of **fatigue**:



Loosing focus

Patients lost focus and therefore performed worse as the training progressed.

Taking breaks

Patients sometimes had to take frequent breaks, either by closing their eyes for a short period or by changing the vision therapy exercise.

Ending the session

One patient wanted to discontinue the session altogether.

5.6 DIVERSE TRAINING

A session of vision therapy usually consists of many different and varied methods. The TVIs made use of various methods, to fit the needs of each patient. While every session had similarities, differences were apparent.

Starting with warm-up exercises
A common feature that was observed between sessions was that the training usually started with a warm-up exercise. While the techniques were different, the goal was to ready the patients for training. This was seen in all sessions that were observed.

Changing exercises
During training sessions, the frequency of methods varied considerably. The TVIs changed methods in order to maintain the focus and interest of the patients, as the patients sometimes got bored and tired. When this happened, the TVI made adjustments to the training, to both give the patient a break and a chance to regain their focus.

Motivated patients
Some of the patients were accustomed to vision therapy and had a significant endurance compared to other patients. These were often eager to conduct the training and could remain focused for a longer period. For these patients, the therapy was more uniform, and fewer methods were used.

5.7 LIMITED FOCUS ON THERAPY AT HOME

Figure 5.3 | Image of Cogpack, a program used for home training of vision therapy

During the observations, there has been little emphasis on therapy at home. Most of the focus during sessions have been on making the most out of therapy while at the TVI's office. One of the TVIs mentioned that vision therapy could be difficult to do without help, as most of the training is based on continuous feedback and instructions. However, several of the patients were familiar with systems that could be used at home and used these to various extents. This section goes through the patients take on pros and cons with therapy at home.

Easy to cheat

Patients often said that they often felt like they cheated during training at home. Without instructions, it was easy to find techniques which made the exercises easier.

During exercises patients often move their head involuntary. The TVIs often have to hold the patients head still during exercises. At home, it is difficult for the patient to control this. It is possible to buy a device that holds the head still during exercises, see Figure 5.3. None of the patients at HSMS had this device at home.

Home training is not rewarding
Most of the patients said that vision therapy is boring to carry out at home. Without instructions, training becomes both more boring and tiresome. The patients said that when an instructor was not present, no one is there to tell them how they perform, which makes training both monotonous and less motivating.

Quantity of training
The patients said that the opportunity to train at home made it possible to achieve a greater amount of training. Most of the patients said that they had an understanding of the importance of their training and that they had experienced improvements from therapy. They were, therefore, appreciative of the opportunity for home training.

Accessible
The biggest advantage of training at home was said to be the accessibility. Some of the patients stated that they lived far from the closest TVI and that one therapy session could take up a whole day. Training at home requires a lot less effort. This way only a few minutes are needed to commence with training.

Methods used for training at home
Cogpack, see Appendix F.7, was by many patients mentioned as a good alternative for therapy at home. Most of the patients had acquired this program, which had been recommended by their TVI. Most did also practice on reading and writing, from e.g. regular newspapers or on their computer.

5.8 MOTIVATIONAL FACTORS

There are several factors that motivates patients to do vision therapy. This section presents some of the motivational factors that were mentioned by patients and which were observed during therapy.

Believing that it works

One of the most motivating elements of vision therapy was the belief that the therapy improves the patient's vision. This was evident throughout the stay at Hurdal, where some patients were sure that their vision was improving, while others were skeptical.

> *Vision therapy is boring, but I know it's good for me!*
>
> Quote by patient during focus group

An evident turning point during our stay was a presentation made by one of the TVIs, see Appendix C.10, which was related to the effect of vision therapy. Some of the patients became visibly more engaged during training, as their belief in the treatment was strengthened. Many patients said that their hope of getting an improved vision was their sole reason for going through with the therapy, even though they thought it was both boring and tiresome.

Making progress

Progress was a very motivating factor for the patients. This could both be progress which they noticed in their everyday lives or an assessment of progress provided by the TVIs.

During some of the patient's first vision therapy session, they enthusiastically told the TVIs about the progress they had made since their last stay at the center. The patients who had made visible progress were considerably more eager to get going than those who had not.

Some of the patients had not noticed any progress. However, the TVIs were able to see progress, based on some of the patient's previous perimetry tests. While this was not as motivating as self-noted progress, it was still a strong motivational factor.

Sense of achievement

Methods which provided a sense of achievement were more engaging to the patients. These methods were goal oriented and presented the users with challenges that were attainable. For these methods, the patients were more task oriented and not as easy distracted, while they had more fun in general.

Aimed at my problems

One of the factors which often made vision therapy motivating, was when the patients felt like the therapy was aimed at their problems. These problems were often chosen as the focus area of the therapy session, as seen in Section 5.2. This factor was especially evident when the TVIs provided examples from real life, where the patients could make use of the skills they learned from therapy.

Computer games are motivating

Some patient preferred computer games over analog methods. They felt that these methods were more predictable, and made it easier for them to keep track of how they performed. Games that made progress measurable, and provided clear goals, was experienced as fun and motivating.

5.9 VISION THERAPY IN PRACTISE SUMMARY

Vision therapy sessions have many similarities and differences, here are a summary of **findings from vision therapy.**

Adapted to the patient

The TVIs adapt vision therapy to fit every individual patient, based on their level of skill, endurance, physical and cognitive impairments, and other visual impairments. The patient's personal preferences are also emphasized during training.

Diverse Training

Vision therapy sessions are never alike. While all start with a warm-up method and have similar features, they have a different structure and contain different methods.

Difference between the TVIs

TVIs structure their sessions differently. Some utilize a lot of computer training, and others emphasize discussions with patients.

Focus areas

Vision therapy sessions are affected by the TVI and the patient's focus area. Observed focus areas were; visual orientation, reading, driving and oculomotor control.

Vision therapy is intensive

Vision therapy is very intensive. Most patients get tired during training which can lead to loss of focus, frequent breaks and even ending the session altogether.

Limited Focus on therapy at home	Motivational factors
During therapy sessions, there is often limited focus on training at home. Patients mentioned several pros and cons of home training. The cons were; it is easy to cheat, it is not rewarding, and it is difficult without assistance. The pros were; It is easily accessible, and it allows for higher quantities of training.	Patients mentioned various motivational factors for vision therapy. Some of these were; believing that it works, providing a sense of achievement and making progress. Some patients also preferred therapy methods that were aimed at their problems and computer training.

METHOD CREATION

Chapter 6 | Presenting ideas and concepts

CHAPTER OVERVIEW

At this stage in the process, the target group, HVFDs, and vision therapy have been covered. The aim of this chapter is to use this insight to generate feasible methods for vision therapy, that can be used in a VR application.

Content
The chapter begins with presenting the different stakeholders, and how they were involved in the idea generation. Then, the ideas that were selected from this involvement are presented. Lastly, the four methods that were created from these ideas are presented.

Result
The result from this chapter is four methods, which is meant to be used as a framework for creating a vision therapy application. These are presented at the end of the chapter.

6.1 INVOLVING PATIENTS AND STAKEHOLDERS

This section elaborates on how target users and project stakeholders were involved in the idea generation phase.

The goal of including the target users in this phase was to ensure that the patient's interests and requests were taken into consideration when the concepts were created. The target users were involved when the initial ideas were created and when evaluating ideas from the ØH workshop.

Figure 6.1 | Method creation workshop at ØH

Idea generation workshop

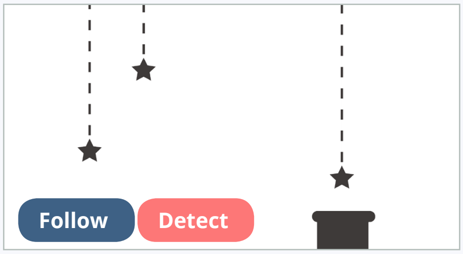
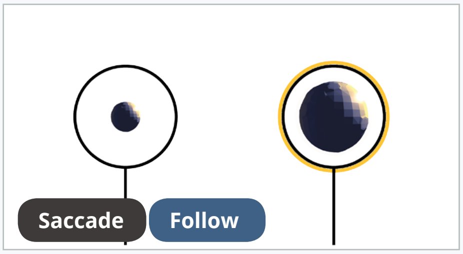
To generate ideas of methods for vision therapy, a workshop with the project stakeholders was conducted, see Figure 6.1 and Appendix C.13. The attendants at this workshop were from several different fields, namely: neurology, psychology, and game design. This resulted in a diverse range of ideas, where those with most votes are presented in the following sections.

Co - Creation
Two small unstructured idea generation workshops were held with two different patients. The goal of the workshops was to get new inputs for the idea generation phase. The workshops both started with talking loosely about existing methods in vision therapy and fun mobile games. Then a discussion on how vision therapy could become fun and entertaining was held, with a humorous tone. This was meant to foster creative ideas for everybody to build upon. The workshops provided new ideas for vision therapy methods, but more importantly, it gave a good indication of what patients considered fun, and what was important for the patients regarding vision therapy.

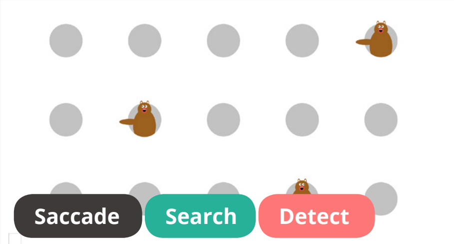
Guerilla Testing
In order to rapidly test new ideas and concepts, quick and simple prototypes of the ideas were created in Experience Design CC. These were then tested on patients, to reveal whether the ideas had potential or not. This allowed for the bad ideas to be dismissed, and for improvements to be discovered. Some of these prototypes can be found in Appendix D.3.

6.2 IDEAS

From the idea generation workshops that were conducted, nine ideas were selected. These were chosen based on how well received they were among the patients and how suitable they were for vision therapy. They were also selected to cover all principles, categories, and skills collectively, presented in Chapter 4. This section presents all nine ideas, along with which category they belong to and which eye movements and skill that are used.

Idea 1: STAR FALL	Idea 2: PLANET CATCHER
	
Description *Star fall* is a method that is currently used in Vision therapy, see Appendix F.10. The user is supposed to catch as many of the falling objects as possible. The objects are appearing and falling randomly from the top of the scene.	**Description** For this idea, the user is supposed to keep track of two or more catchers. Planets are appearing from around the scene, and the user is supposed to keep track of when these objects are within the reach of the catchers.
Task Don't let the stars fall to the ground	**Task** Keep track of approaching planets
Goal Catch all the falling stars	**Goal** Catch planets at the right moment
Eye movement Saccadic, Smooth pursuit	**Eye movement** Saccadic, Smooth pursuit
Visual skills Skill 1: The ability to follow a moving object	**Visual skills** Skill 1: The ability to follow a moving object
Skill 3: The ability to see over a large area	Skill 3: The ability to see over a large area

Idea 3: WACK-A-MOLE



Description
This idea is similar to the arcade game with the same name, *Wack-a-mole*. Holes are arranged in a grid layout, where the user is supposed to detect which direction the emerging moles are pointing, as fast as possible.

Task
Find which way most moles point

Goal
Choose direction as fast as possible

Eye movement
Saccadic

Visual skills
Skill 1: The ability to aim the eyes on a series of stationary objects

Skill 3: The ability to see over a large area

Idea 4: WORD GAME

Description
Two objects are placed at a set distance from each other. The task is to keep track of both, and tell whether the objects are in coherence. An example is to check whether two sub strings produce a word.

Task
Check if the objects are in coherence

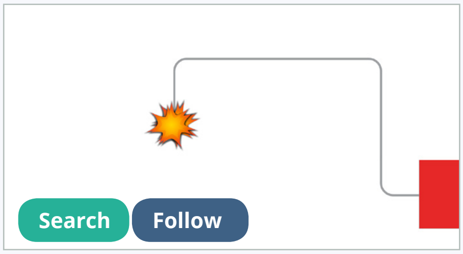
Goal
Make a decision as fast as possible

Eye movement
Saccadic

Visual skills
Skill 1: The ability to aim the eyes on a series of stationary objects

Skill 3: The ability to see over a large area

Idea 5: DYNAMITE



Description
The scene consists of a dynamite and a fuse. The fuse is then lit at the end. First, the dynamite has to be located. Then the goal is to follow the ignited fuse to the dynamite, and stop it as late as possible. New scenes are generated continuously.

Task
Locate the dynamite, track the fuse.

Goal
Stop the fuse as late as possible.

Eye movement
Smooth pursuit

Visual skills
Skill 1: The ability to follow a moving object

Skill 3: The ability to see over a large area

Idea 6: WHERE'S "WALLY?"

Description
This task is similar to the British game called *"Where's Wally?"*. The user is supposed to find one relevant object among others.

Task
Scan the scene

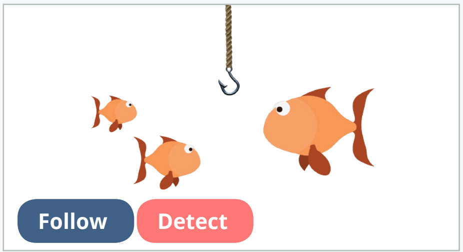
Goal
Find the relevant object

Eye movement
Saccadic movements

Visual skills
Skill 1: The ability to see and recognize in a short look

Skill 3: The ability to see over a large area

Idea 7: CATCH THE FISH



Description
Catch the fish requires the user to control a fishing rod in order to catch a fish. The user has the ability to raise and lower the hook, and is supposed to align the height of the hook with the fish that emerges.

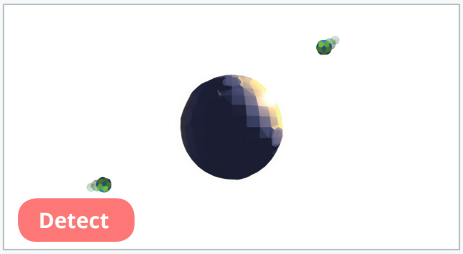
Task
Align the hook with the fish

Goal
Catch the fish

Eye movement
Saccadic, Smooth pursuit

Visual skills
Skill 1: The ability to see over a large area

Idea 8: UFO



Description
UFO is a vision therapy method that is currently used, see Appendix F.7. The user is supposed to detect emerging objects as quickly as possible.

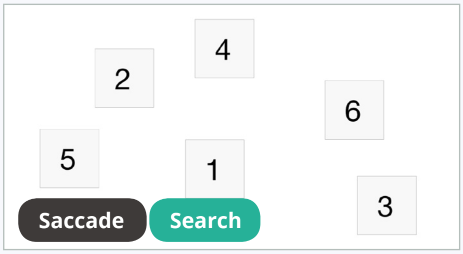
Task
Detect the UFO

Goal
Shoot the UFO as quickly as possible

Eye movement
Saccadic, Smooth pursuit

Visual skills
Skill 1: The ability to see over a large area

Idea 9: NUMBERS



Description
Numbers is based on a method that is currently used in vision therapy today, see Appendix F.5. The user is supposed to select elements in a correct order. An example is to select on every number from 1 to 10 in ascending order.

Task
Select elements in a correct order

Goal
Locate them as quickly as possible

Eye movement
Saccadic

Visual skills
Skill 1: The ability to aim the eyes on a series of stationary objects

Skill 3: The ability to see over a large area

6.3 FEEDBACK FROM TVIs

In order to evaluate the nine ideas suitability for vision therapy, they were all brought to be evaluated by two TVIs, see Appendix C.14 and C.15. Firstly, the basis for creating them was presented, see Chapter 4, to confirm that the starting point for the idea generations workshops was accurate. Then the selected ideas were presented one by one.

This section sums up the feedback on three of the ideas. These ideas stood out as being preferred by the TVIs, namely; *UFO, Word Game*, and *Wack-a-mole*.

UFO

The version of *UFO* as seen in Appendix F.7 is regularly used by both of the TVIs. It was, therefore, no surprise that this idea was favored. Some of the positive aspects of this method are that the visual stimuli appear from all directions and in different orientations. This means that the patient has to keep track of their full field of view to get good results. This is beneficial for training the patient's attention to both sides.

Word Game

The *Word game*, see Appendix D.3, was also positively appraised. One of the TVIs said that they would have used the method if it was available. One of the positive aspects of the method was that it could be very multifunctional, and be used for different types of training. By using it as presented, it could be used as a reading exercise, while if it was simplified it could be used for unmitigated saccade training. The distance between the objects could also be adjusted, allowing the patient to practice saccades of different lengths. Another positive aspect of this idea is that it could also be used for cognitive training. By making the objects more demanding to compare, it could also be used for training cognitive abilities.

Wack-a-mole

Wack-a-mole, see Appendix D.3, was also well received among the TVIs. It requires the user to both detect and make decisions based on relevant visual stimuli. This method could, therefore, be a great exercise for training the patient's attention and alternatively their cognitive abilities. One of the TVIs also said that he thought this method would be well received among patients, as it was entertaining.

6.4 METHODS FOR VISION THERAPY

This section elaborates on how four methods for vision therapy was created. The four methods are presented in the following sections.

Vision therapy methods
The methods that were created are meant to provide a complete program for vision therapy and touch on all aspects relevant for patients with HVFDs. The methods were evaluated with two TVIs, see Appendix C.14 and C.15, which believed that they would provide a sufficient foundation for this assignment.

Origin
The main source for creating the methods was feedback from the TVIs when showing them the ideas from the idea generation workshop. However, the requests from patients were also emphasized.

Presenting the methods
The following sections present the four methods. Each method is presented with an explanation of the set-up, execution and its scalability. All methods have the fundamental principles of vision therapy as their basis, represent one of the four categories seen in Section 4.4. Which eye movements and visual skills that are used in each method are also presented.

All methods have been made as abstract as possible. The themes seen in the ideas has been removed, and all methods have been given the same aesthetics.

6.5 METHOD | WARM UP

Warm Up is an exercise meant to prepare patients for vision therapy. This section goes through the origin of the exercise and explains how it is performed.

Background

Warm Up is based on a combination of methods used by the TVIs at the beginning of sessions. These methods were very different, but all had the same purpose, to prepare the patient for the session. One of the most used methods were the *Ball method*, see Appendix F.13, which is very similar to the method that was created.

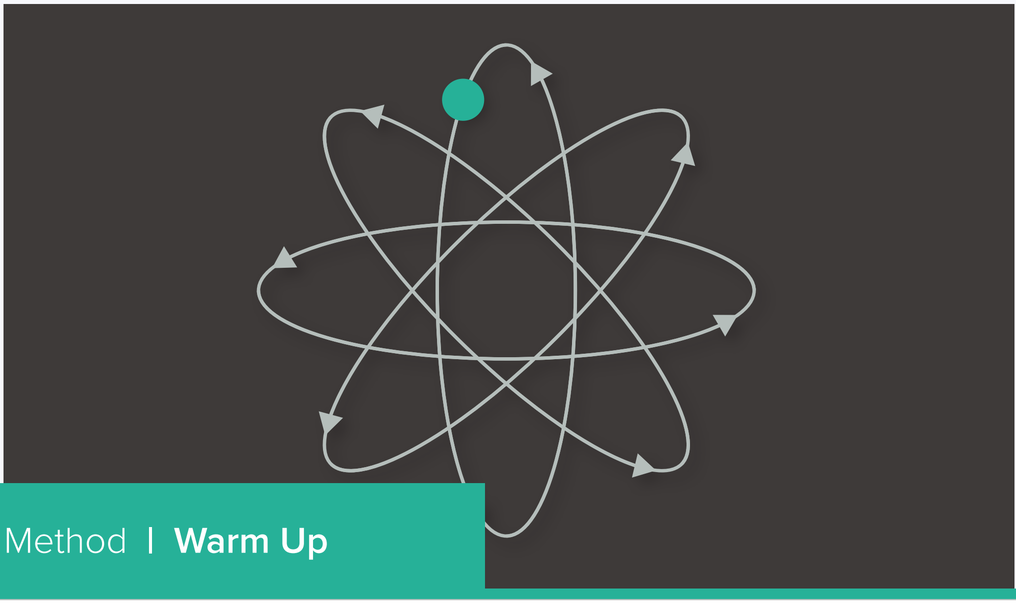
Warm Up is closely linked to the category *Follow*, where the objective is to keep track of an object, using smooth pursuit movements. This enables the user to train Skill 1, the ability to follow a moving object.

Set-up and execution

For this method, it is important that the patient keep their head steady. This ensures that only the extraocular muscles are used. An object is then placed inside the patient's field of view, where the patient's task is to keep track of this object. The object is moved around in front of the patient, in a smooth motion. The position of the object should vary from the center of the patient's field of view, out towards the edge. The idea is to make the patient look in all directions.

Scalability

This method is scaleable in several different ways. Firstly, the speed of the moving object can be increased. This would make smooth pursuit movements more difficult. Secondly, the object could be moved even further out towards the edges of the patient's visual field, making it more difficult to track. Lastly, the object could be made less visible, or distractors could be added to the scene. This would make the task more demanding, as this makes it easier to lose track of the object.



Method | **Warm Up**

Description
An object moves in a smooth motion in front of the user.

Categories
Follow

Task
Follow the object along its path. The object's movement covers large parts of the visual field.

Goal
Improve oculomotor control, and control of the extraocular muscles.

Eye movement
Smooth pursuit movements

Visual skills
Skill 1: The ability to follow a moving object
Skill 3: The ability to see over a large area

6.6 METHOD | SCOUT

Scout is an exercise where the aim is to be on the lookout for new visual stimuli. This section goes through the origin of the exercise and explains how it is performed.

Background

Scout is a method that is based on the *UFO* method, see Appendix F.7, which is already used in vision therapy. This method has from the beginning of this project stood out as a great method for vision therapy, based on comments from both the TVIs and patients.

Scout is derived from the category *Detect*, where the goal is to detect visual stimuli as quickly as possible. In order to accomplish this goal, the patient has to explore the affected visual field, in order to keep track of the entire scene. This requires the user to practise visual Skill 3, which is the ability to see over a large area.

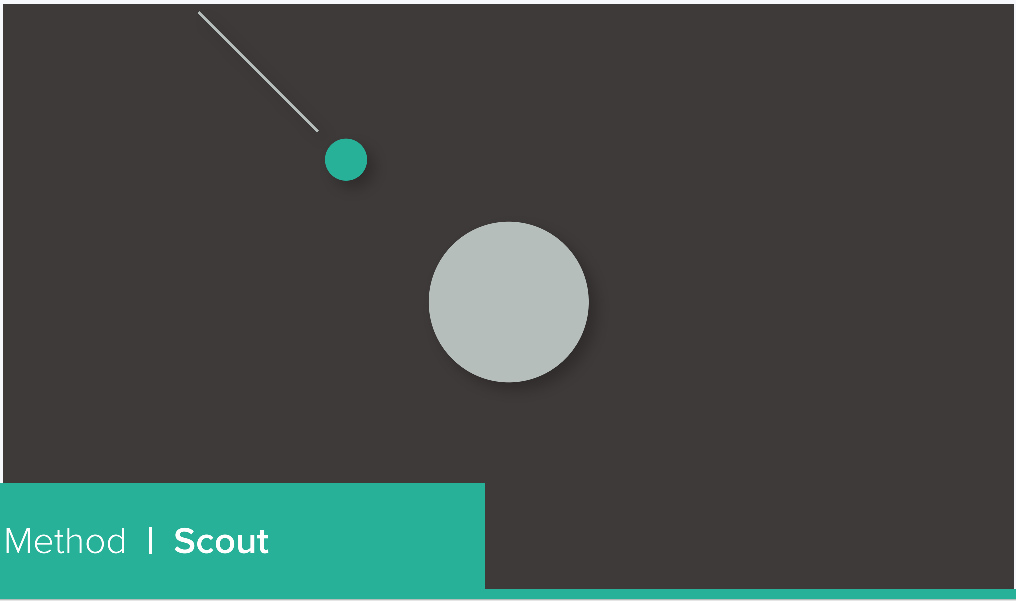
This method is also meant to train saccadic movements, as long and efficient saccades are required to effectively keep an overview of the scene. This means that the method is also associated to the category *Saccade*.

Set-up and execution

For this method, an object is placed directly in front of the patient, in the center of their visual field. Projectiles arrive from outside the patient's visual field, moving towards this object. The patient's task, is to detect and destroy these projectiles, before they collide with the centered object.

Scalability

This method is scalable several different ways. Firstly, the size of the centered object can be increased. This way the patient has to detect the projectiles earlier, and is thereby forced to explore bigger parts of the visual field. Secondly, the speed of the projectiles can be increased, giving the patient less time to detect and destroy them. Lastly, the frequency of new projectiles can be increased, making the pace of the exercise more hectic.



Method | **Scout**

Description
Incoming projectiles are sent towards an object which is placed directly in front of the patient.

Categories
Detect

Task
Detect incoming objects as quickly as possible.

Goal
Increase the detection of visual stimuli and improve the patient's awareness of the affeced parts of the visual field.

Eye movement
Saccadic movements
Smooth pursuit movements

Visual skills
Skill 3: The ability to see over a large area

6.7 METHOD I MONITOR

Monitor is an exercise which is based on monitoring two objects, and making decisions based on their current state. This section goes through the origin of the exercise and explains how it is performed.

Background

Monitor is based on the idea called *Word game*, from Appenix D.3. This idea was well received by the TVIs, as patients are forced to adopt efficient saccades. At the same time, it was also said that it was both multifunctional and scalable.

The method is also similar to the two methods described in Appendix F.16 and F.17, in terms of execution. These methods are used for saccade training, with a focus on improving reading skills.

The goal of the method is to practise more precise saccades. The exercise is therefore directly linked to saccadic movements and the category called *Saccade*. The skill that is practised in this exercises is mainly Skill 2, which is the ability to aim the eyes on a series of stationary objects.

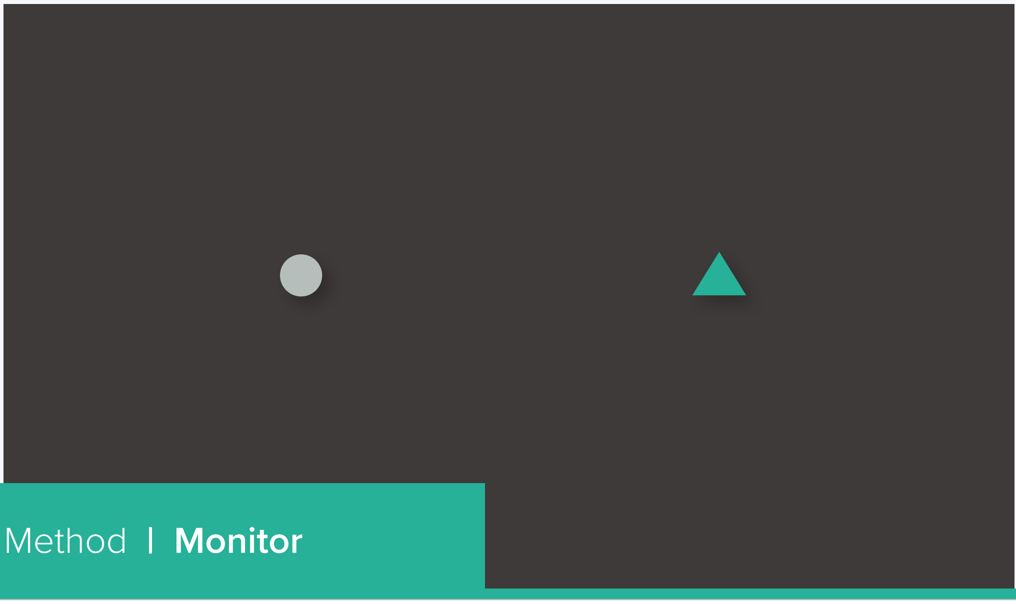
Set-up and execution

For this method, two objects are placed at a fixed distance apart from each other. The objects consist of different properties, and the patient's task is to assess and make decisions based on these object's properties. The idea is that the two objects do or do not correlate, and that the patient has to find out whether they do, as quickly as possible. When the user has made a choice, the two objects are replaced with two new objects.

The method at this point use primitive objects, where the patient is supposed to tell whether the two shapes are the same. However, many different types of objects can be used for this method. As for the idea *Word game*, two substrings were used. The patient had to assess whether the combination of the two substrings resulted in a word.

Scalability

The method is also scalable. Firstly, the distance between the two objects can be adjusted to train saccades of different lengths. Secondly, the exercise could also automatically progress, giving the patient a limited amount of time to make a choice before the objects change.



Method | **Monitor**

Description
Two objects are placed in front of the patient while changing properties periodically.

Categories
Saccade

Task
Monitor two fixed objects. Check for changes in the objects properties.

Goal
Improve saccades of different lengths. Improve the patients awareness of the affected part of the visual field.

Eye movement
Saccadic movements

Visual skills
Skill 2: The ability to aim the eyes on a series of stationary objects
Skill 3: The ability to see over a large area

6.8 METHOD | SEARCH

Search is an exercise which is based on searching for patterns in a grid. This section goes through the origin of the exercise and explains how it is performed.

Background

Search is based on the two studies on vision therapy methods for HVFD patients[16,22], see Appendix F.2, which has proven to be effective for treating HVFDs. These methods are based on a fixed grid layout, where the patient is supposed to search for relevant information. The method is also based on the idea called *Wack-a-Mole*, from the idea generation workshop. The TVIs said the exercise could be effective for training both attention and cognitive abilities.

Both Skill 2 and 3 are relevant for this exercise, as saccadic movements are used between the fixed objects and the goal of the exercise is to get an overview of the scene. The method could therefore also fit under both the Detect, Saccade and Search category, as it consists of several steps.

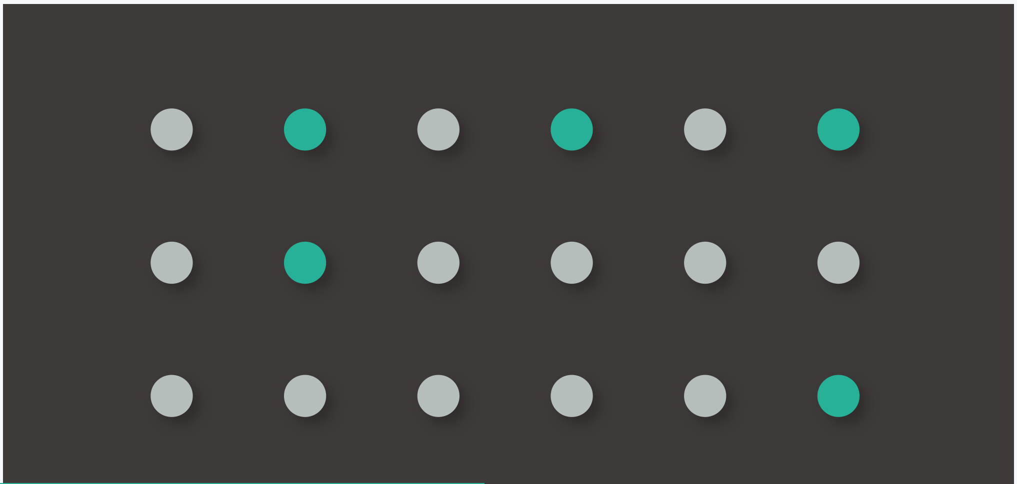
Set-up and execution

The method is set up by creating a grid of objects in an m-by-n matrix. This matrix is spread evenly in front of the patient, covering a set portion of their visual field. Then some of the object changes and the patient's task is to detect whether the grid contains a specific pattern of objects or not. This could for example be a sequence of three similar objects in a row. When the patient has made an answer, a new grid of objects are appear.

This method is the most extensive of the once created for this project. It requires the patient to both get an overview of the scene, and to make decision based on the objects presented.

Scalability

The method is scalable in the same way as *Monitor*, as the distance between the objects can be increased and the exercise could automatically progress. However, this method could also vary the number of rows and columns in the grid. The pattern the patient is supposed to detect, could also vary.



Method | **Search**

Description
A matrix of objects is placed in front of the patient, periodically containing patterns

Categories

Search

Task
Monitor a grid of objects, and look for specific patterns.

Goal
Improve search strategy and the patients awareness of the affected part of the visual field.

Eye movement
Saccadic movements

Visual skills
Skill 2: The ability to aim the eyes on a series of stationary objects
Skill 3: The ability to see over a large area

6.9 METHOD CREATION SUMMARY

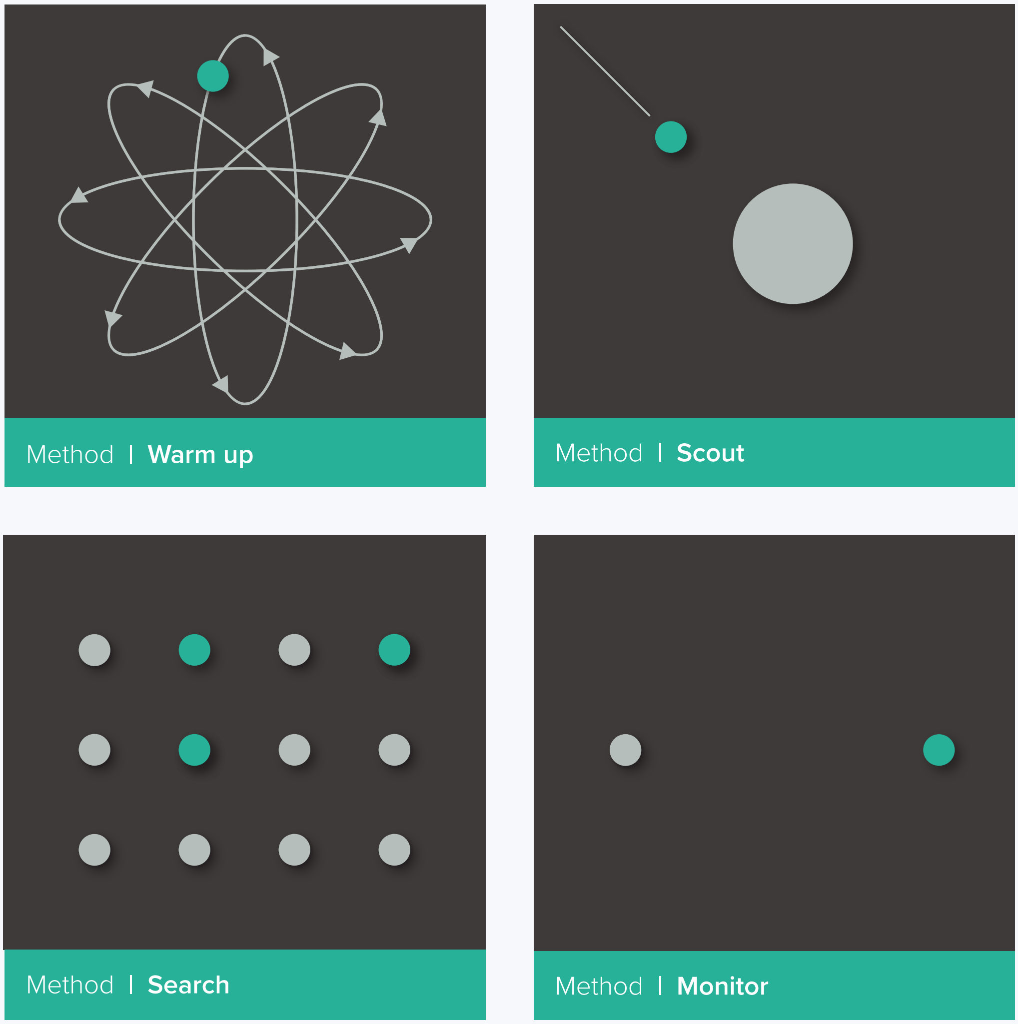


Figure 6.2 | The four methods for vision theray created in this chapter

A total of four methods has been created, see Figure 6.2, as a foundation for the future of this project. The aim of these methods is to be adequate for vision therapy program and to help the intended user to compensate for their HVFDs.

Framework
The four methods are the result of the assessment of vision therapy in this project. These are meant to be used as a framework, to further develop a concept for vision therapy. They are described in detail, to be easy to recreate and to be accessible for the later stages of the innovation project.

Training program
The methods cover all principles, relevant eye movements and skills mentioned in Chapter 3. They are intended to be easy to execute and are meant to help the intended user to compensate for their HVFDs.

VIRTUAL REALITY EQUIPMENT

Chapter 7 | Presenting the selection of a suitable VR-Equipment for this project

CHAPTER OVERVIEW

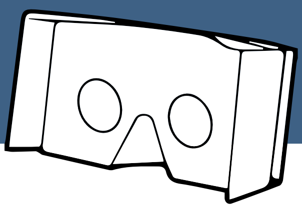
At this stage in the process, four methods for vision therapy has been created. To make use of these, suitable hardware has to be selected. This chapter assesses different types of VR headsets, to find appropriate equipment for use in this project.

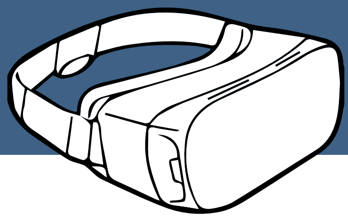
Content
This chapter starts with an introduction to the current consumer-grade VR headset market. Four headsets were selected and used in an analysis, to find which were most suitable for this project.

Result
The VR headset that was chosen was the Merge VR Goggles, which was found to be cheaper, more user-friendly and durable than the alternatives. This VR headset is presented at the end of the chapter.

7.1 CATEGORIES

This section categorizes consumer-grade VR headsets into three categories: low-end, mid-range and high-end.





> *These headsets provide limited interactivity, and are often best suited to view videos.*

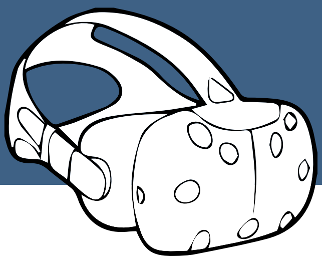
> *These headsets allows for simple interactivity, and are suited to play simple games, in addition to viewing videos*

Low-end

Numerous low-end VR headsets for smartphones are available on the consumer market. These solutions use the phone's display, sensors, and computing power, and are primarily made as mounts for holding the phone in place. Input methods are usually reliant on mechanical switches or magnets, which usually come in the form of one or two buttons. A notable example is Google Cardboard, which is a simple VR headset made from cardboard. However, numerous durable and well-built alternatives also exist.

Mid-range

Mid-range VR headsets are similar to low-end VR headsets, considering that they rely on smartphones. However, these do also offer additional sensors and functionality. An example is the Samsung Gear VR, which uses the phone's display and computing power, but offers more accurate tracking, in addition to a dedicated touchpad and input buttons.



”

These headsets provide great interactivity, and are suited to play complex games in addition to viewing videos

High-end

High-end VR headsets are often more complex. These have dedicated parts for tracking, computing, display, and input. The headsets have built-in displays and are tracked externally. This allows for moving in space, in contrast to stationary viewing. These setups also offer dedicated input controllers and rely on devices such as gaming consoles or computers for computing power. The main players in this market are currently Sony, Oculus, and HTC. While the products are relatively expensive, they are still aimed at the consumer market.

7.2 CHOOSING EQUIPMENT

In order to choose a proper VR headset for this project, devices from all categories were acquired. This allowed for a hands-on comparison, to get an overview of what exist in this market. This section goes through the devices and the reason for why they were chosen.

Merge and Cardboard

The low-end category offers a wide variety of different devices, from cheap ones made from cardboard to sturdy ones in aluminum. These also vary in terms of interactivity and is usually different in the number of buttons. The main requirements from the headsets in this category are to have at least one input button and to be cardboard-compatible. As this category contains such a wide range of products, it was decided to obtain two different VR headsets. The first one was Google Cardboard [23], which is one of the cheapest VR headsets available. The main reason for choosing this was its low price and overall popularity in the VR market. The second was the Merge VR headset [24], which is made from a sturdy foam material. This VR headset was chosen based on its solid build and based on a recommendation by Attensi.

Samsung Gear

Contrary to the low-end marked, the mid-range market offers little choice. The Samsung Gear VR [25], see Figure 7.1, was, in reality, our only choice, as few phone manufacturers offer custom VR headsets. This was chosen because a compilable phone was already available, and also because Attensi has a lot of experience with development for this platform.

HTC Vive

From the High-end market, the different products were assumed to be relatively equal in terms of what they offer to the consumer. This includes dedicated input controllers and the ability to move in space. The options were either Oculus Rift, HTC Vive or Sony PlayStation VR. However, as HTC Vive [26] already was acquired, this VR headset was chosen.

The four VR headsets which were chosen were; Google Cardboard (Cardboard), Merge VR Goggles (Merge), Samsung Gear VR (Gear VR) and HTC Vive (Vive).

Figure 7.1 | Martinus using Gear VR

7.3 COMPARISON OF VR-EQUIPMENT

Equipment Secifications

NAME	TYPE	PRICE	HIDDEN COST*	TOTAL COST	PLATFORM
Cardboard	Mobile	100	4000	4100	Most phones
Merge	Mobile	600	4000	4600	Most phones
Gear VR	Mobile	800	4000	4800	Most phones
HTC Vive	Theadered	9500	8000	17 500	PC

Table 7.1 | Equipment specifications

In order to choose a proper VR headset for this project, an analysis was conducted, see Table 7.1. This analysis compared the four devices which were chosen.

Set - up process

All the mobile VR headsets had a simple setup process. The Merge and Cardboard had no requirements, except having a VR application installed on the phone. Aside from this, the user just has to put the phone inside the dedicated slot on the headset.

The Gear VR had some additional steps for it to work. It required the phone to be installed with the correct software for the trackpad and input buttons to work. However, this installation process was straightforward and should be considered to be relatively simple.

Setting up the Vive was a rather complex process. Firstly, the necessary software and drivers had to be installed, along with firmware updates for the hardware. Then the two lighthouses, for tracking, had to be mounted with a minimum of 3 square meters of open space between them. It also required five power outlets for all the components. This setup should be considered to be stationary, in contrast to the other VR headsets.

TRACKING	INPUTS	FOV	REFRESH RATE	FOCAL ADJ	DISTANCE ADJ
Fixed position	1 Button	90	60	No	No
Fixed position	2 Buttons	96	60	No	Yes
Fixed position	2 Buttons & touchpad	96 (100)	60	No	Yes
4.5 x 4.5 meter	2 Controllers	110	90	Yes	Yes

Cost of equipment

The different VR headsets varied greatly in price, from the Cardboard costing about 100 NOK to the Vive which costs about 9 500 NOK. However, this does not mean that a VR program can run with a 100NOK Google Cardboard alone. As this headset requires a phone, hidden costs are an important factor to take into account.

The Samsung Galaxy S6 is the cheapest phone which is compatible with all the mobile VR headsets which were chosen for this project. This phone costs about 4000 NOK, which means that the actual cost of acquiring the Cardboard is about 4100 NOK.

The HTC Vive does also require additional equipment to run. This includes a VR compatible computer, keyboard, mouse, and monitor. A quick estimate for this equipment is 8000 NOK. This means that the actual cost for using the HTC Vive is about 17500.

The prices mentioned in this section are rough estimates. It is not taken into account that many people already own a VR-compatible smartphone, while fewer own a VR-compatible computer. For this project, the price will not be considered a determining factor. However, the cost of acquiring the HTC Vive will be considered a drawback.

Build, quality, comfort & maintenance
Build quality and comfort were evaluated based on our perception of the equipment through usage and testing.

Figure 7.2 | Cardboard

Figure 7.3 | Merge

The Cardboard, see Figure 7.2, had an overall poor quality. The equipment was not comfortable to wear, as the cardboard was pressed firmly against the face. The user's skin was directly exposed to the velcro straps, which in addition were difficult to adjust to get a good fit. Mounting the phone in the dedicated slot was straightforward, but the headset did not seem to hold the phone securely in place. After just a short time of use, there were visible marks and stains apparent on the headset. The Cardboard was also impossible to clean, as any water would spoil the cardboard material.

The Merge, see Figure 7.3, proved to be a well-built VR headset. The foam material was sturdy and relatively comfortable against the face, while the head straps were satisfying to wear and offered great adjustability. Mounting the phone was a very simple process, and only required the user to slide the phone into the dedicated slot. With bigger phones, the dedicated phone slot seems somewhat tight. Users also mentioned that the headset felt secure, in terms of being difficult to break and securing the phone in place. No apparent marks or stains were noticeable from use, and the headset is easy to clean and maintain.

Figure 7.4 | Gear VR

Figure 7.5 | HTC Vive

The Gear, see Figure 7.4, is a well-built headset. The plastic material seemed to be of good quality but felt like it could be somewhat easy to damage. Regarding comfort, this headset was experienced as very comfortable. Mounting the phone, on the other hand, was both tedious and problematic, but did secure the phone. No apparent stains or marks were noticeable from use. The headset did have a replaceable foam padding, and maintenance and cleaning of the headset were simple.

The Vive, see Figure 7.5, provided a feeling of quality. The headset was well-built, very comfortable, and felt secure. As this headset had a built-in display, mounting was not an issue. It had a replaceable foam padding but was not as easy to clean and maintain as the Merge and Gear VR. No marks or stains were apparent after use.

Input

The devices that were selected, all support different kinds of input options.

Cardboard provides a single magnetic slider on the side of the headset. This slider uses the phone's magnetic lock mechanism as a button. This means that the slider only works with phones that support this lock function.

Merge provides two built-in spring-loaded buttons on top of the headset. These work similar to levers, which are used to touch the phone's screen when clicked. These are therefore supported by all phones with touch-displays.

Gear VR has many inputs, located on the right side of the headset. These are; volume buttons, a back button and a trackpad which supports both taps and swipes. These inputs are connected to the phone through USB, and acts similarly to native phone inputs.

The Vive has two dedicated controllers. These are tracked similar to the headset and are also rendered in the display in real time. This means that the controllers are visible to the user when wearing the headset. The controllers have three buttons, a trigger, and a clickable trackpad. This allows for a great variety of interactions.

7.4 ELIMINATION OF HEADSETS

After the equipment analysis, it was apparent that some VR headsets were more fit for this project than others.

his section sums up why the Cardboard, Vive, and Gear were eliminated.

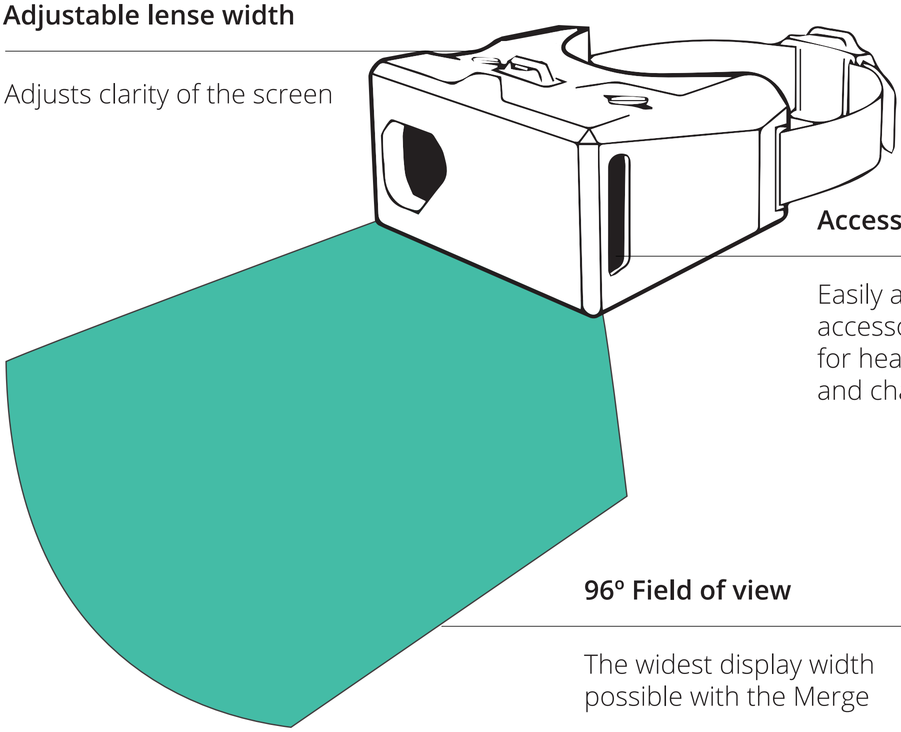
Eliminating Cardboard
The Cardboard was not considered for this project. While the headset is affordable and relatively simple to use, the limited input options and poor build-quality render it useless for the scope of this project.

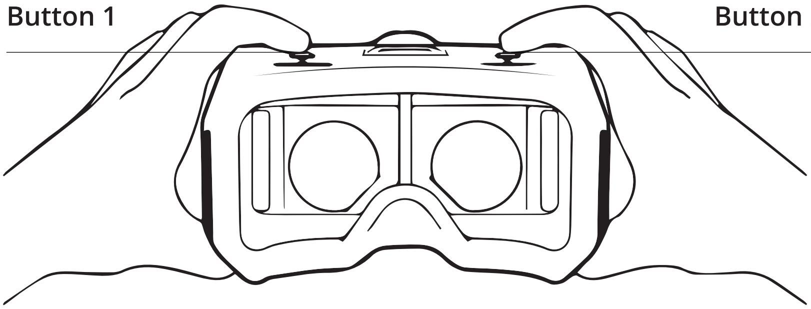
Eliminating Vive
The Vive was also discarded at this point. While this headset was considered to be best in terms of input option and quality, was some of the drawbacks too apparent to overlook. The setup process is very complex and requires both physical space and some level of technical knowledge for maintenance. The fact that the setup needs a relatively powerful computer in order to work was also considered a major drawback, as acquiring and maintaining such a computer is more difficult than utilizing a phone.

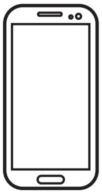
Eliminating Gear
The plan was at this point to have a more thorough comparison of the Gear VR and Merge. The Gear VR provided noticeably better tracking and more input options, to the same price as the Merge. However, the Merge quickly stood out as the superior headset for this project.

Firstly, mounting the phone to the headset was easy with the Merge and cumbersome with Gear VR. Secondly, the Merge input buttons were reliable and satisfactory, while unintuitive and complicated for the Gear VR. The last major advantage with the Merge was that almost every modern smartphone is compatible with the headset, while the Gear VR is compatible with just the Samsung flagships. For these reasons, the Gear VR was eliminated at this point of the project.

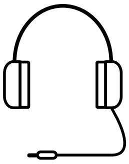
7.5 CLOSER EXAMINATION OF THE MERGE



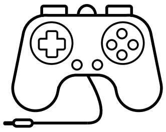




Mobile



Headphones



Controller

Accessories

Testing the Merge

The Merge was tested on several different people. Firstly input and instruction test was conducted, see Appendix D.1 and D.2, with both students and patients. Secondly, the Merge was tested during a focus group with patients, see Appendix C.12.

The headset was well received among all test subjects. Most thought it was a great experience to try it and expressed that the headset was comfortable and robust. However, there was also several negative aspects about the headset.

Positive Feedback:

- Seems solid
- Comfortable to wear, fits well
- The buttons are easy to push
- Intuitive buttons
- The image and text is sharp
- You can adjust the straps
- The color is refreshing

Negative Feedback:

- Heavy to wear
- Difficult to get the lenses right
- Difficult to read the text
- A little flashy
- Tiering to hold the buttons for a long time

STROKE CHALLENGES

Chapter 8 | Presenting stroke related impairments related to this project

CHAPTER OVERVIEW

At this stage in the process, both vision therapy methods and VR equipment are in place. However, there are several aspects about the target group that could have an impact on this project. There are several stroke-related challenges which could relevant for this project. This chapter aims to cover these challenges in relation to vision therapy and the use of VR equipment.

Content
This chapter starts by listing stroke-related challenges. Then the ones that are most relevant for this project is covered in further detail.

Result
This chapter finds that impairments in one hand, fatigue, and difficulties with instructions are difficulties are most relevant stroke-related challenges for this project. A summary of these challenges is presented at the end of the chapter.

8.1 STROKE AND RELATED FUNCTION LOSS

Stroke is a medical condition, caused by a disruption of blood supply to the brain. The lack of oxygen causes brain cells to die. Dying brain cells results in loss of brain function. Type, size, location and number of strokes determines how a person is affected [27], and which functionality is lost. The brain is divided into three main areas: Cerebrum, Cerebellum and the brain stem. Figure 8.1 shows which functionality will be affected, from damage to different parts of the brain.

Cerebrum

Depending on the area and side of the cerebrum affected by the stroke, any, or all, of the following body functions may be impaired.

- Movement and sensation
- Speech and language
- Eating and swallowing
- Vision
- Cognitive (thinking, reasoning, judgment, and memory) ability
- Perception and orientation to surroundings
- Self-care ability
- Bowel and bladder control
- Emotional control
- Sexual ability

In addition to these general effects, some impairements may occur when a particular area of the cerebrum is damaged.

Cerebrum | Right hemisphere

- Left-sided weakness (left hemiparesis) or paralysis (left hemiplegia) and sensory impairment
- Denial of paralysis or impairment and reduced insight into the problems created by the stroke (this is called “left neglect”)
- Visual problems, including an inability to see the left visual field of each eye (homonymous hemianopsia)
- Spatial problems with depth perception or directions, such as up or down and front or back
- Inability to localize or recognize body parts
- Inability to understand maps and find objects, such as clothing or toiletry items
- Memory problems
- Behavioral changes, such as lack of concern about situations, impulsivity, inappropriateness, and depression

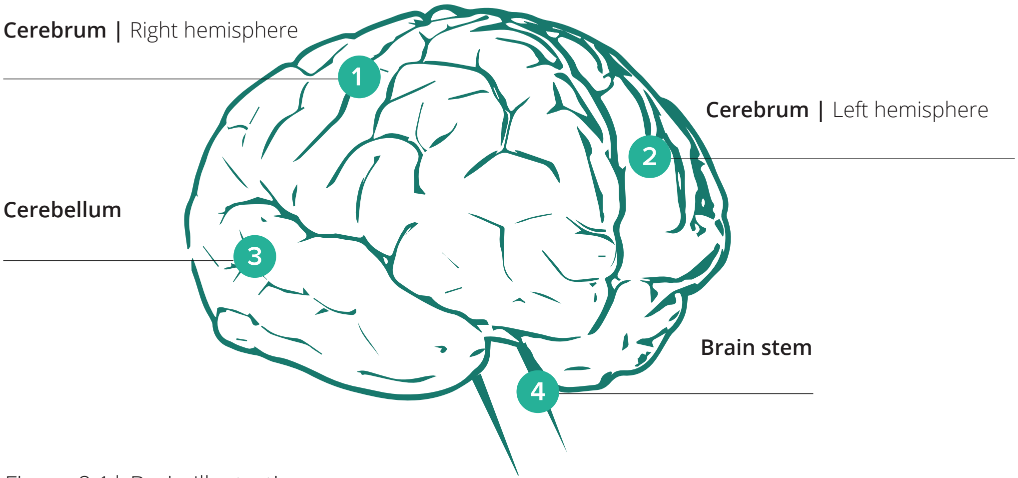


Figure 8.1 | Brain Illustration

Cerebrum | Left hemisphere

- Right-sided weakness (right hemiparesis) or paralysis (right hemiplegia) and sensory impairment
- Problems with speech and understanding language (aphasia)
- Visual problems, including the inability to see the right visual field of each eye (homonymous hemianopia)
- Impaired ability to do math or to organize, reason, and analyze items
- Behavioral changes, such as depression, cautiousness, and hesitancy
- Impaired ability to read, write, and learn new information
- Memory problems

Cerebellum

- Inability to walk and problems with coordination and balance (ataxia)
- Dizziness
- Headache
- Nausea and vomiting

Brain stem

- Breathing and heart functions
- Body temperature control
- Balance and coordination
- Weakness or paralysis
- Chewing, swallowing, and speaking
- Vision
- Coma

8.2 PHYSICAL IMPAIRMENTS

This section goes through the most relevant physical impairments related to the use of VR-equipment, namely; motor deficits and other visual deficits. The impairments that were empathized, where chosen based on the observations conducted at HSMS, see Appendix E for notes from the observations.

Motor deficits

48.0% of patients with HVFD suffer from motor deficits [1]. While not all of these deficits are relevant in this project, impairments in one hand, see Figure 8.2, was noted as a possible challenge. Half of the patients observed at Hurdal had problems with one of their hands being impaired. These patients had problems with raising their hand above shoulder height and struggled with finger movements. Some kept their hand clenched in a fist, while others had slow and staccato movements. Spasticity and reduced sensibility were also observed.

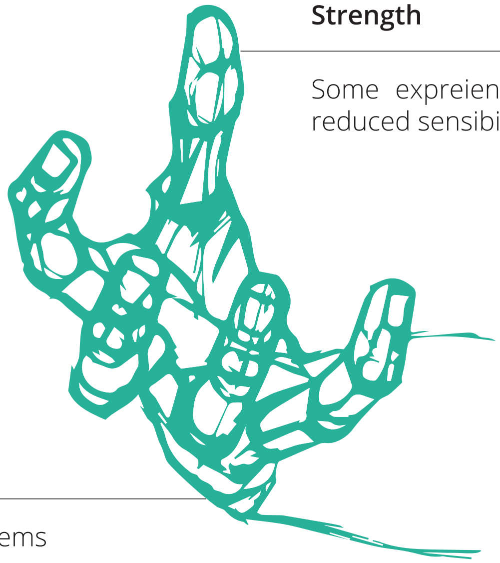
In this project it is important to consider that up to half of the intended users may have troubles with using one of their arms.

Other visual deficits

Patients with HVFD can also have other visual deficits. Examples of visual deficits that may be relevant in this project are increased light sensitivity, reduced contrast sensitivity, decreased visual acuity, problems with oculomotor control, nearsightedness, and farsightedness.

In this project, it is important to consider that many in the target group may have other visual deficits in addition to a loss of parts of their visual field. Small changes such as, increasing contrast and reducing the luminance of bright lights, could, therefore, be helpful for patients within the target group.

When it comes to problems with oculomotor control, this often leads to problems with HVFD related vision therapy [22]. From observations of vision therapy, patients with poor oculomotor control often had this as their main focus area during training. Training related to oculomotor control will not be a focus in this project, as this falls outside the scope of this thesis.



Strength

Some expreience spacicity, and reduced sensibility and strength

Above shoulder height

Some patients had problems raising their hand above shoulder height

Finger movements

Some clenched their fist or had slow and staccato movements.

Figure 8.2 | Hand Impairments seen in patients

8.3 COGNITIVE IMPAIRMENTS

This section goes through the most relevant cognitive impairments related to vision therapy, namely: attention, fatigue, memory and neglect. These were chosen based on the observations conducted at HSMS, see Appendix E. It should be noted examples mentioned in this section does not always originate from stroke.

Attention
Many have problems with attention after stroke. They are easily distracted and loose their concentration, and struggle with focusing on a specific task in the presence of competing information. At Hurdal several problems with attention were observed. Patients often changed the subject and started talking about other things, patients could abruptly stop in the middle of exercises, and the TVI sometimes had to repeat themselves as the patient was not paying attention.

Fatigue
Fatigue is one of the invisible symptoms post stroke, and is one reason why many patients struggle with getting back to work. Fatigue and tiredness during and after vision therapy were a common occurence at Hurdal. Patients could suddenly put their head in their hands during training or rub their eyes, see Figure 8.3. It was often mentioned by patients that they were tired. Several of the patients had to take naps after their session.

It should be noted that vision therapy is an intensive form of training, and that experiencing fatigue after a session is normal, also for people without excessive fatigue difficulties.

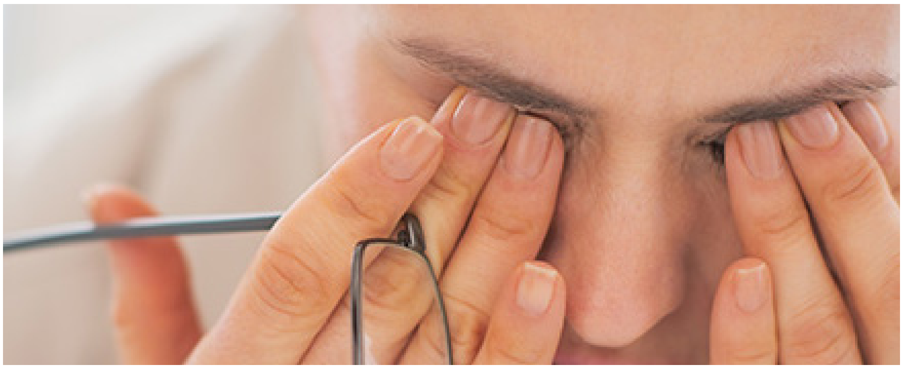


Figure 8.3 | Fatigued woman

Memory
Reduced memory is not the most common impairment as a result of stroke[5]. Still, this has to be taken into consideration as having a HVFD often causes additional problems with memory, see Appendix C.10.

Patients who struggle with their vision, use more capacity, concentration and time on perceving information. As a lot of their cognitive capacity goes to visual perception, remembering what was seen gets more difficult. The most evident example of this at Hurdal was that patients could forget what they had to do during an exercise because they had used so much energy on the previous step of the exercise.

Visuospatial Neglect
Visuospatial Neglect is a cognitive impairment resulting from stroke which often is confused with HVFD. The condition have a very similar outcome as an HVFD, and a patient can have both an HVFD and neglect at the same time. Visuospatial neglect is decreased visual attention to one side of space, which results in not being able to see one side, without there being anything wrong with the eyes[28]. As it is a cognitive impairment not a visual, the treatment of Visuospatial neglect and a HVFD is not the same.

Several of the studies examined in this thesis chooses to deliberatly exclude patients with visuospatial neglect, as they interfere with the results from the studies [6,10,29]. Based on a reccommondation from neurologist Volker, one of the main stakeholders in this project, we have chosen to do the same.

8.4 DIFFICULTIES WITH TASK COMPREHENSION

This section goes through problems with task comprehension that can affect vision therapy. These problems can be divided into three categories, namely: *understanding the instruction, following the instructions, and understanding terms and wording.* The problems presented where found from observation of vision therapy sessions at HSMS, see A ppendix E for a summary of these observations.

It should be noted that problems with task comprehension can lead to a wrongful assessment of a patient's visual skill. A patient can for example perform a task at a poor level, not due to poor visual skill, but due to having difficulties with task comprehension.

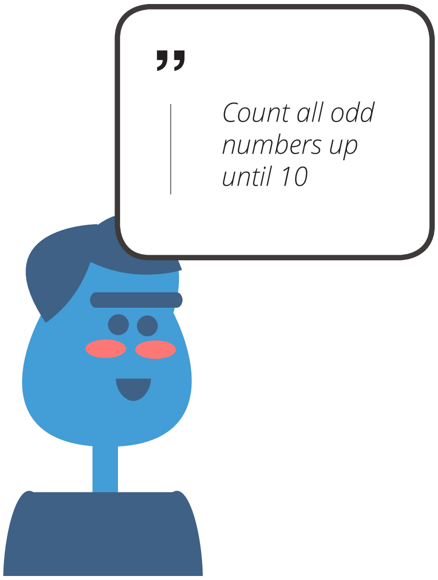


Figure 8.4 | TVI giving instructions

Understanding the instruction
Some of the patients at Hurdal had difficulties with grasping and interpreting what the TVI told them to do. Some tasks were often wrongfully executed, which resulted in the exercises starting slow and hesitant. Understanding what to do from oral instructions was observed to be especially problematic for patients with aphasia, who struggle with comprehending language. An interesting observation was that small changes to a task can cause troubles with task comprehension.

Following the instructions

Sometimes patients had troubles with executing tasks according to instructions. These situations occur when a patient understands the instructions which are given, but executes the task wrongfully. Failing to understand how to follow an instruction can suddenly occur after some time in an exercise, even after a patient has correctly executed the task several times.

Understanding terms and wording

Problems with task comprehension can be caused by the use of unfamiliar terminology and definitions. Several occurences of this was observed. Examples of this are understanding the meaning of odd andeven numbers, or the different suits in a deck of cards.

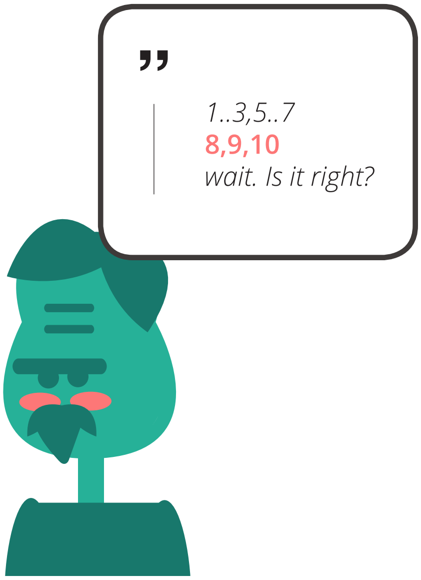


Figure 8.5 | Patient forgetting instructions in the middle of an exercise

Cause of task comprehension issues

After stroke there are several cognitive impairments that lead to difficulties with task comprehension. Examples of cognitive impairments that cause task comprehension difficulties are: Aphasia, agnosia, apraxia, reduced attention span and memory difficulties. A TVI at HSMS estimated that about a third of her patients had problems related to task comprehension, see Appendix C.15 for full interview. The TVI often had to repeat and rephrase the task, until reaching an understanding with the patient. The TVI recommended demonstration as a powerful tool for explaning a task. At HSMS varying degrees of difficulties with task comprehension were observed. Some understood what they had to do immediately, while others needed the task to be repeated several times before understanding what to do.

8.5 STROKE CHALLENGES SUMMARY

Many stroke-related challenges can affect the use of VR equipment and how vision therapy is conducted. This is a summary of the **most relevant stroke-related challenges.**

One hand impairment
Many stroke patients suffer from motor deficits. The most apparent are when one of their hands is impaired.

Attention and Fatigue
Reduced attention and fatigue can be seen as a result of a stroke. This means that some patients are easily distracted and can loose focus. Many patients do also get tired quickly.

Other visual deficits
Visual deficits, such as increased light sensitivity, reduced contrast sensitivity, decreased visual acuity, problems with oculomotor control, nearsightedness, and farsighted-ness, can be seen as a result from stroke.

Memory
Some patients experience reduced memory after stroke. This is often linked to both reduced attention and fatigue.

Task comprehension
Many patients have problems with understanding instructions, following instructions, and under-standing terms and wording.

USER INTERFACE IN VIRTUAL REALITY

Chapter 9 | Designing a virtual reality user interface for stroke patients with HVFD

CHAPTER OVERVIEW

Designing interfaces for virtual reality is an immature field, with few defined conventions. This chapter aims to cover aspects of designing virtual reality user interfaces (VRUIs).

Content
To begin with, virtual reality user interfaces is discussed in relation to more traditional user interfaces. Then some of the current conventions for designing VRUIs are covered. Lastly, this will be linked to the target users, by discussing how these user interfaces can be adapted to their needs.

Result
The result from this chapter is a summary of relevant aspects for designing VRUIs for the intended users. This summary is found at the end of the chapter.

9.1 USER INTERFACES

A user interface (UI) is the parts of the system users interact with. These exist in endless variations. The most common is graphical user interfaces (GUIs), seen in operating systems, applications or web browsers.

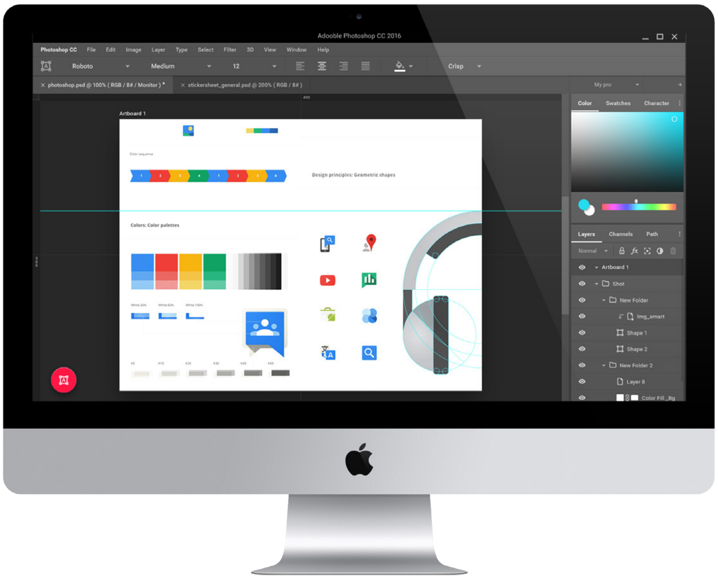


Figure 9.1 | Graphical user interface

Graphical User Interfaces
In GUIs, users interact with screen-based applications through graphical icons, See Figure 9.1. These has existed since the 1960s and is found in everything from smartphones to ticket machines. Designing GUIs is an established field of practise with numerous conventions. Examples of such conventions are navigation bars, tabs, and checkboxes.

Input in GUIs is traditionally achieved by using physical devices such as 2D pointing devices, e.g a mouse, or keyboards. However, there exist various other methods, such as touch input or video input.

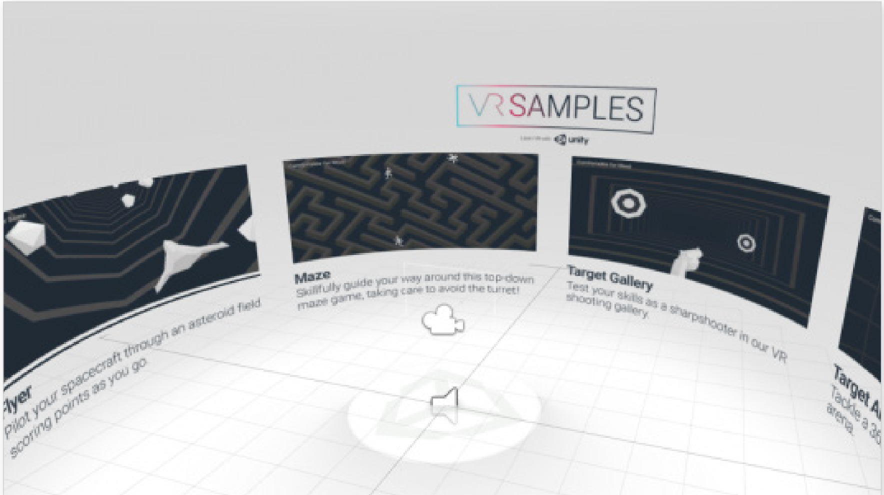


Figure 9.2 | Virtual Reality user interface

Virtual Reality User Interfaces

Designing VRUIs is a new and immature field, with few established conventions. These type of interfaces are often quite different from traditional screen based UIs, see Figure 9.2. The most apparent difference is that the user's field of view is covered by the display. This means that the user will only be able to see the virtual world and that the real world is hidden.

As the real world is hidden from the user, providing satisfactory input with external devices can be difficult. However, some of the emerging conventions for input will be presented later in this chapter.

9.2 USER INTERFACES IN VIRTUAL REALITY

This section elaborates upon ways of implementing a user interface in a VR environment. The subjects that will be discussed are placement of objects in VR and different types of VR interfaces, namely; diecetic, non-diegetic, spatial and head-up displays.

Figure 9.3 | Objects placed in the edges of the VR environment can get blurry

Placement of objects

When designing for VR the user has the possibility to look in all directions. This means that the whole world could be an interface and contain elements. This is an opportunity for creating new and exiting interfaces, as things do not have to be limited to a flat rectangular surface area.

The resolution in current consumer-grade VR headsets is not uniform, like regular displays. The number of pixels per inch is much higher towards the center of the display than towards the sides. This means that information that is presented in the center of the screen, directly in front of the users, will be the sharpest while getting increasingly blurry towards the edges.

Figure 9.4 | Diegetic interface

Diegetic interfaces

Diegetic interfaces are UI elements that exist inside or are part of the virtual environment. The idea behind it is to make the interface a part of the experience instead of being a layer between the user and the virtual world. This could help increase the feeling of immersion. An example of a diegetic interface can be seen in figure 9.4, where the user has to interact with the computer which is a part of the virtual world

Pinning UI elements in the virtual environment could also possibly help increase the user's overview of the environment. By fusing the in-game elements and the UI together, the relation between them can become unambiguous. This way the UI will not become an additional system for the user to learn, but rather a part of one complete experience.

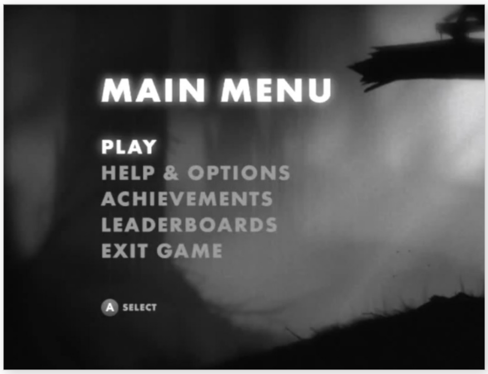


Figure 9.5 | Non-diegetic interface

Non-diegetic interfaces

Non-diegetic interfaces are very similar to the traditional GUIs commonly seen in computers and smartphones. These interfaces are placed as an overlay over the virtual world, segregated from the rest of the environment. Figure 9.5 is an example of this, where a menu screen lay as an overlay over the environment.

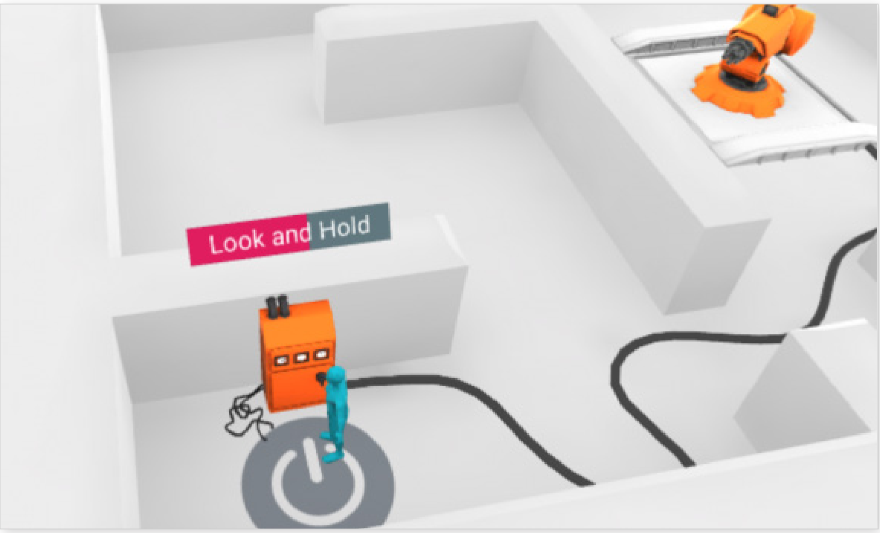


Figure 9.6 | Example of spatial interface, from Unity 3D samples

Spatial interfaces
Spatial interfaces are located inside the virtual environment but are not part of the virtual world. These are therefore a combination of a diegetic and a non-diegetic interface, see Figure 9.6.

Head-up display

Head-up displays(HUDs) are transparent displays providing information, which are available to the user at all times, see Figure 9.7. This could be very relevant for VR applications, as elements can easily be fixed in space relative to the user's head position. While these solutions make information visible at all times, they can be challenging to implement as elements towards the edges of the display often get blurry and difficult to see.

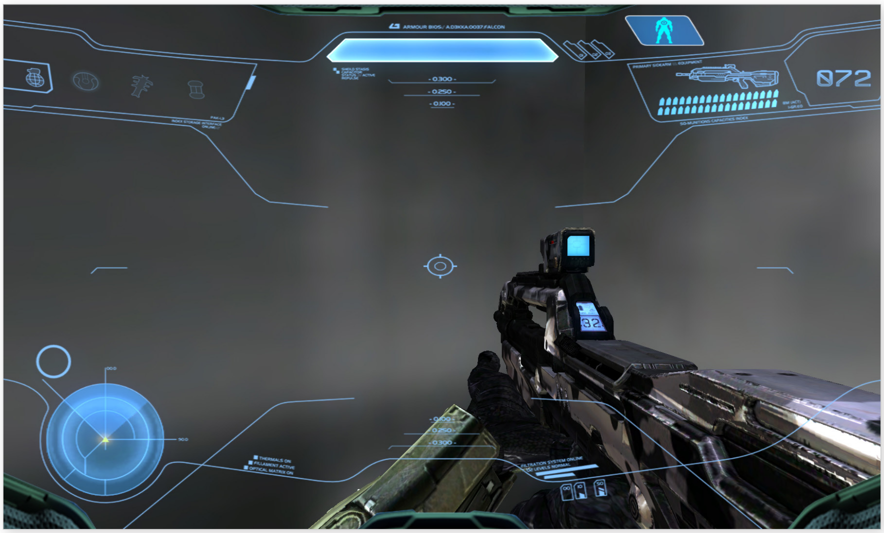


Figure 9.7 | Example of a head-up display

9.3 INTERACTIONS IN VIRTUAL REALITY

As the user's body and surrounding enviroment are hidden in VR, interactions can be difficult. High-end VR systems solve this by providing trackable controllers, which allows the user to see the controller they are using. While this is currently not possible in low-end systems, other conventions have appeared, namely; reticles and non-trackable controllers.

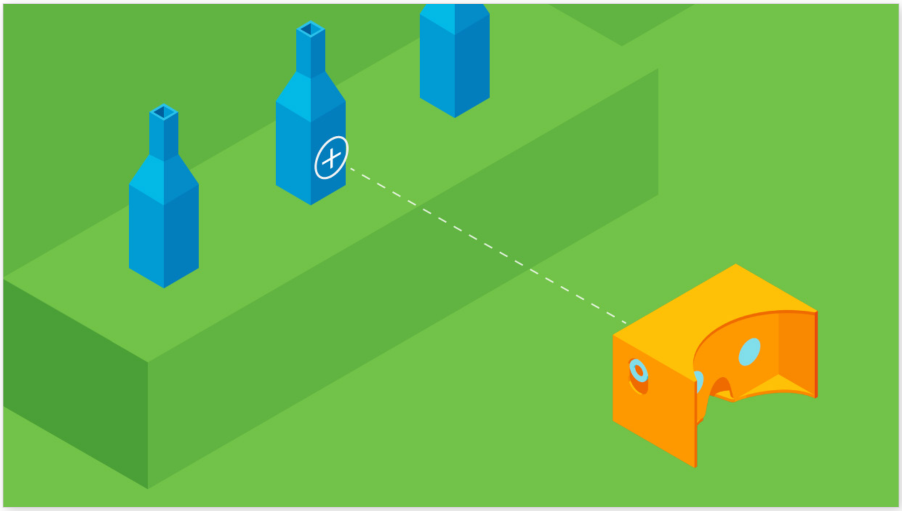


Figure 9.8 | Reticle, illustrated by a circle with a cross in the middle.

Reticles

A reticle is a visual aid placed in the center of the user's field of view, see Figure 9.8. The reticle follows the user when they look around and gives a visual cue of what the application counts as their current focus.

No currently available consumer-grade VR headset supports eye tracking as a mean of interaction, even though this could be a great way for users to navigate by using their gaze. Reticles have in many ways become a standard for tracking users gaze.

Gaze Cues

Gaze cues are similar to hover cues, often seen in traditional user interface design. These cues help the user to uncover new information quickly, by gazing towards an object. In combinations with reticles, these can provide a clear and straight-forward way for the user to uncover interactable elements and information about the element in focus. This could simultaneously help hiding information which does not always have to be visible, while still keeping it readily available to the user.

Non-trackable controllers

Keyboards and 2D pointing devices work in VR but can be difficult to use since the equipment is invisible to the user and their screen positions are relative. However, several of the current VR applications make use of this type of equipment. The most commonly used 2D pointing device are simple handheld controllers. While these are still invisible to the user, their simple button layout and increased tactility prove them superior to traditional keyboards.

9.4 REDUCING MOTION

VR simulations are known to cause motion sickness. This is due to the user expecting to feel something different than they are actually feeling. An example is when a movement is simulated in VR while the user is stationary in the real world. There exist several simple methods to help avoid unnecessary motion sickness[30]. This section discusses how this can be done.

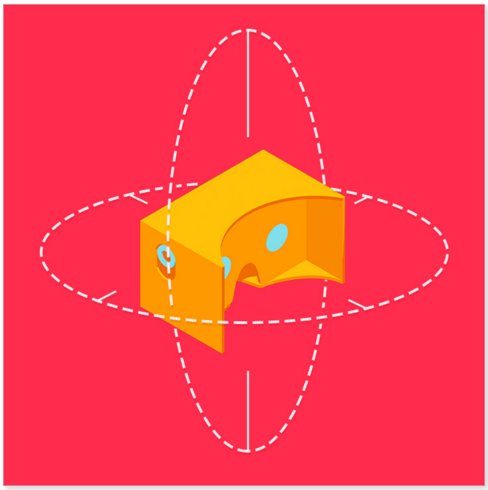


Figure 9.9 | Illustration of Head tracking

Enable head tracking

A simulation should always keep head tracking enabled. Head tracking allows objects in a virtual environment to appear stationary to the user's head movements, see Figure 9.9. Head tracking enables the user to foresee movements, and thereby be prepared for the feeling of motion. Freezing the environment or turning head tracking on and off, may cause the user to feel disoriented.

Point of reference

It should be noted that the user also can experience a sense of movement when they are stationary in the scene. This could be induced by other objects moving, causing the user lose their point of reference. By creating visible fixed points in the scene, this could contribute to maintaining the user's point of reference.

Figure 9.10 | Picture from the game *Tempel run*

Avoiding acceleration and turns

In order to reduce motion sickness, it is wise to avoid acceleration and turns. These movements can make the user expect a feeling of change in velocity, not corresponding to the user's real environment. A game known to easily induce motion sickness because of the several turns is the game is *Temple run*, seen in Figure 9.10. Constant speeds do not induce any sense of motion, and the user should preferably only be exposed to this type of movement.

9.5 INPUT METHODS

When creating ways to interact with the VR application, there are several important aspects to consider. Firstly, it should be suitable for users with one arm. Secondly, it should consider that users can be right or left handed. Thirdly, it should provide consistent feedback on user inputs. Lastly, the interactable elements should have appropriate affordances. This section elaborates on these recommendations.

Suitable for users with one arm
Several patients in the target group have an impaired arm. This limits how the user interacts with the system, as the number of possible input options is severely reduced. It is, therefore, important to choose a suitable number of input buttons. In addition, it is important to find a combination of buttons that is possible to use with only having one arm available and which work with a one-handed input device, see Figure 9.11. It should be noted that many of the patients in the target group can use both hands and that choices made on behalf of those with one hand should not be inconvenient for those with both.

Users can be left or right handed
It is important to consider that both the left and the right hand can be affected by stroke. When creating methods for input, these should work properly or be adaptable to both hands. When choosing an input device and input methods, these should be suitable for users using their dominant and users using their non-dominant hand.

Consistent feedback on user inputs
User input and system feedback should be consistent throughout the application. Patients in the target group can have cognitive impairments, e.g. reduced memory and attention, and an intuitive system could make interactions easier and help reduce the cognitive load. By providing consistent feedback, inputs could more easily become a habit, and thereby make the application less demanding to use.

Affordance of interactable objects
It would be beneficial to have a logical coherence between user input and how the system looks and reacts. This means that when an input device is chosen, it is important that the interface resembles the actions that this device can perform. For instance, if the chosen input device is a touchpad, the interface should offer the affordances of tap, swipe, and pinch.

Figure 9.11 | Google Daydream controller

9.6 CREATING TEXT

Reading difficulties are common among the target group in this project, as explained in Section 3.5. Some of the problems are reduced reading speed and reduced understanding of the meaning of the text. It is essential to be careful when creating text for this group.

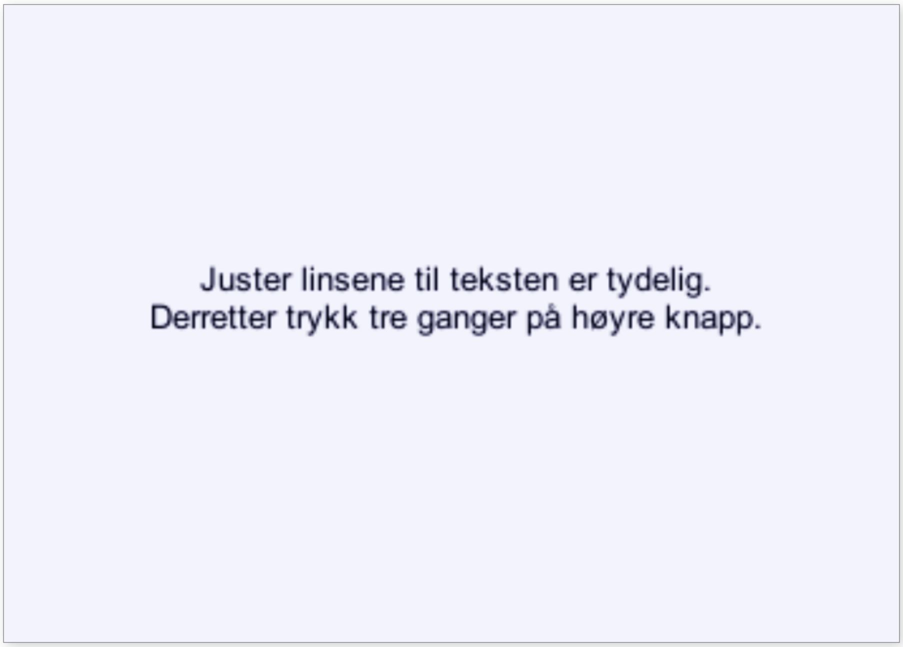


Figure 9.12 | Text in VR often becomes unsharp and difficult to read.

Reduce the amount of text
A big part of the target group struggle with reading text altogether. A solution is reducing the amount of text as much as possible. This could be done by using plain, concise and precise wording. Another solution is replacing text with other visual elements where possible, for instance by using icons and symbols where these function equally well.

Clear and readable
HVFDs are often connected to reduced contrast sensitivity and decreased visual acuity. As reading texts in virtual reality applications can be difficult in the first place, this becomes even more essential. Therefore it is important to adapt all text to this platform by making it easily readable and clear. Fonts should be easily read, and contrasts should be sufficient.

Sentence length and placement
Patients with left-sided HVFDs often struggle with finding the beginning of lines, whereas patients with right-sided HVFDs often struggle with reading lines all the way to the end. Therefore it is essential to be accurate when constructing paragraphs of text by aiming for a middle ground between creating short lines and having few line breaks. Preferably it is best to avoid paragraphs of text to evade this problem altogether.

Placement of text is also essential for the patients in the user group and finding the start and the end of the line should be simple. Text which is displaced too much to either right or left could lead to problems for the users.

Auditory Support
As many patients from the target group have reading difficulties, many patients would benefit from other ways of receiving information. Using auditory support is a way of providing information, without relying solely on text.

Combining auditory and textual information is a way to increase understanding. This is especially important as the target group struggle with cognitive difficulties such as difficulties with memory, attention and task comprehension, as seen in Section 8.4. In addition, this was the preferred choice in both input tests, with users with and without HVFDs. See Appendix D.2 to see the full tests.

9.7 INSTRUCTIONS

Instructions are messages explaining to the user what they are supposed to do. Creating instructions for the target group in this project can be difficult, as many struggle with task comprehension, see Section 8.4. This section cover how a user interface can be designed to better alleviate this difficulty.

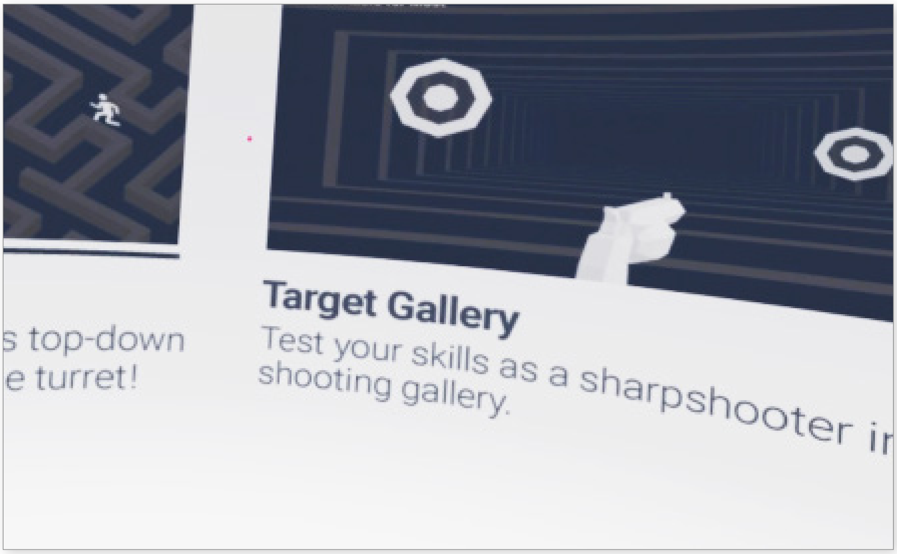


Figure 9.13 | Unity VR samples use animation to show how games are played.

Animation and visual representations
Providing instructions by using animation is a good way of demonstrating to the user what they are supposed to do, see Figure 9.13. Using demonstration was recommended by one of the TVIs at HSMS, see Section 8.4.

Another way of demonstrating a task is by the use of visual representations. For instance using images for presenting what the user is supposed to do. A benefit of using visual representation instead of animation is that particularly challenging parts can be highlighted. This way the user can progress whenever they want to, instead of having to watch the whole animation before continuing.

Short and precise
Instructions should be short, precise, and easy to understand. By reducing the amount of text, and avoiding difficult terminology, instructions should become more comprehensible.

Learn by doing
Allowing the user to get to know the game by trying is a great way of increasing understanding. The instruction should be short and concise, and the user should as soon as possible start the game, and then try and fail until reaching an understanding of how the game works. Learning games this way is great if the games are simple and intuitive.

Repeating instructions
Repeating instructions is a way of compensating for several of the cognitive difficulties the target users may have problems with. The user can watch the instructions as many times as they want to until they feel prepared to play the game. If they lose focus or do not understand what to do, they can read or listen to the instructions over again.

9.8 USER INTERFACES IN VIRTUAL REALITY SUMMARY

Designing virtual reality user interfaces is a new and immature field. This section presents a summary of **relevant aspects of creating VRUIs for this project:**

VRUIs

VRUIs are very different from traditional GUIs, as these are not limited to a flat rectangular area. This allows for testing more untraditional types of interfaces, such as diegetic and spatial interfaces.

Controllers

The controllers used in this project should be suitable for the intended users. This means that it should be possible to use with one hand, be equally usable with both left and right hand and be intuitive and simple to use.

Input in VR

Gaze cues and reticles have quickly become a standard convention in VRUIs. These are often easy and intuitive compared to alternative input methods.

Non-trackable controllers

Tracked controllers are currently not possible with mobile VR. Simple and non-trackable controllers do therefore have to be used instead.

Avoid fixed elements

Elements which are fixed toward the edges of the display often becomes blurry. HUD interfaces may therefore not be ideal for use in VRUIs.

Reducing motion

A few simple tricks can be used to reduce motion sickness. These are; always enable head tracking, provide points of reference and avoid acceleration and turns.

Text in VR

Text in VR can be difficult to read, in the first place. To be suitable for the intended users, the text should be; short and precise, clear and readable and be supported by audio.

Instructions

Instructions should be specific and comrehensible, without difficult terms and wordings. They should also be repeated a desired amount of time, and be assisted or replaced by demonstration, images or animation if necessary.

CREATING GAMES

Chapter 10 | Presenting prototype 1

CHAPTER OVERVIEW

At this stage in the process methods for vision therapy has been created, and designing a virtual reality application for the target user has been discussed. This chapter is about tieing these together to create an application.

Content
This chapter covers how each of the four vision therapy methods was made into minigames, by using the guidelines presented in chapter 9 and game design theory. In the end, all minigames are combined to one game.

Result
The result from this chapter is a vision therapy prototype utilizing virtual reality technology. This prototype is presented in Sections 10.5 to 10.11.

10.1 FOUR BASIC ELEMENTS

Schell[31] provides a framework for breaking down and classifying games. Figure 10.1 shows the categories that are used. This section briefly explains this framework. The following sections use this framework to create minigames.

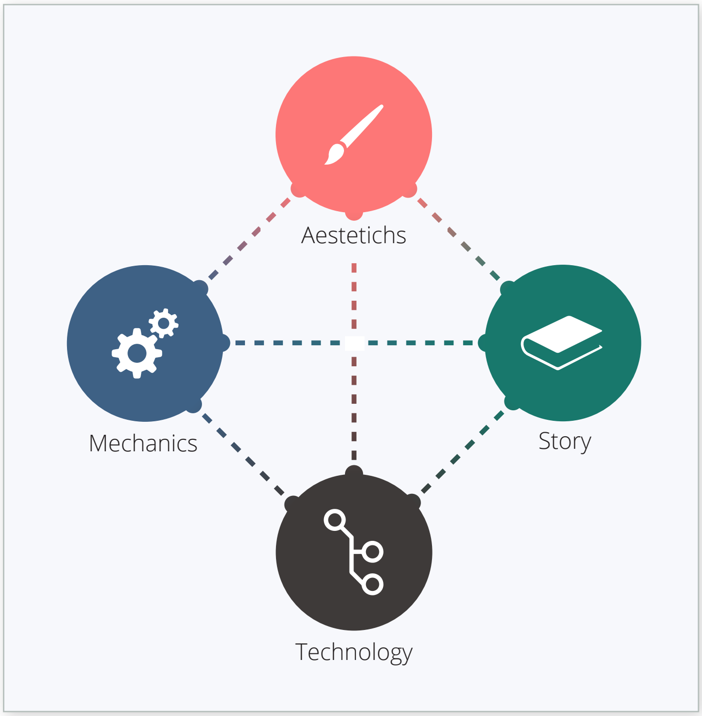


Figure 10.1 | The four basic elements [31]

Aestetichs
The aesthetics are the look and tone of the game. This includes sounds, visuals, and other stimuli in the game. The feelings these stimuli provide are important as they have a direct influence on the user's experience of the game.

The task of the aesthetics is to make the game world feel real to the user and to create a unifying atmosphere. This helps reinforce other game elements and makes the story, mechanics, and technology all work together.

Story
The story of the game is the sequence of events that unfold when playing it. This does not have to be a story in the sense that it has to contain rich dialogues and vibrant characters, but rather that it has a world, progression, and a plot. These elements help to bring life to the game and to immerse the user.

Mechanics
The game mechanics are the procedures and rules within the game. These confines what the user can and can not do. For this project, the methods described in Chapter 6.4 to 6.7 heavily defines the game mechanics. The reason for this is that the rules and procedures of the game have to be in line with vision therapy principles, for the training to be effective.

These mechanics will influence both the story, aesthetics, and technology that is used in the project. These will, therefore, be used as a foundation for creating the rest of the game.

Technology
The technology is the medium where the game takes place. This could be anything from a boardgame to an arcade machine. The technology influences the interactions that are possible within the game, which in turn affect the mechanics, story and aesthetics of the game.

10.2 STORY AND AESTETICS

To create a holistic world and experience, the story and aesthetics have to work together with the mechanics and technology. At this stage in the process, the story and aesthetics were thought of as a creative tool and framework, to be used for creating the rest of the application.

The world
Several key factors were involved when selecting a theme for the game world.

Firstly, the theme should be uncomplicated and transparent. A game world that is well organized, uncluttered, and provide tranquility, would hopefully not affect the therapy and contribute to making a user-friendly application.

Secondly, the theme should be simple and straightforward, to facilitate a swift and efficient design process. Therefore a theme which is easy to implement would be beneficial.

Lastly, the theme should be suitable for VR. A theme that goes well with and utilizes the possibilities of this technology could fortify the overall experience.

Theme
Several themes were considered, however, space felt as a natural choice at this point. This had been mentioned both during the user testing and at the ØH workshop. Additionally, some of the most popular vision therapy methods had space themes. This theme also seemed simple and straightforward to work with, in addition to being appropriate for a VR application.

Aesthetics
To create a holistic experience, the visuals and sounds play an essential role. These should coincide with the theme, to unify the whole application. The focus when creating the aesthetics was, therefore, to be consistent and stick to the theme that was chosen.

With a Space theme, it is natural to think of e.g. planets, stars, astronauts, meteors, quiet ambient sounds, and spaceships. By using elements that are associated with space, the theme can be reinforced.

The most important aspect of the aesthetics is how it makes the user feel. For this application, the goal is to create a pleasant and enjoyable atmosphere. This will be one of the main goals when creating the application. Figure 10.2 presents some initial sketches of how the four methods could be made to fit within the Space theme.

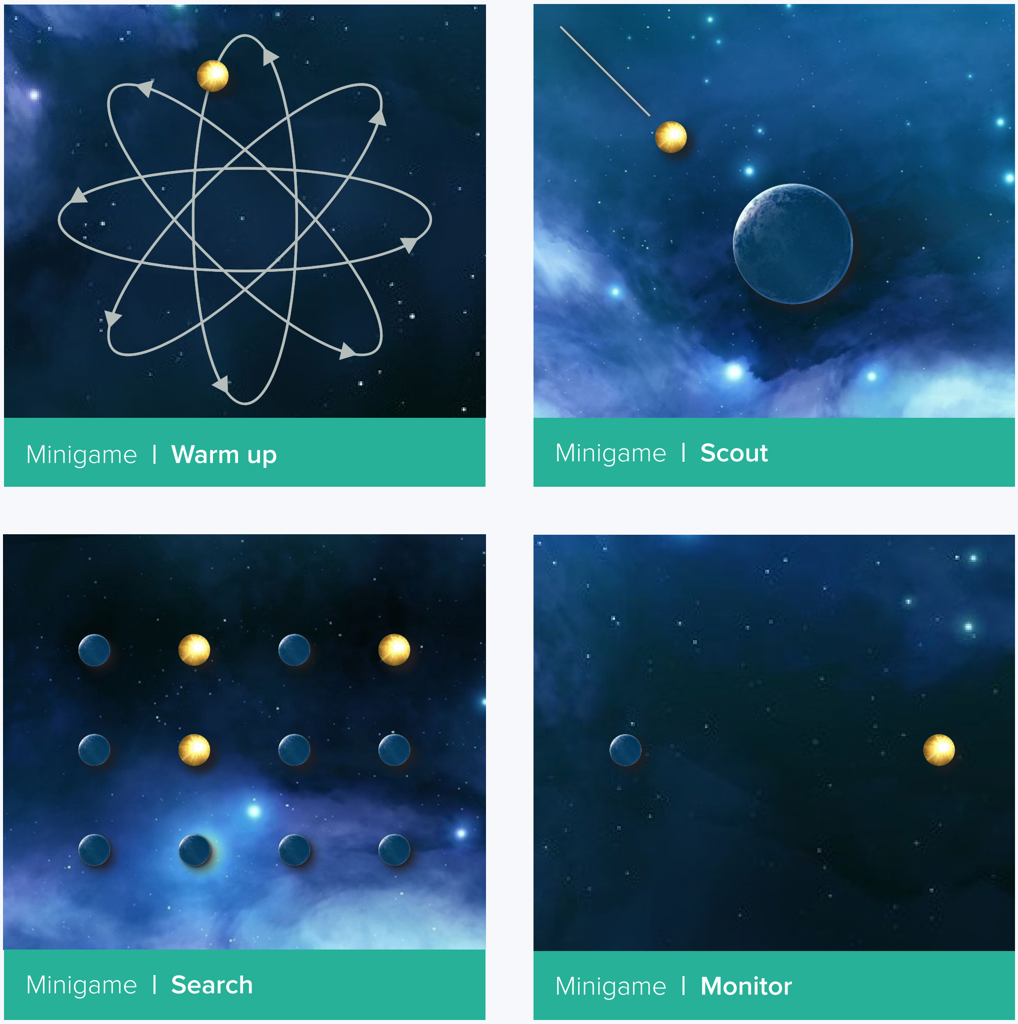


Figure 10.2 | Initial sketches of methods with a space theme

10.3 TECHNOLOGY

The technology is the medium that presents the game. This medium defines what is possible for the user to do. For this project, the technology is defined by the Merge VR headset and the chosen controller.

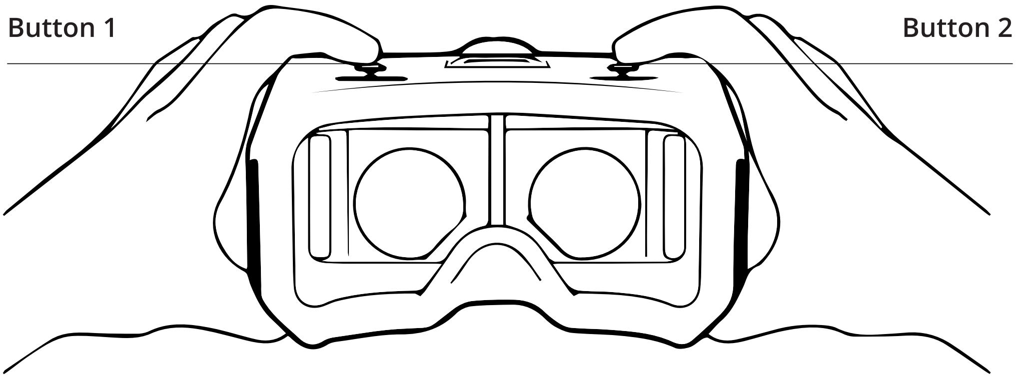


Figure 10.3 | Illustration of Merge VR

The Merge

Chapter 7 goes through why the Merge, see Figure 10.3, was chosen. The application is designed to be used with the Merge, which has two robust and tactile buttons. However, these buttons are both tiring to use and limiting for patients with physical impairments.

As an alternative to the Merge buttons, the application will also be designed to be used with a one-handed controller.

Choosing an input device

A simple Bluetooth controller was chosen as a secondary input device. Exactly which controller is used in this application is not essential, as long as it satisfies the requirements for the input device presented in Section 9.5. This input device was chosen primarily based on its availability and its affordable price. The controller that was used in this project can be seen in Figure 10.4.

Figure 10.4 | Bluetooth controller

The controller consists of a joystick and four buttons. This controller is designed to be used with one hand and is suitable for both left and right handed users.

In order to provide a combination of inputs that is easy to use with one hand, using the joystick was assumed to be the best alternative. This was both easier and more intuitive to use than the buttons on the controller.

Possible interactions with the joystick
The joystick offers four primary types off input, namely; push up, push down, push left and push right. These inputs can be expanded, by accounting for how long the user pushes the joystick.

Other types of inputs are also possible, such as double pushes or pushing at different speeds. However, to limit the number of input options, it was believed that only using the four primary inputs would be best suited for the intended users.

10.4 MECHANICS

The project's primary goal is to improve patients reaction and detection of visual stimuli. All game mechanics should, therefore, be relevant to this overall goal. This section presents what Schell defines to be the main mechanics in a game [31]. The following sections will use these definitions to describe the mechanics of the minigames.

The Most Important Rule

Games often have many rules. However, all games have one superior rule, namely the objective of the game. This rule is important, as it gives purpose to the player's actions. The primary objective should be concrete and apparent at all times, and achievable to all users without being boring.

Actions

Actions are the most apparent game mechanic. These define what the user can do, and how they can interact with the application. One apparent action is to "look around", as VR provides a three-dimensional room for the user to explore. This is an example of an action that will always be available to the user. While some actions are universal throughout the application, most actions will exist only in the context of each minigame.

Time Limits

Time is an essential element when creating games. The time in games can be limited, and pressure the user to accomplish as much as possible within a fixed timeframe. It can also be relative, by having a fixed amount of tasks. This is meant to pressure the user to complete the tasks as quickly as possible.

Adjusting to the player's level of skill

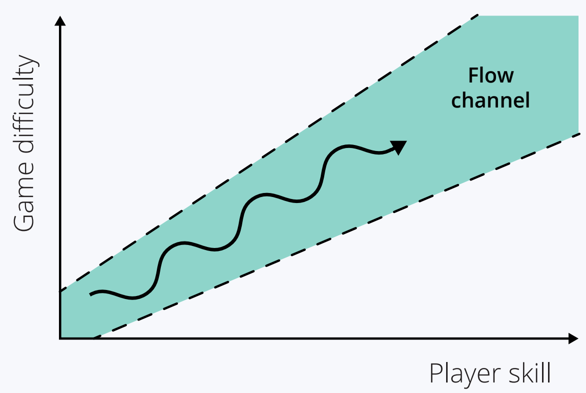


Figure 10.5 | Flow channel [31]

The user's level of skill

One mechanic is to focus gameplay on the user's level of skill. This is particularly relevant for this application, as it is meant for training visual skills. However, games rarely rely on only one individual skill. Therefore it is important to balance the required skills, to be sure the user mainly exercises skills relevant for vision therapy.

It is important to adjust the game difficulty according to the user's level of skill. If the level of difficulty and the required skills are properly balanced, the user will stay in the flow channel, avoiding boredom and anxiousness, see Figure 10.5.

Chance

Chance is a game mechanic introducing uncertainty and surprises. Without chance, games often become predictable and monotonous. By randomizing variables and events, decision-making can become engaging as the user has to make strategies and predict outcomes to overcome challenges.

10.5 MINIGAME 1 I WARM UP

Description
A planet is placed directly in front of the user, with a meteor orbiting around it. The meteor is the key component in the game, which the user is supposed to track. The meteor provides visual cues at random intervals, where the user's task is to push the joystick to the right when such a cue appears.

Blinking Meteor
The orbiting meteor which the user is supposed to track, starts to blink at random intervals.

Clock Timer
A timer activates when the user starts the minigame. When the timer has ended, the game ends.

Planet
The planet is placed in the middle of the screen and can be used as a reference point to the center of the scene. It rotates to make the scene more dynamic and alive.

GAME MECHANICS

The most important rule
The user's task is to keep track of the orbiting meteor and to react as soon as it starts to blink.

Actions
To deactivate the blinking meteor, the user has to push upwards on the joystick or press one of the buttons on the Merge.

Chance
The meteor starts to blink at random intervals between 4 and 8 seconds. The player can never know exactly when it will start to blink.

Time limit
The time in the game is limited, and the game is set to last for 3 minutes.

Skill
The game difficulty can be adjusted by increasing the speed of the orbiting meteor or the distance between the meteor and the planet. The size and the subtleness of the meteor can also be changed to make the game more difficult.

10.6 MINIGAME 2 | METEOR SHOWER

Description
A planet is placed directly in front of the user, with meteors approaching from outside the user's visual field. These meteors appear at random intervals, and the user is supposed to detect them as fast as possible. When a meteor is discovered, the user's task is to push the joystick in the direction of the meteor, as quickly as possible.

Meteors
Meteors appear from all around the scene, moving towards the planet.

Explotion and color change
When the planet is hit, the meteor explodes, and the planet's color gets darker.

Lives
The planet starts with five lives and loses one every time the user makes an error.

GAME MECHANICS

The most important rule
The user's objective is to protect the planet from getting hit by meteors.

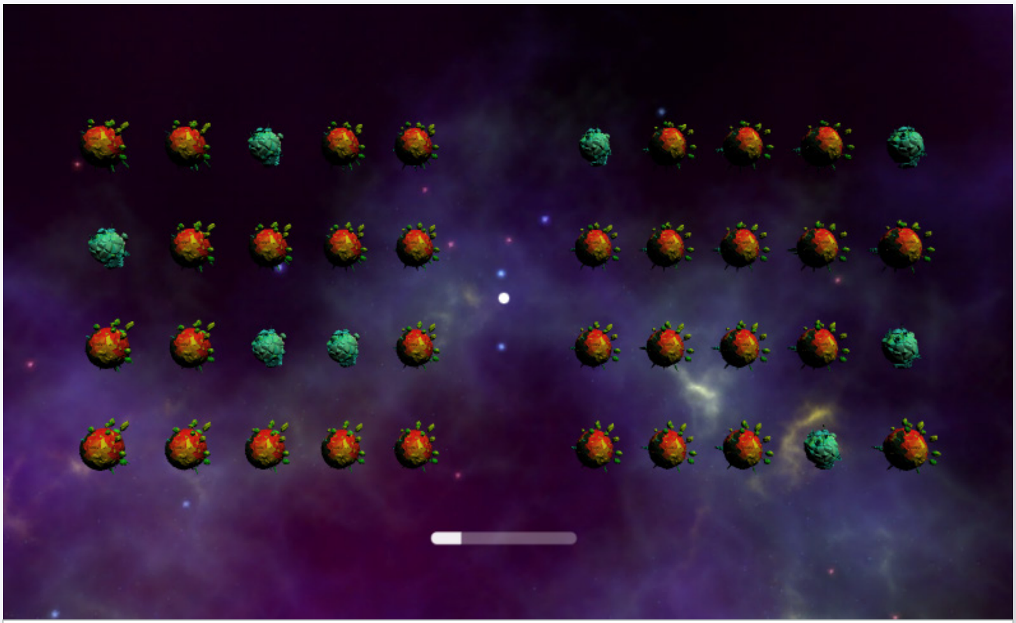
Actions
To destroy a meteor, the user has to push the joystick in the direction the meteor is coming from. If they are using the merge buttons, they have to click left if the meteor approaches from the left, and right if it approaches from the right side.

Chance
The meteor has a 50/50 chance of appearing from either left or right. The vertical direction is entirely randomized. This way the user has no way of knowing where the meteor will approach from next.

Time limit
The time in this game is relative, and will vary based on how long the user survives. The planet has five lives, which allows a total of 5 errors made by the user before the game ends.

Skill
The game difficulty is adjusted by the speed and interval between the incoming meteors. The size of the planet can also be increased to increase the difficulty.

10.7 MINIGAME 3 | PATTERN



Description
A number of planets are placed in front of the user, arranged in two grids. The minigame is slightly altered from the initial method which it is based upon. Now the user is supposed to tell whether the pattern exists to the right, or to the left. When the user has found the pattern, their task is to push the joystick to the corresponding side of where the pattern is located.

Two Grids
The grid is split in two using a vertical division line. This makes the two grids separable.

Two-in-a-row
In this example the pattern is two-in-a-row. This pattern only appears in one of the two grids.

Timer
A timer activates when the user starts the minigame. When the timer has ended, the game ends.

GAME MECHANICS

The most important rule
The user is supposed to detect as many two-in-a-rows as possible within the time limit.

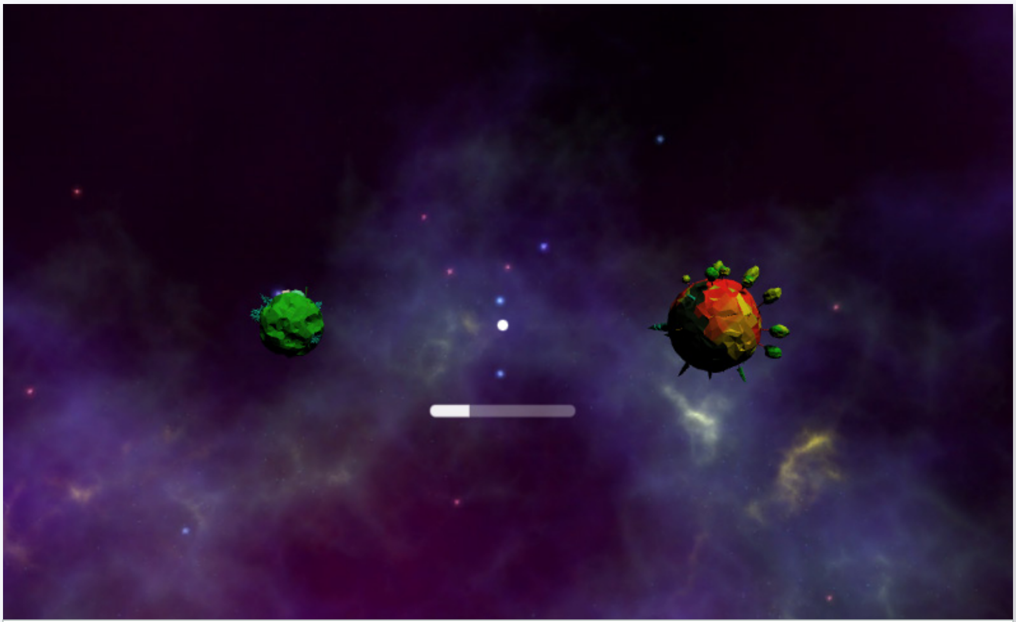
Actions
When the user detects two-in-a-row, they have to push the joystick in that direction or push the button on the merge that corresponds to the side where the pattern appears.

Chance
As the two-in-a-row has a 50/50 chance of appearing to either the left or right, the user has no way of knowing to which side.

Time limit
The time in the game is limited, and the game is set to last for 3 minutes.

Skill
The game difficulty can be adjusted by making the user look for different patterns. Other colored planets could also be introduced to increase the difficulty. Additionally, the number of rows and columns could also be changed.

10.8 MINIGAME 4 | TWIN



Description
Two planets are placed next to each other, on a horizontal plane in front of the user. These alternate at set intervals, by changing appearance. The user is supposed to detect when the two planets are similar and respond by pushing the joystick to the right.

Separation
The two planets are separated, to make it difficult to monitor both at once.

Changing Planets
The two planets are changing appearance alternately. The pace of the change is uniform and predictable.

Timer
A timer activates when the user starts the minigame. When the timer has ended, the game ends.

GAME MECHANICS

The most important rule
The objective of the game is to detect when the two planets are the same before they change.

Actions
When the two planets are the same, the player is supposed to push to the right with the joystick or click one of the two merge buttons.

Chance
The game alternates between five different planets. The user knows which planet is going to change, but do not know which planet is going to appear next.

Time limit
The time in the game is limited, and the game is set to last for 3 minutes.

Skill
The difficulty of the game can be adjusted by increasing the speed of which the planets are changing. The similarity of the available planets can also be used to change the difficulty. Additionally, the distance between the planets can be increased, making it harder to monitor the two.

10.9 INSTRUCTIONS

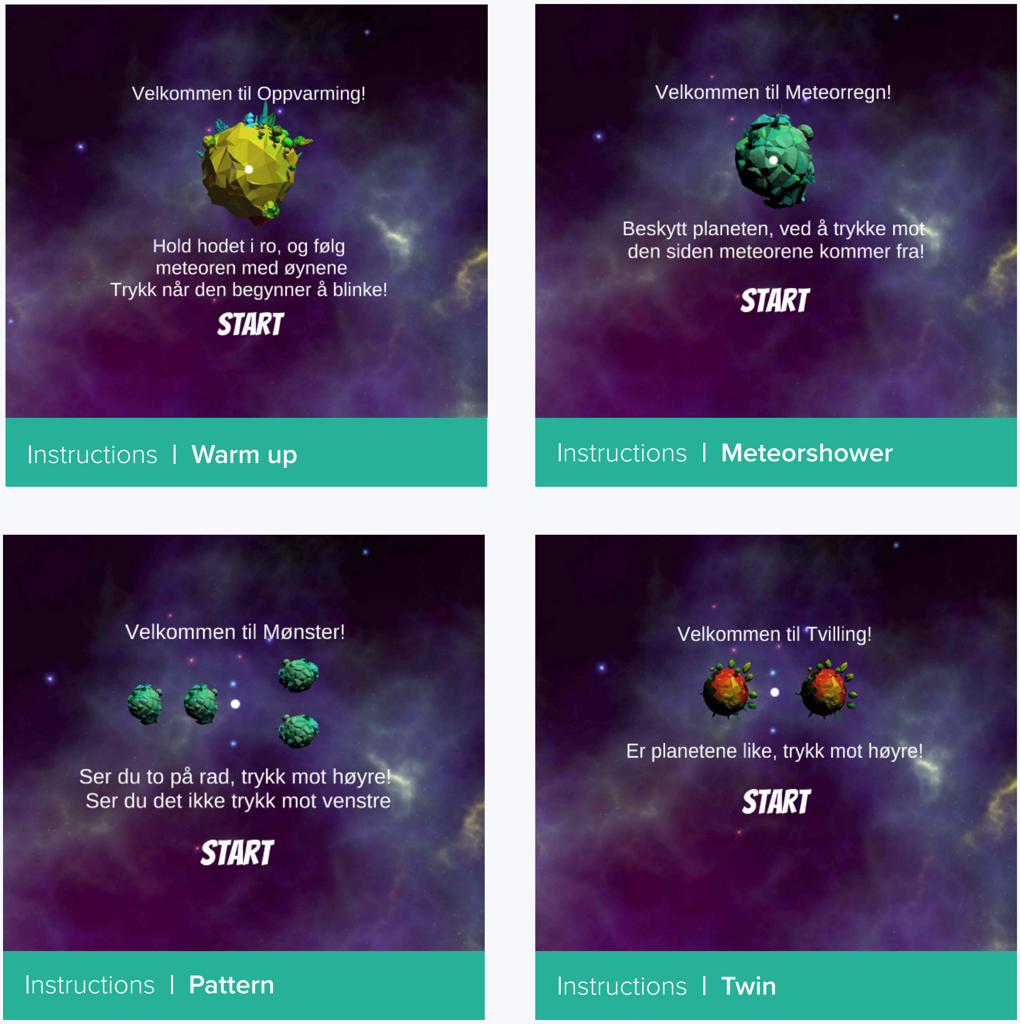


Figure 10.6 | Instructions

Before every minigame, an instruction explaining the main objective of the game is presented. The instruction consists of a written message supported by voiceover and a visual representation, see Figure 10.6. Only the most important rule is displayed to keep the instructions as short and precise as possible.

Using the "Learn by doing" - strategy
The minigames are simple games with few actions and therefore the instructions are based on the "learn by doing" - strategy presented in Section 9.7. This means that some of the rules of the minigames will not be explained in the instruction, but rather become evident to the user when they start to play the game. In the minigame meteor shower, the most important rule is presented in the instructions, while how the planet loses lives is something the user will learn when they start playing.

Instructions are repeated
The instructions are repeated as recommended in Section 9.7. The instructions are visible until the user chooses to press "start", in addition to that the voiceover will start over if the user has not taken action. The "start" button enable the possibility to start the game immediatley, without hearing or reading the instructions. It is entirely up to the user when the game starts.

10.10 INTERACTING WITH THE APPLICATION

This section elaborates on how the user interface has been designed for this application. The main aspects are choosing a spatial interface, using a reticle for navigation, indicating interactable elements with gaze cues, placing objects in the center of the scene and avoiding motion sickness.

Spatial interface

The user interface in the application has been designed to be mostly spatial and diegetic. This means that the user navigates by interacting with objects in the virtual world, and that information related to the interactable objects are placed beside them. This interface was chosen to make the application appear and act as a whole and to avoid a separation between the menu system and game system.

Indicating interactable elements

Interactable elements are indicated with the use of gaze cues. The gaze cues activate when the reticle is pointed towards interactable elements. An example is seen in the menu, where pointing the reticle at a planet will initiate gaze cues such as enlarging the planet, rotating the planet and showing information related to the planet.

Placement of objects

To make the most relevant elements of the application easily accessible, these are placed in the center of the scene. Placements towards the edges of the display have been avoided, as these locations often appear blurry, see Section 9.2. In some parts of the application, this has been difficult to avoid, as some of the minigames require the use of large areas of the user's visual field. This can be seen in the minigame pattern, where the entire display is used.

Precautions against motion sickness

Several precautions have been done to avoid motion sickness. Firstly, screen freezing is avoided by having head tracking enabled at all times. Secondly, the user is always stationary to avoid acceleration and turns. Lastly, the scene background is always the same to make sure the user always has a point of reference.

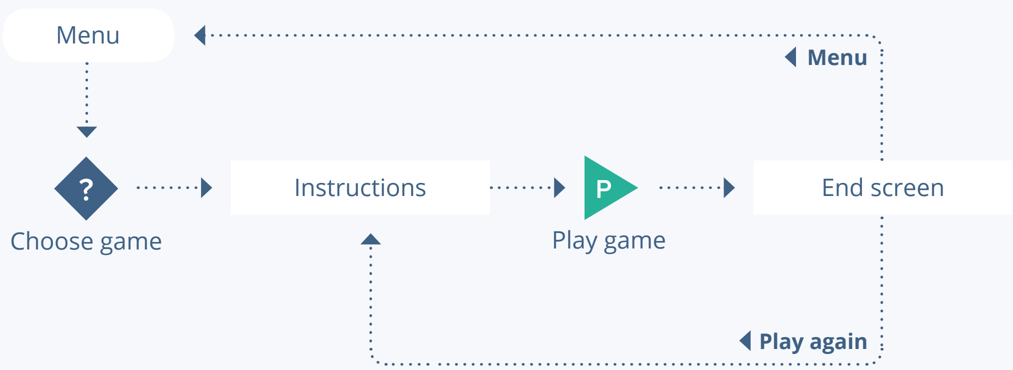


Figure 10.7 | Flowchart Prototype 1

Using a reticle for navigation
A Reticle is implemented throughout the application and is always visible to the user in the form of a small white dot in the center of the screen.

The user navigates in the application by using this reticle, and its appearance is made to not interfere with the rest of the world. The reticle is used similarly to traditional pointing devices, where the reticle is used to point and the controller is used to select.

Navigation
Navigating in the prototype is meant to be simple and straightforward. The users are provided with a limited amount of choices, to make the game flow orderly and consistent, see Figure 10.7.

When the users open the application, they arrive in the menu. At this point, they are presented with four minigames and a play-all button. The play-all button is supposed to allow the user to play all games consecutively, but this is not implemented in the first prototype.

The user is then allowed to choose between all four minigames. Choosing a minigame leads them to the instructions for the chosen game. They decide for themselves when they want to start the game.

After the game has ended, they are presented with feedback on their performance. From this point, they can either go back to the menu or play the game again.

10.11 THE MENU

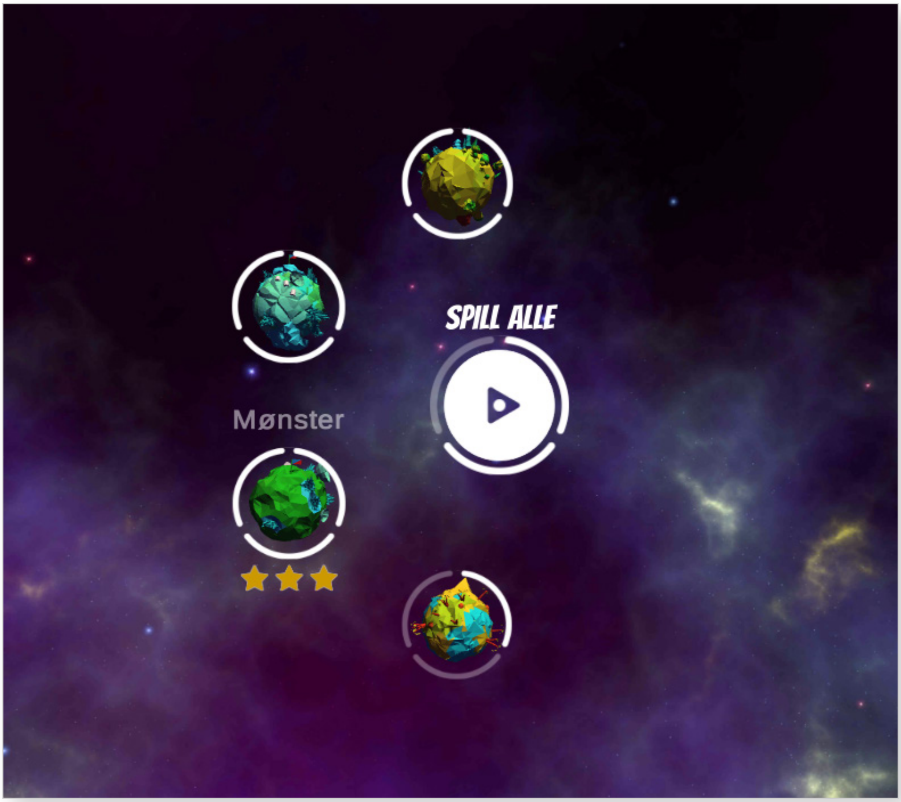


Figure 10.8 | Screenshot of the menu

Description
The main task of the menu, see Figure 10.8, is to tie all minigames and the application together. Its primary goal is to give the user easy access to all parts of the application. The menu consists of five elements. Four planets, representing each of the minigames, and a centered play all button.

Placement
The minigames are presented as planets located around the play all button. These are placed on the opposite side of where the patient's vision is impaired. This example is made for a patient with a right-sided HVFD. This way they will be visible to the patient when the application starts.

Gaze cues
All elements contain gaze cues, to hide all information which does not need to be readily available. On gaze, the minigame planets get enlarged, the name of the game is displayed, and the user's level is shown represented as stars. The play all button also gets enlarged and the text "play all" is presented.

Actions
To enter a minigame the user has to point the reticle at a planet and push the joystick upwards or clicking one of the Merge buttons.

Go to Menu
An action which is available througout the application, is to go back to the menu. This is done by pushing the joystick downwards or holding both Merge buttons down for over 2.5 seconds.

Play all button
The play all button is presented in the center of the scene.

Progress
The daily progress is coupled with every minigame and the play all button. These are presented as circular progress bars. The bars show how much they have played of each game.

10.12 TOOLS USED TO CREATE THE PROTOTYPE

Prototyping tools

Unity3D and Visual Studio was chosen as tools for rapid prototyping, to create the UI, minigames and interactive elements. These where chosen based on their ease of use, quickness, and flexibility. Version 5.6 of Unity3D also have native Cardboard support, which makes implementation of head tracking in VR simple.

Figure 10.9 | Prototyping tools

Asset tools

Adobe Illustrator, Photoshop, and Audition were selected for creating game assets. These assets were mainly graphical elements, icons, images, and sounds.

Figure 10.10 | Asset creation tools

Free assets

Some of the assets that were used in the project were found on various online markets. Firstly, most of the 3D models, textures, skyboxes and particle systems, are found in the Unity Asset Store. Secondly, some of the audio clips that are used in the prototype are acquired from freesound.org. Thirdly, some of the images that are used are found from the thenounproject.com. Lastly, some of the code that is used is from the Unity Samples packages.

Figure 10.11 | Free assets sources

10.13 CREATING GAMES SUMMARY

This section presents a summary of **creating games:**

The Minigames
4 minigames were created based on the methods presented in Chapter 6, namely; Warm Up, Scout, Pattern, and Twin. The framework from Schell[31] was used to create the minigames.

The Application
The minigames were tied together in an application and instructions, menu system and navigation were set in place. A user interface appropriate for the application was created by using the findings from Chapter 9.

The result
The result from this chapter is a prototype of a virtial reality application created for virtual reality.

USER TESTS

Chapter 11 | Results from testing the Prototype

CHAPTER OVERVIEW

At this stage in the process, a prototype has been created based on the insights and methods from previous chapters. To get feedback on this prototype, it was tested by various users.

Content
This chapter presents the results and feedback from testing the prototype. Firstly, the test methods are presented. Secondly, the results from tests on students and lecturers are presented. Lastly, the results from tests with the project stakeholders, a TVI and a HVFD patient are presented.

Result
The results of this chapter is an overview of several aspects of the application which could be improved or changed. An overview of these are presented at the end of the chapter.

11.1 USER TEST | PROTOTYPE 1

Figure 11.1 |Student during user test 1

The prototype was evaluated through user tests. A total of three students and two lecturers at the Norwegian University of Science, ranging in age from 23 to 55, were tested. Each test lasted between 40 and 80 minutes.

The primary goal of this user test was to find whether navigation within the applications was intelligible, whether the users understood the instructions and if they were able to play each of the minigames. The test was also intended to uncover flaws and inconsistencies in the prototype, before testing it on patients

.

The focus of the tests was on each minigame, the menu and the controller. All questions were therefore asked concerning these elements.

11.2 QUESTIONNAIRES

Questionnaire set-up
After each test, the test subjects was asked to fill out two questionnaires. The first questionnaire utilized the System Usability Scale(SUS) [32], a Likert scale used to measure the usability of a system. The questionnaire contains ten statements related to the user's experience with the application. This scale is then used to calculate a score, which gives an indication of a system's usability. The full questionnaire and results are presented in Appendix D.4.

***System Usability Scale* score**
Average score: 84.25
Ranging from: 77 - 90
The prototype got an average System Usability Scale score of 83. This score is well above the average of 68, and indicates that *People love your product and will recommend it to their friends* [32]. However, for this project, it suggests that the users though it was user-friendly and easy to use.

Enjoyment scale
The second questionnaire was made to evaluate each minigame, the menu, controller and VR headset. It consisted of seven questions, asking the user to rate each element on a scale from 1 to 6. Similarly to SUS, this was based on a Likert scale, estimating how enjoyable the prototype was to the user. The full questionnaire and results are presented in Appendix D.4.

11.3 GENERAL FEEDBACK

This section presents the most important feedback from the user tests. The most important feedback was selected based on how many of the users gave this feedback and how critical they were to the prototype.

Unclear Purpose
Little information about the application was given to the test subjects in advance of the test. Some of them did not understand what the games was meant for and though that the application was a test of reaction time. Most subjects desired a more apparent overall purpose.

”

> *I'm not sure what I just accomplished. Is this meant as a reaction test?*
>
> Student 27

Straightforward to Navigate
The navigation system got positive feedback from the test subjects. All navigated throughout the application effortlessly and found each of the minigames with ease. However, on of the subjects said that the menu was somewhat cramped.

The reticle was also well received. The subjects said that it was visible and helpful, without being distracting.

Calm and Soothing Environment

All test subjects mentioned that the aesthetics of the applications was satisfying. They expressed that it was good-looking and calming. Most also liked the ambient music, although some noted that it could become bothersome in the long run.

Bugs

During the testing, all of the subjects ran into bugs. How these bugs impacted the test is difficult to assess. One of the most apparent bugs was seen when the center of the scene moved towards either the right or left. This forced some the users to change their sitting position while playing the games. The bug was fixed by restarting the application.

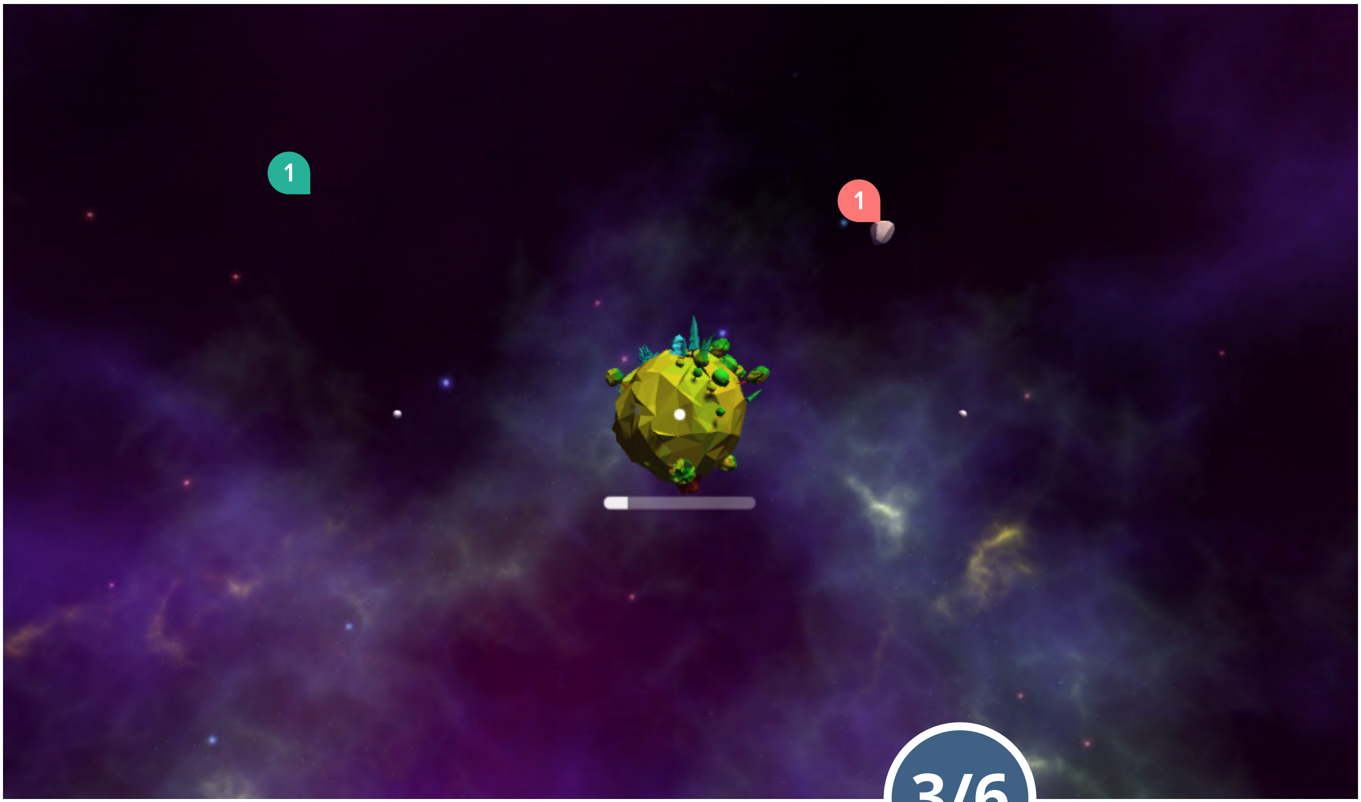
”

> *I liked the music and the atmosphere*
>
> Lecturer 32

Controller

The one-handed controller received very variable feedback. Most subjects initially though the joystick was a button, which it is not. Some thought it was small and clumsy, while others thought it was satisfying to use.

11.4 FEEDBACK | WARM-UP



3/6

Overview of feedback
Most of the subject liked this game. They did not think it was very entertaining but found it relaxing and enjoyable.

Level of enjoyment
The game got an enjoyment rating on 3 out of 6, which suggests that the game is neither boring nor entertaining.

1 **Relaxing and Soothing**

All subject said that the exercise was soothing. The background and music provided an enjoyable and calm setting, which allowed for the subjects to sit back and relax.

1 **Lack of Positive Feedback**

Some of the subjects expressed a lack of positive feedback when they were able to detect the blinking meteor.

Missing Tutorial

Some of the subjects felt the game started abruptly. The objective was not clear to all users, and some said that they did not know what to do. However, all subjects understood the objective before the game had ended.

Input was not Intuitive

The input method was not favored by the test subjects. Pushing the joystick to the right to stop the meteor from blinking was not intuitive. The affordance of the controller was to push downwards or upwards, which the users said would have had been more intuitive.

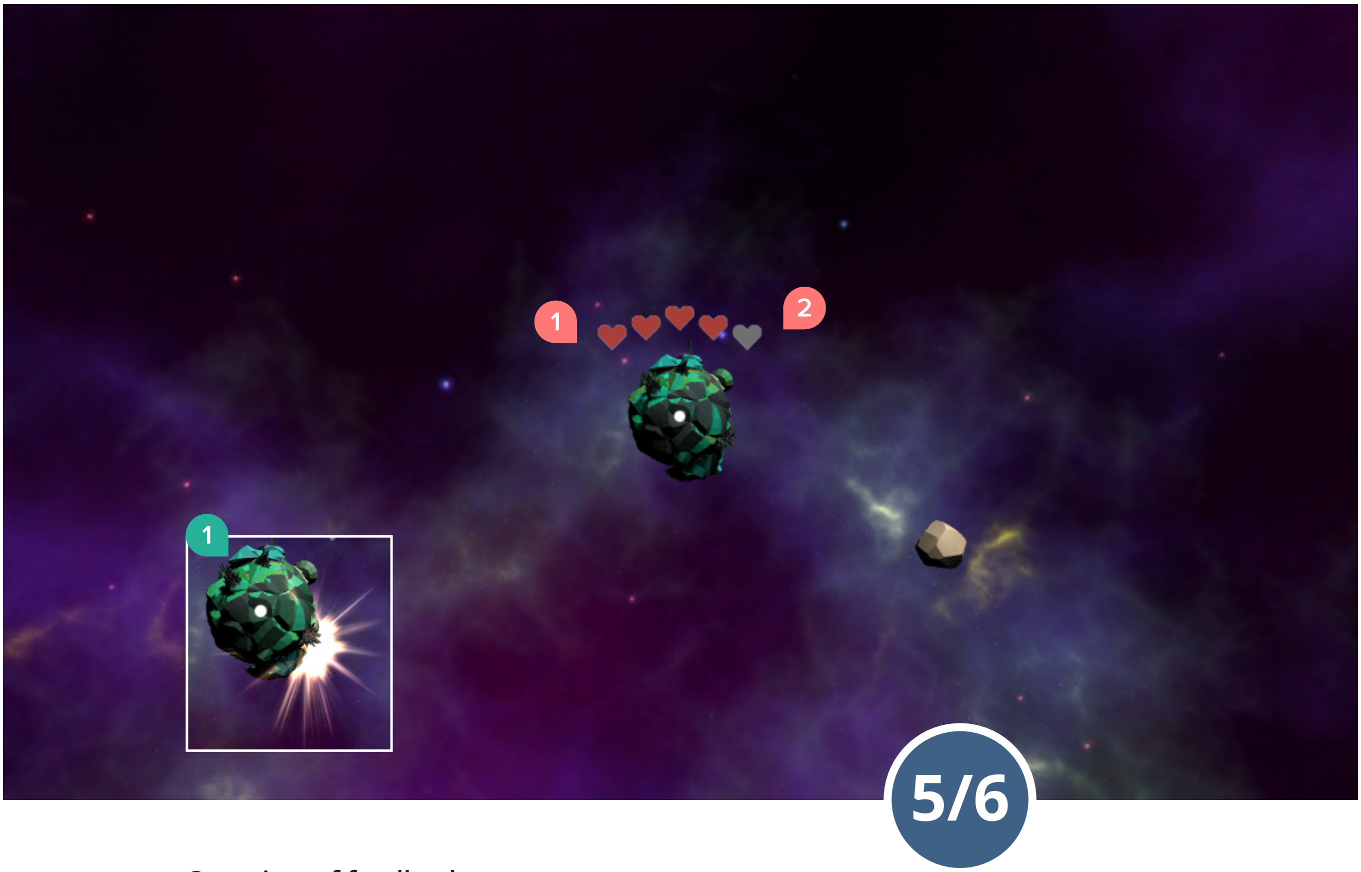
Feels like a Test

Some of the users expressed that Warm-up felt like a test. They said that the purpose and context were somewhat obscure and that they did not understand the purpose of the exercise.

Misleading Name

Some user thought Warm-Up was a tutorial and not a game on the same line as the other minigames. Some of the subjects were, therefore, expecting to see something more similar to a tutorial when the started the game.

11.5 FEEDBACK | METEOR SHOWER



Overview of feedback
All of the subjects enjoyed this game. They found it both motivating and intuitive.

Level of enjoyment
The game got an enjoyment rating on 5 out of 6, which suggests that the game is entertaining.

1 **Cool explosion, a bit intense**
All users liked the explosion at the end of the game. However, most thought it was somewhat intense.

Motivating
The game is motivating and has a clear goal, and was experienced as more engaging than "Warm-Up". Most users wanted to try again to improve their score.

Easy to understand
Users had a clear understanding of what they were supposed to do after hearing the instructions.

Intuitive mapping
All of the users though the mapping between controller and actions was intuitive.

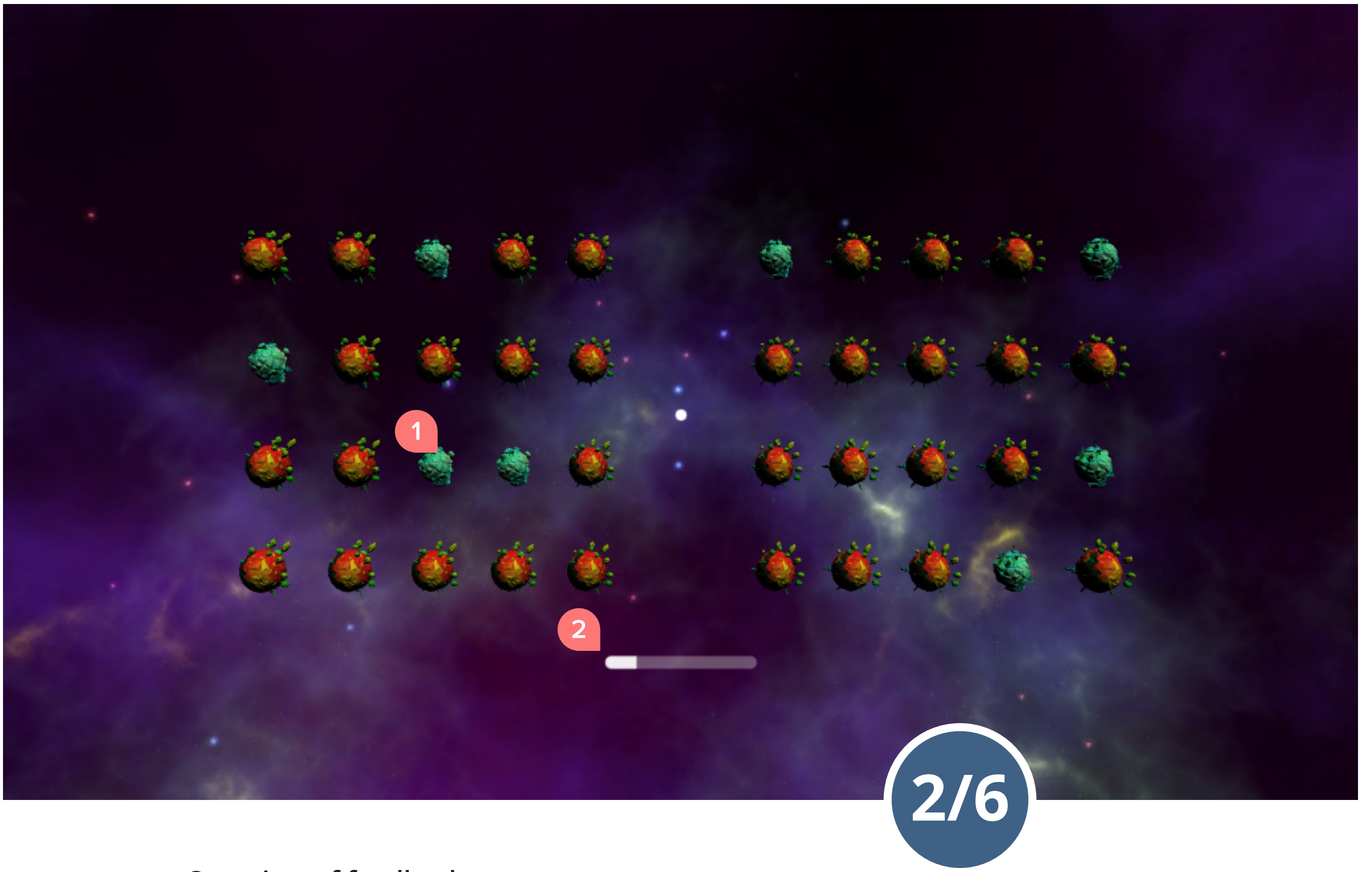
Relaxing
Even though the game is fast paced it was not experienced as stressful.

1 **Difficulty increase too quickly**
Most of the subjects thought that the game difficulty escalated too quickly as the game progressed.

2 **Double punishment**
When some of the users pressed the wrong direction, the meteor also hit the planet straight afterward. This resulted in the users losing two lives. Why this happened was not clear to all users, and it was experienced as a double punishment.

Not clear how the game is lost
Users did not realize how they lose in the game until they lose their first life. This often happens late in the game, which causes users to wonder how the game is lost.

11.6 FEEDBACK I PATTERN



Overview of feedback
None of the test subjects liked this game. They did not think it had any purpose and found it too easy to cheat.

Level of enjoyment
The game got an enjoyment rating on 2 out of 6, which suggests that the game is boring.

1 Unclear pattern

Not all of the subjects were able to understand the rules of the game at the beginning. Some though that the pattern could be arranged diagonally, while others thought that three in a row was not a part of the pattern. However, all subject were able to figure this out as they played.

2 No purpose

None of the subjects considered the game to have any purpose. While the goal is to detect as many patterns as possible within the time limit, this was not properly communicated to the users.

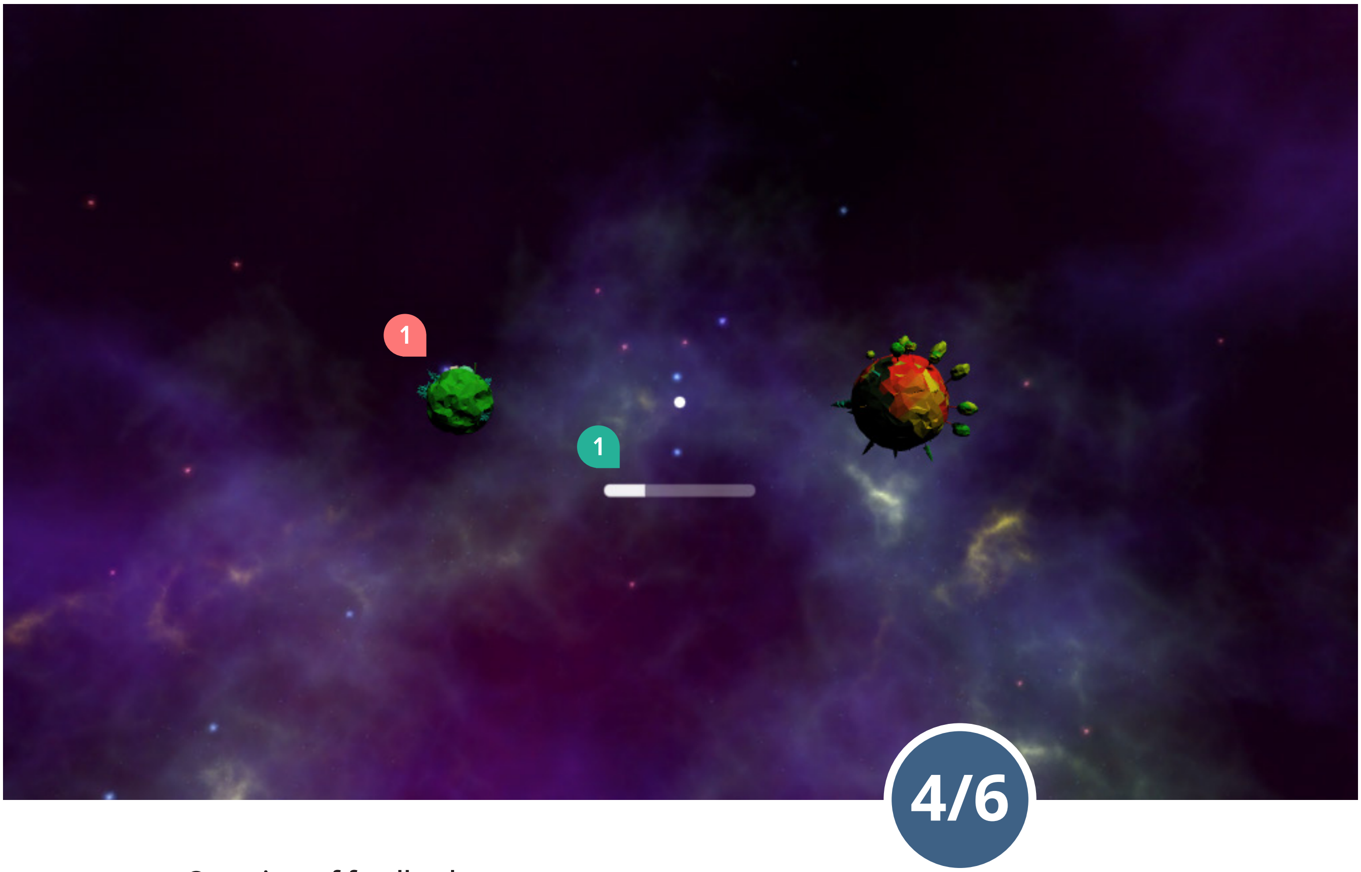
Cheating

Most users found that if they just looked at one of the grids, they did not have to look at the other. This technique allowed them to cheat, which spoils the purpose of the game.

Too long and little rewarding

None of the users thought this game was fun. Some though it lasted for too long, while others thought it was not rewarding.

11.7 FEEDBACK I TWINS



Overview of feedback
Most of the test subjects like the game. They thought it was challenging and enjoyable.

Level of enjoyment rating
The game got an enjoyment rating on 4 out of 6, which suggests that the game is more entertaining than boring.

1 **Clear purpose**

All of the users understood the purpose of the game. However, some though the game was somewhat long-lasting.

Challenging and fun

Most users thought that the game difficulty was suitable. They thought it started at an appropriate speed, which made it fun and challenging.

1 **Delayed feedback**

Some of the users thought the feedback seemed slow and delayed when they successfully found two matching planets.

Bad controller inputs

None of the subjects though it was intuitive to push the joystick to the right during the gameplay. Some said they would like to have another input for action.

11.8 FEEDBACK I TVI

After the initial tests with student and lecturers, the prototype was tested with a TVI, to evaluate the application's suitability for vision therapy and users with HVFDs. The test consisted of a presentation of our groundwork and a review and test of the prototype. This section covers an overview of the findings.

Figure 11.2 | Computer application

Visualization of performance

The TVI stated that getting an image of what the patient sees within the glasses would be very beneficial when used together with a TVI, see Figure 11.2. This would enable the TVI to easier evaluate and help the patient during training.

Showing progress

It is important that this device shows how a patient evolves, so that the TVI can use these results during vision therapy sessions both for motivation and evaluation. Computer applications in training are a great way to show progress, as the results are very visible for the patient.

Creating awareness
Creating awareness is one of the most important parts of vision therapy. To get a patient to fully understand the extent of the visual field loss it is important to show them how they are affected. Showing patients how they are affected works as a huge motivational factor for conducting vision therapy. It is important to remind them every now and then, it is not enough to show it to them once.

Level of difficulty
An aspect which was discussed during the meeting, was how the application could be adjusted based on the patient's level of skill. As the patient's level of skill is very different, they should be able to play at different difficulties. For a patient with severe impairments after stroke, which is just learning how to use the app, the difficulty should probably be significantly lower than for a patient who has used the application every day for two months.

The TVI said that the minigames "Twin" and "Pattern" were more difficult than the two others, and would be too difficult for some of the patients. For these games, an even simpler version could be valuable for some patients. The conclusion from the discussion was that all games would benefit from being scalable, to fit all patients level of skill.

The TVI stated that it would be beneficial to be able too adjust the difficulty of the games before they are given to patients.

Access to patients
The TVI said that this application was something she did not have any problems with showing to patients. She had two possible patients that could help during the test phase, and would contact them to schedule a meeting.

11.9 PROTOTYPE 1.1

This section presents the changes done on prototype 1 to prepare it for the final user test with a patient with HVFD. However, as the time frame between the test on the TVI and the patient was short, there was no time to do extensive changes, therefore the simple and important changes were emphasized.

Decreased difficulty
The overall difficulty of the games was lowered. In addition, the duration of the games was shortened.

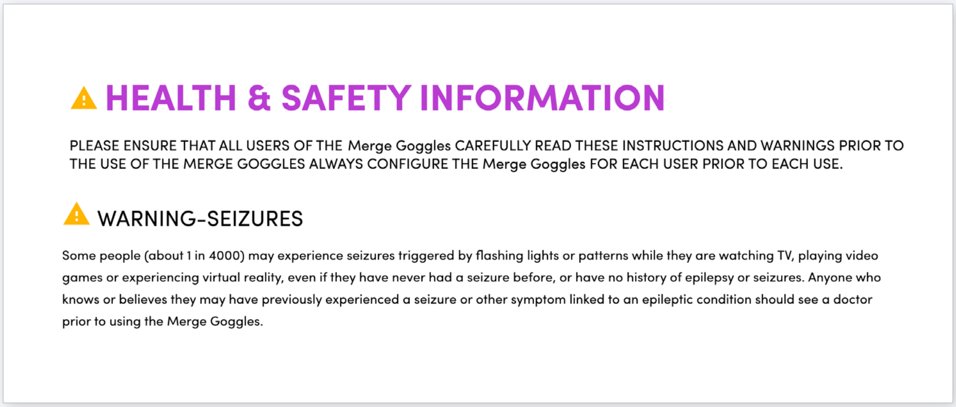
Removed possibility for cheating
The minigame Pattern was edited in order to remove the possibility of cheating. This was done by including the alternative to pushing up if no pattern is found. This way it is no longer possible to monitor just one of the grids.

Tutorial
There was no time to edit the tutorials before the user test. Instead, the patient was taught how to play the games by one of the students.

Modified inputs
The inputs were changed in several games. In both Twin and Warm-up, the primary input has been modified from “press left”, to “press upwards”, as this had proven to be confusing in previous tests.

11.10 TEST WITH PATIENT AND TVI

After the changes to the first prototype, the application was tested on a patient with a HVFD, in collaboration with a TVI.


HEALTH & SAFETY INFORMATION

PLEASE ENSURE THAT ALL USERS OF THE Merge Goggles CAREFULLY READ THESE INSTRUCTIONS AND WARNINGS PRIOR TO THE USE OF THE MERGE GOGGLES ALWAYS CONFIGURE THE Merge Goggles FOR EACH USER PRIOR TO EACH USE.

WARNING-SEIZURES

Some people (about 1 in 4000) may experience seizures triggered by flashing lights or patterns while they are watching TV, playing video games or experiencing virtual reality, even if they have never had a seizure before, or have no history of epilepsy or seizures. Anyone who knows or believes they may have previously experienced a seizure or other symptom linked to an epileptic condition should see a doctor prior to using the Merge Goggles.

Figure 11.3 | Health & safety information Merge Goggles

Epilepsy and virtual reality
Before the test, it was discovered that the patient previously had suffered from epileptic seizures as a result of the stroke. When using the Merge, and other VR headsets, it is recommended that people suffering from epilepsy get a doctor's evaluation before using the equipment. In order to not take any risks, the patient tested the games on a computer instead.

Collaboration with TVI
The user test was performed in collaboration with a TVI. The TVI observed the test and was responsible for the patient's wellbeing. The TVI paused the test by taking small breaks, ensuring that the patient did not feel discomfort. The patient has previously worked with the TVI, which helped create a more comfortable and familiar setting.

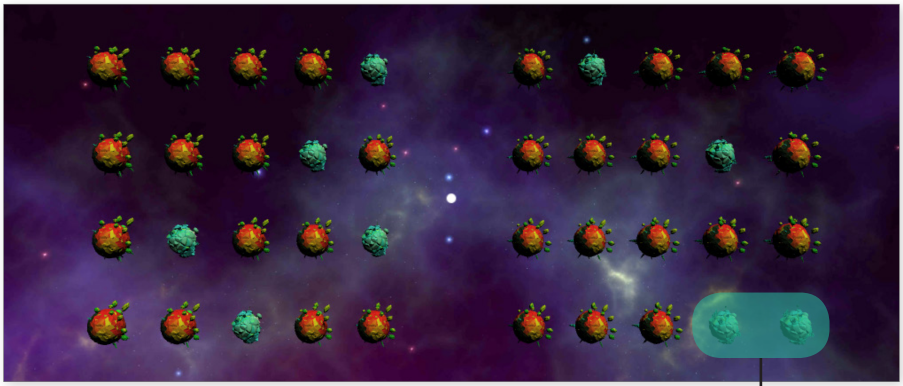


Figure 11.4 | Minigame *Pattern*

Pattern in the patient's blind area was overlooked

The visual deficit was evident
When playing the game "Pattern" the patient's HVFD became evident. When the two-in-a-row appeared inside the patient's blind area, the pattern was never found. However, the game did not manage to indicate this to the user, which meant that the patient was never informed about this.

Level of difficulty
The games Warm-up and Twin needed almost no explanation, and the patient almost immediately understood what to do. On the other hand, Pattern was experienced as more difficult than the other games, it was more difficult to teach the patient how this was played. The absent of proper feedback made this even worse.

Confusing feedback
Sometimes when the patient did a wrong action in a game, it was not always obvious to the patient why it was wrong. It was difficult to understand why the game gave negative feedback on what the user felt was the right answer. Two occurrences of this kept repeating themselves. In the minigame "Pattern" the patient chose "no pattern"

when the pattern occurred in the patient's blind area, which resulted in the patient getting negative feedback. In the minigame "Twins" the green and the blue planets are very similar in color and shape, and as the patient decided that these were the same, negative feedback was provided. The confusing feedback caused the patient to doubt whether or not the games were fully understood or believed that there was something wrong with the games.

What is the point?
During some of the exercises, the patient wondered what about the purpose of the exercises. The TVI told the patient that the goal is to be able to look to the affected side more efficiently, which did not satisfy the patient. Neither did telling the patient that reading skills and visual exploration would improve.

Reading Difficulties
Reading was not possible for the patient, which suffered from aphasia. All text which was not already supported by audio, had to be read out loud for the patient. The fact that the patient suffered from aphasia could also explain why some of the instructions were not properly understood.

Learning the games on computer first
The TVI thought that using a computer first would be a great way of teaching patients the games. By doing this, the TVI would be able to look at the screen together with the patient, and easier help patients who struggle with the games. The TVI also believed that learning the games on a computer first would make patients more confident when playing the games with the VR headset afterwards.

Color blindness
The TVI noted that the green and red planets used in some of the games could be a problem for patients who suffer from color blindness in addition to the HVFD.

11.11 USER TESTING SUMMARY AND REFLECTIONS

This chapter has presented several important findings from the user tests. The overall impression is that the application works, the theme is appreciated and that minor adjustments to the prototype can make a big difference. In addition, the tests indicate that the groundwork has been thorough, as some of the feedback from the users verify findings from earlier in the report.

This chapter elaborates on several areas of improvements. However, these have not been examined in this thesis. It is reccommended to assess these before further development and the pilot test.

This section presents the summary of the user tests, by pointing out **main findings and aspects which should be changed:**

General Feedback

- Navigation in the application is easy and straightforward.
- The games provide a calming and soothing atmosphere.
- The purpose of the application should be made more apparent.
- The objective in the minigames should, in general, be made more clear.
- Other options than text, can be beneficial for users

Controller Feedback

- The controller received variable feedback, both positive and negative.
- Inputs and actions should, in general, be tested and evaluated

Creating Awareness

Proper feedback should be provided, to highlight the areas where the users struggle. This could help increase the user's awareness of their HVFD.

Warm-up Feedback

- The game is neither boring nor entertaining.
- It lacks positive feedback.
- The purpose and objective of the game should be made more clear.
- The name should be changed to avoid confusion.

Meteor shower Feedback

- The game is fun and motivating.
- The objective is easy to understand.
- The game difficulty should be adjusted to every user.
- The timer/life system should be overhauled, to be more comprehensible.

Pattern Feedback

- The game is boring.
- The purpose and objective is not clear.
- The game mechanics should be examined to avoid possibilities for cheating.
- The game does not feel rewarding.

Twins Feedback

- The game is fun and challenging.
- The purpose and objective is clear.
- The feedback does not feel immediate.
- The game difficulty seems properly balanced.

Initial learning on a Computer

In order to get familiar with the application, users could first use it on a computer. This way it would also be easier for others to assist and help the user when learning.

Mirrored display

A monitor which mirrors what the users see inside the VR headset display could be beneficial for TVIs when presenting the games.

INTENDED USE

Chapter 12 | Write description here

CHAPTER OVERVIEW

At this stage, a prototype for vision therapy has been created. This chapter looks further into the applications intended usage scenario and motivational factors for use. It aims to discuss and reveal some of the aspects which could contribute to making the application more fun and rewarding to the user.

Content

This chapter starts by discussing the time frame for which this application is supposed to be used. Then some previously discussed motivational factors are brought up, to see how these could be employed and utilized in the application. Ideas and concepts which are meant to motivate the user are also presented.

Result

The results from this chapter are thoughts, ideas, and concepts for how the application could become more motivating to the user. Reflections on how these could be used are reflected on at the end of the chapter.

12.1 TIME FRAME

The intended time frame for patients to spend with the application is very firm. This section covers some initial thoughts on what this means for the application.

> "How to *motivate* people to *train* for 15 min, 3 times a day for *3 months*?"
>
> Design challenge

Figure 12.1 | Design challenge

Duration of training program

The application is intended to be used for vision therapy. From the workshop at ØH, see Appendix C.5, it was decided that the starting point for the project, was for patients to have two vision therapy sessions every day, however, this has been increased to three. Each of these sessions is supposed to last 15 minutes each, making a total of 45 minutes of use every day. This usage pattern is meant to last for about three months. With this model as a starting point, it is expected that each patient spends approximately 70 hours with the application, see Figure 12.1.

This usage scenario will be used as a starting point for this project. The focus when designing the first prototype will, therefore, be to facilitate for short but frequent intervals of vision therapy.

The design challenge

The main challenge with this usage pattern is to make the users use the application over an extended period of time and adhere to the training program. It is important to ensure that patients are motivated to use the application and that they are motivated to continue to use it over time.

12.2 MOTIVATIONAL FACTORS

This section discusses how patients can be motivated to do vision therapy. Section 5.8 brought up several important factors for making vision therapy motivating. These were; *Believing that it works, aimed at my problems, making progress visible* and *providing a sense of achievement*. This section discusses these factors and debate how they could be addressed in this project.

Believing that it works
Believing that vision therapy works is essential for the patient's motivation and is for many the sole reason they go through with it. This could be proven to the patient if their vision improves or if their everyday lives get easier from the therapy. However, for the patients to complete the therapy program in the first place, it is important that they believe in vision therapy and the application from the beginning.

This could be done by educating and convincing the patients about the effects of vision therapy before they start their training program, and ensuring that they believe it will help them. This could be done by health personnel, e.g. a TVI, by enlightening the patient about vision therapy or with a brochure following alongside the equipment, see Figure 12.2.

Aimed at my problems
Most patients said that therapy was motivating if it was aimed at their particular problems. While all minigames in the first prototype are relevant for all focus areas, namely, visual orientation, reading, and driving, this may not be communicated to the patient. The challenge lies in informing the patients about which areas it intends to improve.

This could be done by choosing a focus area before starting the session. The theme could then change appearance to and imply that it is meant for this particular focus area.

The application could also provide tests related to a patient's focus area. For instance, a reading test, which is conducted before and after training.

Figure 12.2 | Illustration of a brochure providing information about why the patient should conduct vision therapy.

Making progress visible

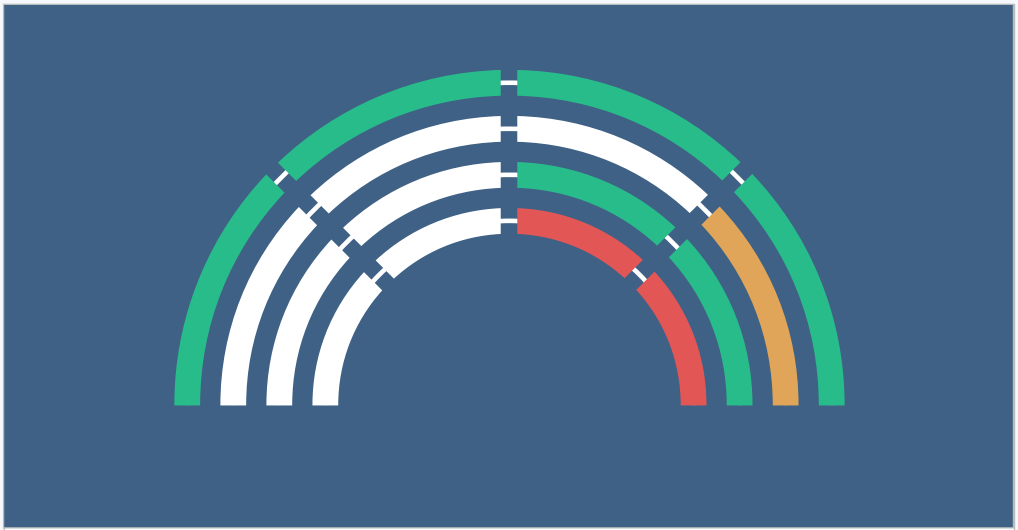
Making progress visible to patients is important to maintain their motivation for vision therapy. However, progress is related to several aspects of the therapy.

Firstly, progress can be about the games, showing how well the player are doing. Secondly, progress can be related to time, showing how much is left of the training program. Lastly, progress can be related to how the patient's vision improve or whether their everyday lives get easier.

Sense of achievement

Giving patients a sense of achievement is an important motivational factor. This could be done by making the game playable for the patient, giving them the feeling of mastering it. Rewards could also be used, to acknowledge the users, when they are following through with the therapy. Various gamification techniques can be used to provide a sense of achievement.

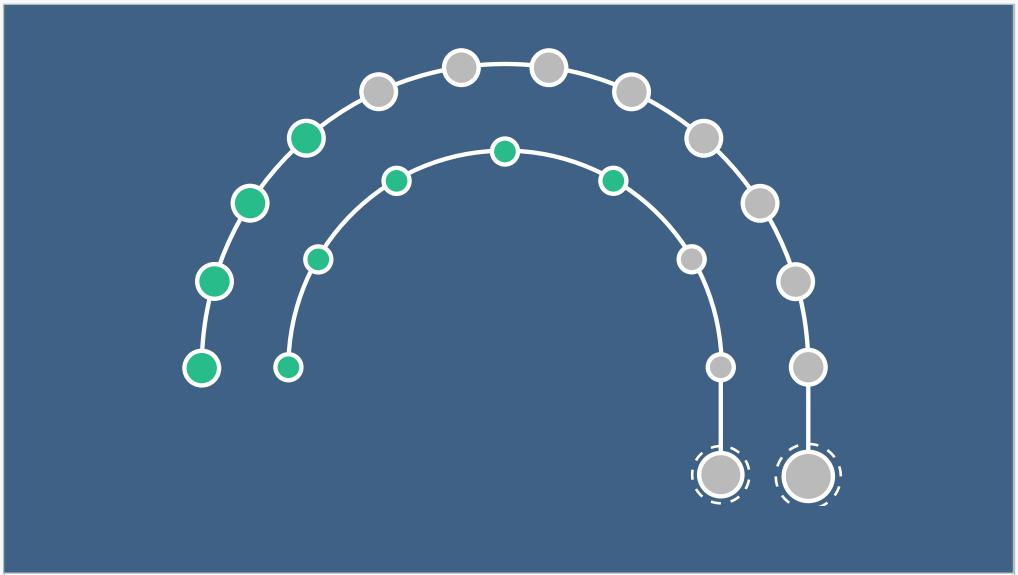
12.3 PROGRESSION CONCEPTS



Semicircle level bar
This concept is a suggestion for a level system. It contains four semicircles, representing the players level in each of the minigames. These semicircles fill up as the player plays the games, and rewards the player with a start every time he completes a semicircle.

Level bar
These could function simlar to level bars, which are common game elements used to show the player overall skill. This could be used in this application to give the player an indication of their overall skill and progress.

Implementation
The reason for these being semi-circles is to fit within the theme of the application. If this level system is to be implemented, it should be placed to fit naturally with the existing prototype.



In order to show the players their current progression in their training. A calendar like progression bar could be used.

Semicircle progression bar
The inner semicircle shows the number of days completed, while the outer circle shows the total number of weeks the player is supposed to finish. From this, the player can get an indication of how much of the program they have finished.

The idea is to make every day and every week a milestone to the user and to provide a sense of achievement when they are able to finish parts of their training program.

Implementation
This concept is a successor of the progression bars seen in Prototype 1. However, the concept would become more of an additional feature than an expansion of the existing feature.

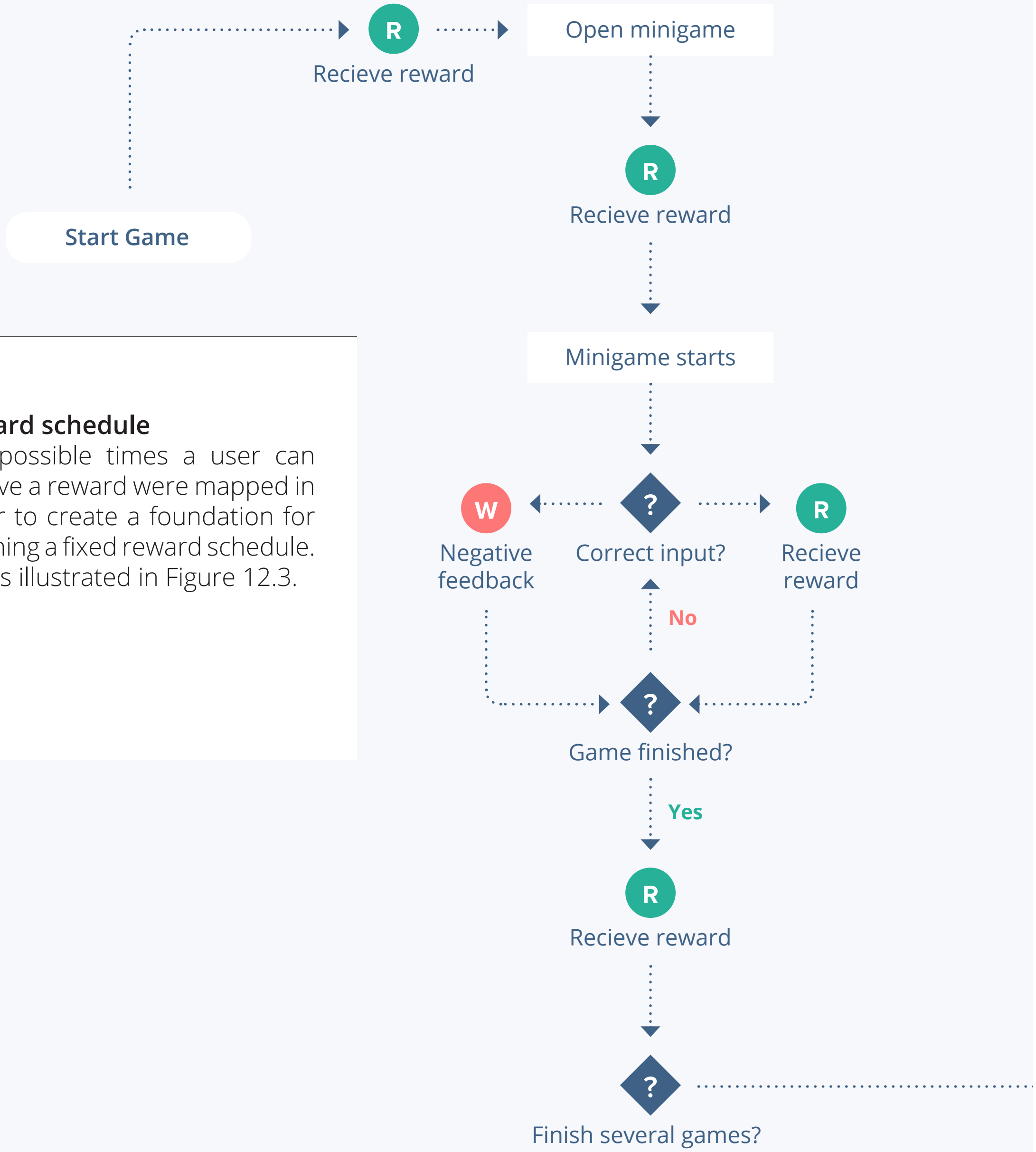
12.4 MAINTAINING MOTIVATION

This section looks at how to make users use the application over extended periods of time. A way of enforcing the continued use of the application is by rewarding the user for using it. This section looks at various ways of implementing rewards in the system.

Reward schedule
Reward schedules are used to reward players at either fixed or random intervals.

These schedules can be used to give the player a sense of achievement, by providing them with a reward if they succeed. This could be when they e.g. beat their previous record or if they play a given number of minutes.

Schedules could also provide players with a clear map of their progress. This could be done by rewarding the players for e.g. every game, every week or every month. Figure 12.3 provides a map over all possible points were rewards could symbolize progress.



Reward schedule
The possible times a user can receive a reward were mapped in order to create a foundation for planning a fixed reward schedule. This is illustrated in Figure 12.3.

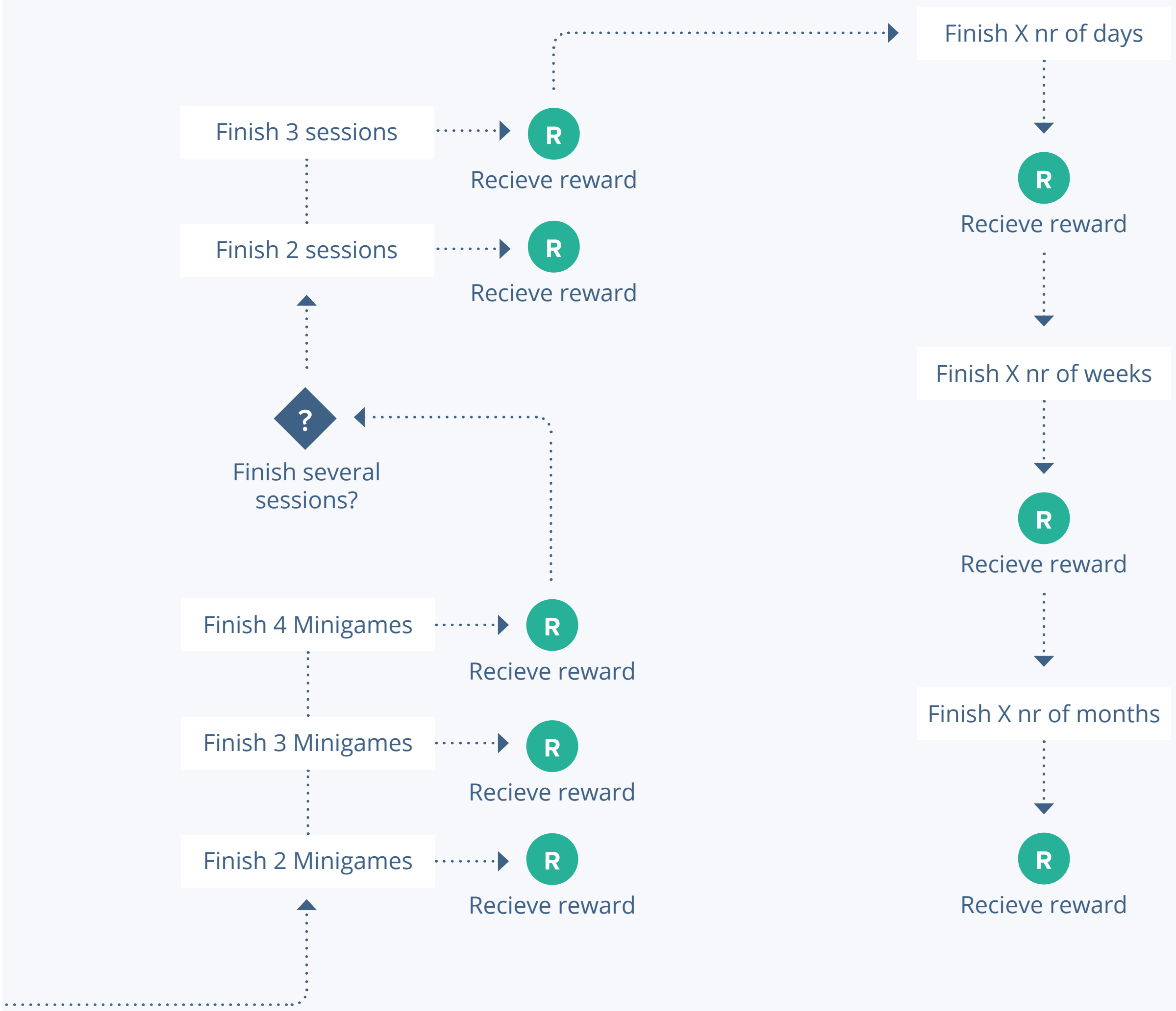


Figure 12.3 | Fixed reward schedule

Different kinds of rewards
There exists several examples of ways of rewarding players for playing. Below are some examples that could be implemented in this application. Marczewski lists 52 game mechanics[33], where those who are considered most relevant to this project are listed below.

Levelsystems - players reach new levels as they progress in the game. The goal of reaching the next level can work as a motivational factor.

Certificates - A way of recognising a players achievements is to use cerificates. A cerificate is a name or illustration indicating that the player is at a higher level than before, for instance going from novice all the way to expert.

Badges - Badges represents accomplishments, which players can work towards. These can represent anything a player can achieve and can be related to the number of times the game has been completed to the number of meteors catched in meteorshower.

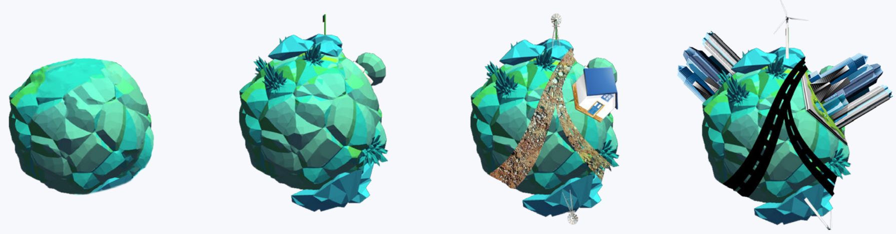
Unlockable/Rare content - By supplementing hidden and scarce elements the novelty level of the game can be increased. The anticipation of what comes next, can create motivation for the player to keep playing over time.

Virtual currency - The points players get from playing the game can represent a virtual currency, which the user can use to by in-game accessory or to unlock content.

Easter eggs - An easter egg is an object that the user discover by accident. These can be surprises or rewards, which are found in unusual ways, e.g. if the user gets curious and looks up, they are rewarded with a special item. Hiding elements in the virtual world can also enforce a feeling of discovery and exploration.

Enhancing the theme
Rewards can be used to enhance the story of the game, by using elements that are closely related to the theme. In Chapter 10.2 some elemets are mentioned related to the space theme chosen for this project, e.g planets, stars, astronauts, meteors and spaceships. Using elements such as these as rewards, can reinforce the theme and create a holistic experience for the user. The following sections contain different reward concepts that are regarded as suitable for the theme and the application.

12.5 REWARD CONCEPTS

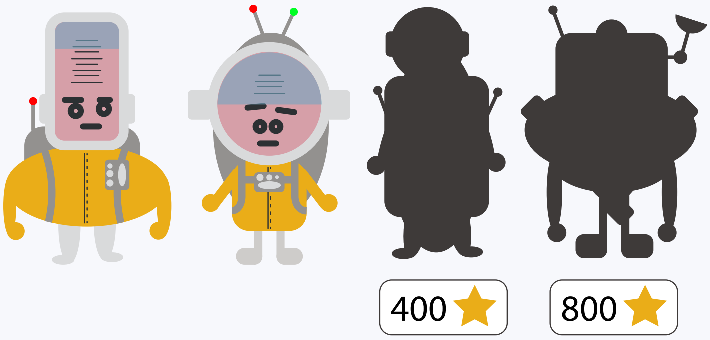


Planet Development
Planet development is a concept which is meant to engage the user, by showing their progression visually. For this concept, the players start out with every planet being blank and empty. The players objective is then to fill their planets with e.g. residents, buildings, and infrastructure.

Showing progress
As the players progress, they will receive rewards and upgrades to their planets. During the first phase of their training, they will recieve trivial items, such as mountains and plants. Then, as they progresses towards the end of their therapy program, the rewards becomes skyscrapers, roads or even inhabitants.

Unlockable content
These planets can also be used together with unlockable content. This could, for example, be receiving a unique item for playing 50 hours or achieving a new high score.

Implementation
This concept should be straightforward to implement into the current prototype. It only affects the existing planets in the system, and additional functionality should be added to these. However, a system which controls when and how the planets develop has to be created.



Companions
Companions is a concept where the players objective is collect astronauts. To begin with, the player is presented with a set of astronauts which are all locked. As the user progresses, more and more astronauts become unlocked.

Who is that Astronaut?
When the player first starts the game, all astronauts are locked, only showing their silhouette. The concept they work similar to the Pokemon guessing game; "Who is that Pokemon?". For the player to unlock astronauts, they have to collect stars, which they can the use to unlock the companion they want.

Achievement
The idea behind these astronauts is that getting one should feel like an achievement. Players do, therefore, have to save stars over a period of time, to unlock an astronaut.

Implementation
This concept is new and not related to the existing prototype. Whether it should be integrated into existing parts of the application or if it could exist separately should be explored. How the user collects stars should also be explored.

12.6 INTENDED USE SUMMARY AND REFLECTION

This chapter presents how motivational factors can be used to facilitate for use of the application over an extended period of time. It also presents some preliminary concepts for how this could be achieved.

Intended use
The intended amount of time to be spent with this application is 70 hours. Facilitating for use over time is therefore essential for this application. If more time were available, motivational factors would be interesting to look further into. This would allow for testing different concepts and find solutions to how the application can support that patients adhere to the vision therapy program.

Concepts and Gamification
The concepts that are presented in this chapter are thoroughly prepared but still preliminary, as they have not been tested on users. These concepts have to be tested over time, as they are not meant to provide motivation for short-time usage. It would be interesting to see whether these concepts provide motivation for using the application. Gamification techniques, in general, would be interesting to look into, to improve the overall experience of the application.

DELIVERY AND FUTURE WORK

Chapter 13 | Defines the delivery and presents thoughts on future work

CHAPTER OVERVIEW

At this stage in the process, several aspects relevant for the continuation of the innovation project has been brought up. Four methods for vision therapy has been created, suggested equipment has been select and a prototype has been made. This chapter aims to inform and reflect on how these are meant to be used and to highlight some of the aspects which need further work.

Content
This chapter starts by presenting what is considered to be the result and delivery of this master project. Then some reflections on the next steps for the innovation project are discussed.

Result
The results from this chapter is an overview of the result and thoughts on future work in this project.

13.1 PRESENTATION OF THE DELIVERY

The following sections present the delivery of this master thesis. This delivery consists of four main sub deliveries, namely; suggested equipment, four methods for vision therapy, a prototype of a vision therapy application meant for vision therapy and a project manual.

These will be presented alongside our recommendations.

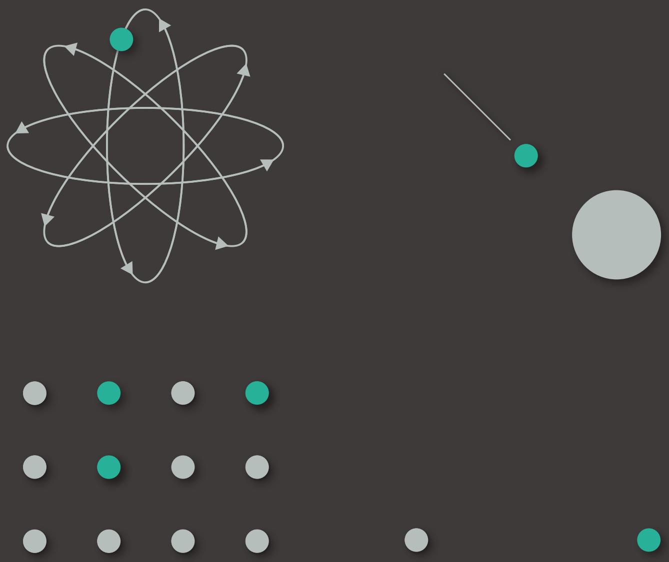
Reccommended
Reference book
Master thesis

PROJECT MANUAL

Master thesis
This thesis touches on many different topics, relevant for the innovation project. Many people are not familiar with these topics, and it is, therefore, important to make this information easily accessible.

Recommendation
The recommendation is to use this thesis as a reference book to find relevant information for the project.

Reccommended
Vision therapy methods
Warm Up, Scout
Search & Monitor



VISION THERAPY METHODS

Creating methods
The methods that have been created are meant to be specific, for the intended users and provide a complete program for vision therapy. These have been made to be easy to adapt and recreate.

Reccommendation
The recommendation is to use these methods as a framework for the development of the prototype for the pilot test.

Reccommended Equipment
Merge VR Goggles
Controller with joystick

THE MERGE VR & CONTROLLER

Equipment
The Merge was well received among users, with satisfactory buttons and a solid build quality. The remote that was used in this project received mixed opinions but proved that one joystick for input is sufficient for the indtended application.

Recommendation
The recommendation in this project is to utilize the Merge along with a suitable joystick controller.

Reccommended Application
Spacemission created in Unity

SPACE MISSION

Unity prototype
The prototype is a virtual reality application created in Unity. The prototype is built around the four methods for vision therapy.

Recommendation
The recommendation is to use prototype as a starting point for further development, or as a source of inspiration.


Oppvarming
Meteorregn
SPILL ALLE
Mønster
Tvilling

13.2 LOOSE ENDS AND FUTURE WORK

This master thesis leaves several loose ends. This section aims to highlight some of the aspects which are left untied.

Test results from Chapter 11
Chapter 11 covers several aspects about the prototype which could be improved or changed. However, these are never reviewed. It would be interesting to look into these aspects and test whether the prototype improves.

Game iteration
The minigames Pattern and Warm-Up received poor feedback from test subjects. One of the goals after the testing was to look into how these could become more entertaining. It would be interesting to iterate on these and see if they are possible to improve.

Concepts from Chapter 12
Chapter 12 discusses how motivational factors could facilitate for use over an extended period of time. The chapter also presents some concepts for how this could be achieved. This is something that would be interesting to look more into, as use over time is essential for this application. Concept development and testing on this particular subject would be a logical next step.

Introduction to patients
This thesis does not touch on how the application is introduced to the patient. However, several ideas for how this can be done, have emerged during the project. During the test with the patient, two ideas were mentioned. The first was starting the training on a computer, before transitioning to virtual reality. The other was a mirrored display, for e.g. a TVI to help explain the content to the patient.

Adapting the training
In order to adapt the application to each user, settings and adjustments could be introduced. This could enable users with severe reading difficulties to e.g. activate voiceover or to increase text size. This has not been in discussed in this thesis, but would be interesting to look into.

Adjusting the difficulty
The current plan for the application is to be adjusted to the patient's level of skill automatically. However, there could also be introduced an option to adjust the difficulty manually. A settings menu could, for example, be used to set relevant parameters for each patient before they start using the application

Testing other themes

A theme was chosen during the concept development process, to be used as a framework for creating a complete application. More time would have allowed for testing other themes, to see how the game would have turned out. One assumption is that the result would have been similar. However, it could also have resulted in something entirely different.

Voiceover

The current prototype is based on little amounts of text. The text that is used is also short, precise and mostly supported by audio. However, some users with HVFDs are not able to read text altogether. It would, therefore, be interesting to see how voiceover can be used throughout the application and to see if this could make it manageable for those who are illiterate.

Facilitate for fatigue and tiredness

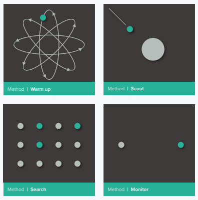
Several of the target users struggles with fatigue and excessive tiredness. It would be interesting to look further into how these problems could be accounted for in this application. By facilitating short and frequent breaks, this could have a huge impact on the experience for those users who struggle with fatigue.

Further valitation

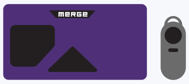
This project has been conducted in close collaboration with TVIs. However, it would be interesting to have an even more elaborate test of the methods and the prototype. This would hopefully validate that the project is heading in the right direction, or possibly highlight pitfalls which have not been detected during this master project.

13.3 CONTINUATION OF THE INNOVATION PROJECT

Master Thesis
A reference book



Methods for Vision Therapy
4 methods for vision therapy



Suggested Equipment
Merge and controller

Early Prototype
Protoype for vision therapy

Tieing loose ends
This thesis mentions loose ends that should be looked into before the pilot test

Medical evaluation
Evaluation of the result, and an assessment for whether this application is useful for vision therapy

Further development
More user testing and further development of the prototype.

Pilot test
Testing the prototype on patients with HVFDs.

Our thoughts on the continuation
The delivery presented in this chapter is thought to be used as a starting point for further development. The previous section presents loose ends that should be looked into before creating the final prototype for the pilot test. The evaluation of the pilot test will determine the future of this innovation project, and whether this equipment will be available to patients with HVFDs

EVALUATION

Chapter 14 | Final thoughts on this project

CHAPTER OVERVIEW

At this stage in the process, the final delivery has been presented, alongside lose ends that should be looked into before the continuation of the project. This Chapter aims to reflect upon this thesis and evaluate the results presented.

Content
This chapter starts by evaluating how this thesis contribute to answering the research questions formulated in the scope of this thesis. Then some reflections upon aspects challenging with this thesis are discussed.

Result
The results from this chapter is an overview of our assessment of this thesis .

14.1 EVALUATING THE RESEARCH QUESTIONS

In the introduction to this thesis, two research questions were defined. This section elaborates on how these questions have been answered, and the validity of these answers.

Research Question 1

What should a virtual reality application contain in order to be useful for vision therapy?

Answer

Our answer to this question is the four vision therapy methods; Warm up, Scout, Monitor and Search. These are meant to provide a complete program for vision therapy, as well as being suitable for a virtual reality application.

How

These methods have been created in collaboration with TVIs to make sure that they are proper for vision therapy. They have also been tested using a virtual reality headset, to see whether they are possible to carry out in virtual reality.

Validity

The feedback from the TVIs and the results from the tests, provide a promising foundation for the methods to be successful. Nevertheless, whether these methods provide a valid answer to the research question is difficult to evaluate. However, this answer will be provided by the pilot test conducted by Attensi and Østfold Hospital Trust.

Research Question 2

How can the application be adapted to the intended users?

Answer

This question is difficult to answer concisely, as it is very open. However, the answer to this is a suggestion for how a virtual reality application could be designed.

How

Our approach has been to involve relevant stakeholders, to gain insight into the needs of intended users, and how to design for virtual reality. The result is a prototype, which has been designed with this insight in mind. One of the primary goals has also been to highlight relevant challenges common to the target group, for the later stages of the innovation project.

Validity

The prototype was evidently user -friendly to the students and professors that were tested. However, only one patient with HVFD has tested the prototype. It is therefore difficult to evaluate how suitable the prototype is for the intended users.

14.2 REFLECTIONS

Starting the project

A task description from Østfold Hospital Trust was provided at the beginning of this project. However, this turned out to be more open than first expected. The beginning of the project was, therefore, an exploration into various subjects which were both relevant and not relevant. While it was not difficult to get started, it took some time before a constructive approach was found.

Figure 14.1 | Image from the method creation workshop at ØH

Creating methods for vision therapy

At the beginning of this project, it was thought that finding a suitable method of vision therapy would be straightforward. However, this quickly turned out the be wrong. It turned out that vision therapy is more complex and less mature field that it first seemed. As a result, the insight phase of this project ended up lasting for almost 10 weeks, more than twice as long as planned. As a result, this resulted in a deeper insight into vision therapy than intended. This insight used to create four vision therapy methods spesifically for this project, rather than using existing ones.

Getting hold of users

Getting hold of people with HVFD has been one of the biggest challenges in this project. Several hospitals, emergency rooms, TVIs and rehabilitation clinics have been contacted in an effort to get in touch with patients.

Throughout the project, seven patients have contributed to the thesis. Six users within the target group were met at Hurdal, during the initial phase of the project, helping with the insight into the condition and vision therapy. These participated in testing the VR equipment and shaping the project in its initial phase. However, only one person with HVFDs has been able to test the prototype. While this was valuable, more people should ideally have tested and provided feedback on the prototype. Then again, this has turned out to bee a lot harder to achieve than expected.

Testing and Prototyping

The initial plan for this project was to have an iterative design process. This plan was to develop concepts and prototypes continuously. Conversely, has the process been slow and challenging, as several aspects of this thesis have been harder than anticipated.

Firstly, the insight phase took more time than expected, as explained previously in this section.

Secondly, the concepts became more challenging to prototype than expected. While Unity3D proved to be an efficient prototyping tool, the concepts quickly became too complex to prototype. As the plan was not to spend unnecessary time with development, only one functioning prototype was created.

Designing within strict frames
After creating the four methods for vision therapy, these provided a strict frame for designing the rest of the application.

These facilitated an efficient design process, as they provided a solid foundation to build upon. This is also evident from the prototype. However, they were also limiting. During the initial phase of the project, several ideas and concepts were created. These had to be disposed of, as they had no ground in vision therapy.

Designing for virtual reality
Designing for virtual reality is very different from other applications. An interface in VR is in no way comparable to an interface on a traditional display. Designing for this type of application is new to both authors, and has proved to be a challenge. When creating ideas and concepts, sketches has provided a poor visualization of the design. However, as the application has been relatively straightforward in both function and number of elements, this has not been a major pitfall.

Collaboration with TVIs, patients and project stakeholders
A lot of people has been involved in this project. The main participants have been TVIs, patients and the project stakeholders. These have involved throughout the project. and provided valuable contributions. Users from the target group have been part of shaping the path for this project from the beginning and provided a valuable insight into their needs. Their contributions have been used deliberately when working on this project. The TVIs has functioned as advisers and teachers in topics relevant for vision therapy. The project stakeholders have provided a foundation for this project to build upon and contributed with support and valuable feedback throughout the project.

While not all of these contributors has been easy to get hold of, they have all been a joy to work with.

ACRONYMS

Appendix A | Presenting abbreviations and acronyms

ADL Activity of Daily Living

App mobile APPlications

AViST Audio-Visual Scanning Training

Cardboard Google Cardboard

CVT Compensatory Visual field Training

EST Explorative Saccade Training

Gear Samsung Gear VR

GUI Graphical User Interface

HMD Head Mounted Display

HSMS Hurdal Syn- og MestringsSenter

HUD Head-Up Display

HVFD Homonymous Visual Field Deficits

Merge Merge VR Goggles

TVI Teacher of students with Visual Impairments

UI User Interface

VFD Visual Field Deficits

Vive HTC Vive

VR Virtual Reality

VRT Visual Restoration Therapy

VRUI Virtual Reality User Interface

VST Visual Scanning Training

ØH Østfold Hospital trust

DEFINITIONS

Appendix B | Defining terminology

APPENDIX OVERVIEW

This appendix gives an provides definitions of spesific terms used in this project

Affected Visual Field
In this report does this refer to the parts of the visual field that is lost.

Agnosia
A condition resulting in a reduced ability to recognice objects.

Aphasia
A condtition resulting in a reduced ability to comprehend and formulate language

Apraxia
An impairment in the muscles responsible for speech.

Binasal Hemianopia
A variation of hemianopia where the vision is lost in the inner half of the visual field.

Bitemporal Hemianopia
A variation of hemianopia where the vision is lost in the outer half of the visual field.

Contralateral
The opposite side of the body, relative to a given point.

Contrast sensitivity
Referes to the ability to distinguish between brightness and colors

Diegetic interface
User interfaces that exists within a game world

Extraocular muscles
The six muscles responsible for eye movement

Farsightedness
A condition resulting in distant objects are seen more clearly

than close objects.

Field of view
The extent of the environment which the eyes are able to see

Fixation
The eyes are maintaining their gaze on a single location.

Game mechanic
Rules or methods which defines what a user is allowed to do within a game.

Gaze Cues
A visual cue that activates on a user gaze.

Head mounted display(HMD)
are worn on the head and provides the wearer with one display in front of each eye. The two displays provide the user with stereoscopic vision of a virtual environment.

Head-up display(HUD)
A transparant display. which displays informaion that is available to the user all the time.

Hemianopia
A condition where the vision is lost to one side.

Homonymous visual field deficit (HVFD)
A condition where parts of the vision is lost to the same sides in both eyes

Ipsilateral
The same side of the body, relative to a given point.

Light sensitivity
Referes to the tolerace of light

Nearsightedness
A condition resulting in close objects are seen more clearly than distant objects.

Non-diegetic interfaces
User interfaces that are not part of the game world

Oculomotor control
Eye movements controlled by the optic nerve

Perimetry tests.
A test intended to detect dysfunctions in the visual field.

Quardrantanopia
A condition where a quarter of the vision in lost.

Reticles
In this thesis, is this refered to an object which indicates where a user is looking.

Saccadic movement
A quick ballistic movement by the eyes, with the goal of chaning the fixation point.

Scotoma
A condition where small parts of the vision are lost.

Search strategy
Is in this thesis refered to as consciously planned or "random" series of saccades and fixations undertaken when viewing a scene.

Smooth Pursuit Movement
A smooth movement by the eyes, to follow a moving object

Stroke
An interruption of blood supply to the brain, which causes brain-cells to die damage

Transient ischemic attack
A short interruption of blood supply to the brain

Vergence Movements
A movement to align the eyes when looking at an object.

Vestibulo-Ocular Movements
A smooth movement by the eyes, to compensate for headmovements while following an object.

Virtual environment (VE)
A three dimensional computer generated environment.

Visual acuity
Referes to the clarity of vision

Visual field
See field of view

Virtual Reality Headset(VR headset)
See head mounted display
Virtual World
See virtual enviroment

Vision Therapy
Therapy of the eye-brain connections that are involved in vision

Visual field deficit(VFD)
A condition where parts of the vision is lost.

Visuospatial neglect
A condition where the brain neglects parts of the visual field.

INTERVIEWS & WORKSHOPS

Appendix C | Summaries of the workshops and interviews

APPENDIX OVERVIEW

This Appendix provides summaries of the interviews and workshops that has been conducted thoughout this project. These starts with a short introduction and ends with an overiew of the main findings.

C.1 MEETING I ATTENSI

About the interview

People attending
Anne Lise Waal (CO Attensi)
Iselin Kanstad (Design Student)
Martinus Ishoel (Design Student)

Method
Interview at Attensi as

Agenda
- Introduction to the company
- Students present their progress plan and planned delivery.
- Establishing roles
- Student questions

Purpose of meeting
Meeting our contact person in Attensi, get to know the project and establish our and Attensi's role.

Students contribution
The plan is that the students develop a concept that Attensi can continue to work with when the master thesis is finished. This is meant to be used in a pilot test with patients. How finished the concept will be is difficult to evaluate, the delivery can be everything from a visual representation of a concept to a simple prototype in VR.

Help from Attensi
Attensi can contribute with knowledge about VR, and have developers that can contribute if this is necessary.

Homonymous hemianopia
A visual deficit caused by having a stroke. The goal of this project is to create a device that teaches patients to compensate for the deficit. Compensation is done by learning to move the eyes efficiently over to the blind area. This can be done by putting visual stimuli in the

affected field of view. It is important to keep the head still and only move the eyes.

Cheap and easy
It is important that the solution is affordable and easy to use for the patients. VR has to be super easy!

Gear VR
Gear VR is recommended as a suitable device for this project. Because it is cheap and relatively easy to use. The trackpad on the side is tricky in the beginning but is easier to use after some time.

Findings
Focus on creating a cheap solution
The VR solution has to be easy to use for the patients.
Attensi can help with development if this is necessary.

C.2 INTERVIEW I PROJECT MANAGER

About the interview

People attending
Jarl Schjerverud (Project Manager)
Iselin Kanstad (Design Student)
Martinus Ishoel (Design Student)

Method
Skype interview

Agenda
- Plan workshop
- Define project
- Jarl presents project problem statement
- Jarl presents his initial idea
- Student questions

Purpose of interview
Introduction to the project

Scheduling workshop
A meeting at SØ hospital was scheduled. This is the first official meeting in the project, both for the students and the main stakeholders, and marks the official start of the project.

The patient's vision does not improve
Vision therapy is not about improving a patient's vision. It is about teaching patient's techniques for compensating for the lost visual field. The goal is to teach the patient to look to the blind side.

Rented out to patients
It is very important that the equipment is cheap. The goal is to create a device and program that can be provided to as many patients as possible.

This is a science project
The goal of this project is to test the medical effect of the equipment.

Limited field of view
VR equipment has a visual field of about 110 degrees, this might be a problem for effective vision therapy.

This Illustrates what is shown inside the VR-headset
(simplified, stereoscopic view is not shown)

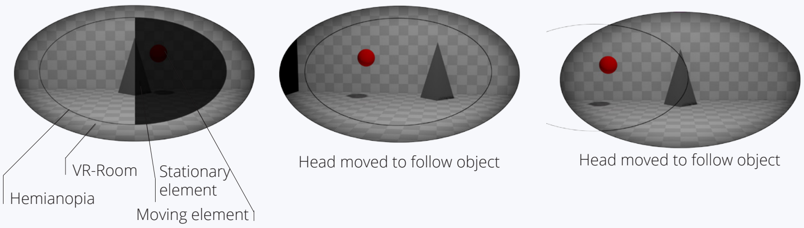


Figure C.1 | Illustration of idea, made by Jarl Schjerverud

Jarl's initial idea

Illustrated in Figure C.1. An empty room with a statue in the middle. Follow a ball which switches between being red and green, and moves in a specific pattern.

Findings

- This is a science project
- Vision therapy does not make the visual field larger.
- The plan is that the hospital lends out the VR headset to patients.
- The limitied field of view in VR might pose a problem for vision therapy.

C.3 INTERVIEW I NEUROLOGIST

About the interview

People attending
Volker Solyga (Neurologist)
Iselin Kanstad (Design Student)
Martinus Ishoel (Design Student)

Method
Mail exchange

Agenda
Questions covering following fields:
- About patients with HVFD
- What is required of the solution to enable self-service rehabilitation at home?
- Virtual reality and compensatory techniques

Purpose of interview
Get to know more about the patients who suffer from HVFD and the condition itself, more about compensatory techniques and the benefits and disadvantages of using VR in this project.

About patients with HVFD
The patients in this project can not be directly rehabilitated, as the patient's vision can not improve. We aim for compensation, not recovery. The relevant candidates will probably not have big difficulties with using smartphones, apart from that their vision does not function properly. Isolated occipital infarcts are not connected to cognitive dysfunction, and have no impact on the mental state of a patient with HVFD. HVFD is usually first discovered through a clinical examination, and then through perimetry (machine measuring field of view). Patients with hemianopia usually manage well in everyday life.

Self-serviced at home
It should be possible for a clinician to follow up progress. This will be a priority and an opportunity for research (both

before and after training). The solution should be self-service, both mounting and the use of the device. The application will most likely not be able to give feedback on progress, but in the future, it might be possible with eye-tracking within the VR headset. Then we will be able to follow the patient's eye movements. If patients have other stroke-related impairments, they might have other kinds of rehabilitation exercises they have to do at home. Then they will be in need of interdisciplinary rehabilitation team, with for instance a physical therapist.

Virtual reality and compensation

The compensatory techniques that are most effective are saccades over in the hemianopic field. The use of VR might cause patients to get headaches and nausea. Whether or not motion-sickness are more troublesome for patients with visual defects or not, is difficult to assess. This might be the case, and will become evident during the pilot test. To have an effect, the least amount of vision therapy required is assumed to be 15 minutes two times a day for six weeks. This will at least be the starting point. But more reaseach has to be coducted before a conclusive answer can be provided.

Findings
Clinicians should be able to follow-up a patient's progress.
Perimetry is used for examination of the visual defect.
The solution should be self-service, both mounting and use of device.
Saccades over in the hemainopic field is an effective compensatory technique
Suggested amount of vision therapy is assumed to be 15 minutes, two times a day for six weeks.

C.4 INTERVIEW I NORWEGIAN ASSOCIATION FOR STROKE

About the interview

10:00 - 12:00

People attending
Arne Hagen
(Head of Norwegian Association for Stroke)
Iselin Kanstad (Design Student)
Martinus Ishoel (Design Student)

Method
Interview at Arne Hagen's house

Subjects for discussion
Questions covering following fields:

- What happens to the patient after the stay at the hospital?
- Who are responsible for stroke patients at home?
- Visual deficits and available rehabilitation offers
- Home rehabilitation, possibilities and disadvantages
- About stroke patients at home, common impairments and the problems they face

Purpose of the interview
The goal of interviewing the head of the Norwegian Association for Stroke patients was to get a better overview of the system surrounding stroke patients with visual field deficits, with a focus on what rehabilitation offers this patient group has today. Also, questions surrounding home rehabilitation were discussed.

Adult education
In Norway hearing, vision, and speech are not included in the public health system. This means that if you get problems with your vision after stroke, you have to contact the adult education system in your municipality to receive help.

The municipality is responsible
When a stroke patient returns home after the stay at the hospital, the municipality is responsible for the patient's welfare. The municipalities have ambulatory teams that are responsible for a safe trip home for the patients. This is an interdisciplinary unit, often consisting of physical therapists, occupational therapists, with available doctors and nurses. The quality of this team is highly dependent on the size of the municipality, and both small and big municipalities struggle. In small municipalities, there is often a lack of people, and the ambulatory team might consist of one physical therapist with a 10% position. The municipalities that have the best

ambulatory teams are the ones with 10 - 20 000 residents. The ambulatory team in Trondheim is very good, and far ahead in this field.

Difficult to get help

Vision therapists and speech therapists are rare in Norway. Few municipalities have available therapists, and many of the therapists have private practices. If you get lucky and get hold of a therapist, there is an issue with payment for the services. As the public health system does not have the responsibility, and the municipality does not have the money, the patient often have to pay for this themselves.

The association for the blind in Norway have facilities that offer vision therapy for patients with HVFD. Hurdalssenteret in Akershus is one such facility that provides great support for stroke patients with HVFD. The patients who are allowed to attain the courses at Hurdalsenteret get knowledge about their deficit and advice on how to train their vision, and how to resume life with a visual impairment.

Next of kin is essential

It is often next of kin who contacts rehabilitation facilities and adult education.
The patient themselves often struggle with organizing this themselves, as they often are reduced due to the stroke and because of the big life alterations several go through post stroke. As next of kin often are responsible and help the patient a lot, the patients who do not have next of kin who can take care of them. The municipality often lacks the capacity to help, and some patients end up in nursing homes instead of going home as no one can take care of them at home.

Rehabilitation at home

Rehabilitation at home can be difficult if the patient has not been to a rehabilitation facility first. After a stay at a rehabilitation facility, the patient learns exercises and gets the aids they need for their impairments. The patients who go directly home does not receive rehabilitation exercises directly from the hospital and has to find and pay for the aids they need. To get rehabilitation exercises to the patients who are sent directly home, the ambulatory team has to write a training schedule, which is then sent to the municipality, and after that sent to the patient.

Rehabilitation at home can be especially difficult if the patient does not have someone to educate them and help them understand. It is necessary to have someone who can teach the patient what to do in the beginning.

Becoming aware of the deficit

The hospital is responsible for checking the patient's vision before the patient leaves the stroke unit. This does not always happen, as there often are other impairments that take priority, and the stay at the hospital usually only lasts for ten days. Patients can be unaware of their deficit as a result of this, and if the patient's vision is somewhat ok, they do not consult an eye specialist.

Stroke patients get easily tired

Most stroke patients get easily fatigued post stroke. The first 4-5 months are the worst. When doing rehabilitation exercises the periods of rest are as important as the training itself. Computers can be especially tiresome, as the brain works continuously without breaks.

Findings
Adult education is responsible for training of vision.
Offers for vision therapy is limited
Municipality responsible for stroke patients who have returned home
Next of kin usually contact rehabilitation facilities and find offers suitable for the stroke patient
Rehabilitation at home is difficult for those who have not been to a facility first
Other stroke related impairments often take priority over the HVFD.
Fatigue post stroke is common and lasts for several months

C.5 WORKSHOP | PROJECT INTRODUCTION

About the workshop

People attending
Volker Solyga (Neurologist)
Jarl Schjerverud (Project Manager)
Ingunn Olsen (SØ)
Anne Lise Waal (CO Attensi)
Stine Tanggaard (Attensi AS)
Iselin Kanstad (Design Student)
Martinus Ishoel (Design Student)

Method
Presentation/Interview/Discussion

Agenda
- Presentation of people and project
- Presentation of HVFD and compensatory training by Volker
- Student questions
- Group discussion covering: REC, scope, future plans

Purpose of the workshop
We had previously met all the main stakeholders in this project, with an exception of Volker Solyga. However, this was the first time everyone involved in the project met at the same time.The main goal of this workshop was to set the scope of the project and clarify every person's role in the project.

Hemianopia
During the presentation held by neurologist Volker Solyga, he presented several estimates he claims to be more correct than those found in most literature. He agrees that in Norway about 15000 people experiences a stroke every year. However, he estimates that about 25% of these has a visual field defect as a result from this, opposing to the 60% suggested by the Norwegian Association of the Blind and Partially Sighted. Lastly, he estimates that about 5% of these patients suffers from just Hemianopia, without other impairments. These numbers suggest that roughly 4000 people suffer visual field deficits every year, while about 200 only suffers from Hemianopia and nothing else.
Note: All numbers mentioned in this paragraph is just estimates.

Compensatory training

He also opposes Nova Visions visual restoration training(VRT) [34], and the findings that this therapy has the possibility decrease patients visual field deficits(VFD) [35]. Solyga supports the claim that compensation training can have a good effect for patients. He mentions Explorative Saccade Training(EST), Visual Scanning Training (VST) and Audio-Visual Scanning Training (AViST) as good methods for improving patients visual searching strategies.

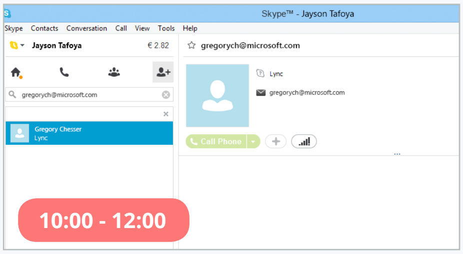
Pilot testing

The scope of the project was also a subject of the workshop. The initial goal of the project is to provide a proof of concept, or in other words; data that supports the claim that VR can be used for efficient compensation training at home. To accomplish this, ØH wants to run a pilot test. This test involves providing patients with equipment suitable for training at home and test to validate improvements in ADLs. The planned patient group for this pilot test is patients with hemianopia and no other major deficits. This means that the patients would have either left or right homonymous hemianopia, but apart from this be ambulant, mentally healthy and proficient.

Findings
Rehabilitation of HVFD not possible.
Compensation trainig for VFD can have a good effect on ADLs
EST, VST and AViST are possible methods for improving patients visual searching strategies
Attensi and ØHs first priority is the pilot test.
The pilot test will be conducted with patients who only suffers from homonymous hemianopia.

C.6 WORKSHOP I VIRTUAL REALITY EQUIPMENT

About the workshop



10:00 - 12:00

People attending
Peter Christopher Bach
(VR- developer Attensi as)
Iselin Kanstad (Design Student)
Martinus Ishoel (Design Student)

Method
Skype Workshop

Agenda
- Present challenge
- Generate ideas (3-5 min)
- Present ideas
- Group discussion about the ideas
- This process was done for all 5 challenges.

The headers on this page represent the challenges presented, and below there is a summary of the generated ideas.

Purpose of the workshop
Finding advantages and disadvantages with using the Gear VR headset. In addition, to investigating if actions can be taken to make the headset more user-friendly.

What difficulties is there with using Gear VR?
Easy to misclick, and for instance accidentally leave/switch application. Gear support different Samsung phones, but not all are well fitted to the headset. The big problem with both Merge and Gear VR is that the way the phone is facing when it is mounted is set as the center of the virtual environment. It is also difficult to plug in headphones after the phone is mounted, as the audio jack is covered by the headset. Pop-ups appearing on the phone cover the VR application, meaning that if mail or messages are delivered while using the headset, they will cover the virtual environment, and the application must be closed, and the pop-up closed in order to continue.

What difficulties would an old person have with using Gear VR?
Mounting and applying the headset might be more difficult. Technical problems can cause problems. Bad hearing can cause audio instructions to be difficult to hear. Physical impairments such as trembling hands and reduced sensibility might cause difficulties with using the touchpad. Reduced vision might cause more difficulties with using the equipment.

How can you make it as difficult as possible to use the system?
Separating all parts, and putting them in different locations. Tighten the head strap as tight as possible. Attach a control that is even more difficult to use than the touchpad. Set the framerate to a level that causes motion sickness. Uninstall the application on the phone, and set a difficult pin code. Make pop-ups that disturb the application and ask for camera permission.

How can you make it as easy as possible to use Gear VR?
Have the application readily available on the home screen. Adjust the focus beforehand. Do not use the touchpad for anything. As little in-game menus as possible. Navigate everything with gaze. Do not use headphones in the application. Turn off sleep-mode and pin code on the phone.

Findings
Navigation with gaze is easy
The touchpad on Gear is difficult to use and unintuitive.
The way the phone is facing when it is mounted is set as the center of the virtual environment.
Pop-ups, pin codes and sleep mode makes VR more difficult to use.
In-person demonstration or video instructions is good for increasing comprehension.

What is the best way to teach an old person to use Gear VR?
Show it to them in-person several times, or include video instructions. Use the exact same phone as they are going to use. Remove the straps, and let them look straight into the headset. Attach a wire between the headset and the phone so they stay togheter. Let them try several other applications so they get used to the headset.

C.7 INTERVIEW I VIRTUAL REALITY EQUIPMENT

About the interview

People attending
Peter Christopher Bach
(VR- developer Attensi as)
Iselin Kanstad (Design Student)
Martinus Ishoel (Design Student)

Method
Skype Interview

Subjects for discussion
- Focus on existing VR equipment
- Discussing Merge vs. Gear VR
- Discussing different VR controllers

Purpose of Interview
Learning more about VR - equipment, and more about which headset, either Gear VR or Merge, that should be chosen.

Gear vs. Merge
Gear have several practical problems - you get problems with everything! Gear has a solid tracking system, with built-in sensors. Gear recognizes the phone immediately, while with the Merge you have to scan the QR-code beforehand.

Merge is easier to use than Gear, and the headset is in foam and is solid and does not break. Merge is a fancy Cardboard and only consists of a case and two lenses. It is a lot easier to mount the phone, and it is easier to launch applications. The tracking in Merge is bad, and it is easier to get motion sickness. The buttons on Merge are sturdy, and the adjustment of the focus comes naturally, especially if you have used old cameras before. Using the buttons as input might cause the focus to change, and it has to be adjusted continuously, which can be annoying.

Other headsets

Everything is easier than the Vive. Oculus is a solid system, but the developer has not used it enough to provide his opinion. Cardboard is not a good headset, and should not be used in this project. There exist several thousand headsets, especially in the cardboard category. The Merge is a solid headset, and the headset I consider to be the best.

Findings
Merge VR is reccommended
Do not use Google Cardboard
The HTC Vive is not easy to use or maintain
Merge have tactile buttons, a solid build and can be used with different mobile brands.
Tracking in Gear VR is a lot better than in Merge.
Gear VR can have practical problems and is more difficult to use than the Merge headset.

C.8 INTERVIEW I TVI KRISTIN

About the interview

People attending
Kristin Lundberg (TVI
Trondheim municipality)
Iselin Kanstad (Design Student)
Martinus Ishoel (Design Student)

Method
Structured interview

Agenda
- Short presentation held by TVI

Questions covering following fields:
- Patients with HVFD
- Purpose of vision therapy
- Challenges with stroke
- Methods for vision therapy

Purpose of the interview
To get a better perspective of living with visual impairments and how visual training is performed, we contacted a Teacher of students with visual impairments(TVI). A TVI is a person which job is helping people with visual impairments, by facilitating training and mapping visual functions.

Vision therapy methods
One of our goals with this meeting was to get an overview of the methods which are most common and to get an instruction on how these are performed. However, the TVI was not able to provide this and said that would be impossible, as all training programs are specially adapted to the patients. She stated that she has a set of methods, but that these are only used as a starting point for creating a suitable program for the patients.

One element which was mentioned by the TVI was the importance of feedback to the user, both regarding the patient's well-being and training progress. Most of the training methods which were discussed were done in some form of collaboration between the patient and TVI. Most of these methods were technically simple and often made us of simple props such as pencils and paper sheets.

The TVI did provide us with information about an application which is used among others by the same profession. This application was Vision Tap[36], which consists of several mini games which cover different methods of vision therapy. Vision Tap is however not coined at patients with homonymous hemianopia.

Focus area
The TVI said that the main focus areas for people with VFD are reading and writing. While problems with mobility and driving can be severe, it is not the main area of focus. When a TVI is assessing the visual impairments of patients, their ability to read and write is often the unit of measure. This does also often help to uncover underlying cognitive deficits. If cognitive deficits are found, visual training often has a limited effect.

Getting help with HVFD
Getting help with vision therapy after getting a HVFD from a stroke can be difficult. Many patients experience discouragement, as they often have no legal rights for getting help.

Findings

- Training is always specially adapted to the patient
- Reading and writing is the main area of focus for TVI and visual training
- Getting help with HVFD can be challenging

C.9 INTERVIEW I TVI GUNVOR

About the interview

People attending
Gunvor Birkeland Wilhelmsen (TVI)
Iselin Kanstad (Design Student)
Martinus Ishoel (Design Student)

Method
Phone Interview

Agenda
Questions covering following fields:
- The target group
- Vision therapy
- Methods for vision therapy

Purpose of interview
Gunvor BrikelandWilhelmsen is a TVI and textbook author that works at Western Norway University of Applied Sciences (HVL). She is the author of the book "Å se er ikke alltid nok"[15], which has been used as inspiration during the initial phases of this project. She is also mentioned as a reference and person of experience in the project handout from Østfold Hospital Trust. The interview which was conducted was done to get an impression of the target group and to get an overview of how visual therapy is done today.

Target group
Similarly to the TVIs description of the target group in Appendix C.8, this group was described as a group of great diversity. The aspect which often varied between patients were; age, the level of motivation, the degree of VFDs and other visual deficits and other impairments from a stroke. However, the majority of this group was described as being elderly.

We did also ask about the groups use of smartphones. Our impression was that the use of smartphones was generally not a big challenge. On the other hand, those suffering from macular sparing were a group which struggles a bit more with using smartphones. Keeping things at a distance was mentioned as a good method for those suffering from HVFDs as this would make the object occupy a smaller amount of the visual field and thereby contributing to get a better overview.

Findings

Patients with homonymous hemianopia is a group with great diversity

Methods used in visual therapy often requires customization to be relevant for the patient

Making the patient acknowledge realistic goals and progress is important for motivation

Methods

Wilhelmsen did also confirm the notion made by the other TVI, that training programs and methods usually have to be customized to the patient's needs. She emphasized that training along with a TVI, is a great benefit, as this allows the TVI to customize training continuously based on what the patient and TVI renders important. This could also prevent the training from getting mundane and tedious, as it allows for swift changes of training methods. A TVI is also able to explain the benefits of the therapy and inform the patient about progress, which is something that is often overlooked in automated trainers.

The inconvenience of using computer programs was also a topic which was discussed, as these programs often require a lot of adjustments and calibrations.

Transfer value

Wilhelmsen also pointed out the importance of explaining the transfer value between the therapy to real life. This is important, as the patient often has no relation to their progress, and can, therefore, get unmotivated and not see the benefits from the training. One of the main task for the TVI is to inform the patient about their progress and remind them why the training is meaningful. This would help the patient to acknowledge what is feasible and what to expect. To hear this from a specialist, rather than a computer program is also essential, as the specialist can answer questions and provide relevant feedback.

C.10 PRESENTATION | ABOUT VISION THERAPY

About the presentation

People attending

Mahnaz Rashidi (TVI)
Iselin Kanstad (Design Student)
Martinus Ishoel (Design Student)
Course attendants at Hurdal

Method

Attending presentation

Agenda

Topics covering following fields:

- Problems with VDs
- Rahabilitation of VFDs
- Training at home

Purpose of presentation

Mahnaz Rashidi is one of the TVIs who are responsible for training with the patients we observed at Hurdal. She has worked 20 years as a physical therapist in Norway and has taken two-year masters in vision education, in addition to a continued education within sight neurology and vision education methodology at the University of Bergen. She works as a TVI in private practice and has earlier been employed as a TVI within adult education in Bærum municipality.

Patients with HVFD

Many areas of the brain are involved in the analysis and perception of visual input. 80% of our sensory impressions are acquired through vision. For patients with VFDs, this capacity is decreased. For patients who get easily tired, it is important to close our eyes and unwind, to increase life quality and the capacity of the vision. Patients with VFD have two main problems: - Reading difficulties - Visual orientation problems.

Visual orientation

Visual orientation is difficult as patients with HVFDs often collide with obstacles. Moving in crowded places can be especially stressful, as there is a lot of sensory stimuli. A good example of a place where visual orientation is straining is at a mall. At the mall, there are often many people, lights, sounds, movements, and other disturbances that require a lot of processing power from the brain. Orientation can, therefore, become difficult. The bigger these areas are, the more difficult for the patients.

Reading difficulties

Patients with VFDs are prone to reading difficulties. When more energy is spent on reading, more capacity is spent on reading techniques, which results in less capacity for both memory and concentration. Additionally, when more energy and time is spent on reading, the perception slows down, and more content is forgotten. It, therefore, gets difficult to stay focused, which this leads to concentration issues.

People with right-sided VFDs often don't see where the line ends, whereas people with left-sided VFDs often don't see where the line starts.

Patients who have visual field deficits, often experience oculomotor problems while reading. This is caused by too many fixations and fibrillations, as visual field deficit makes it difficult to fixate steadily, and to conduct long saccades. The goal of reading training is to get quicker at reading and reduce the number of fixations. In the beginning, it can be wise to use a ruler or finger to guide the eye movements. This will help guide the eyes and is a great way teach how to move the eyes correctly. But, one should not be dependent on these aids, and as soon as possible practicing eye movements without aids should begin.

Hemianopia and visual field

The visual field covers is approximately 180 degrees horizontally, 90 degrees downwards and 70 degrees upwards. This makes it possible to walk forward without moving our head or having to look down on the ground continuously. The visual field of each eye overlaps, and the left eye only covers the outermost left of the visual field, and the right eye covers the outermost right parts of the visual field.

Patients who have left-sided hemianopia may feel that there is something wrong with their left eye, but this is not correct, as both eyes are affected. When to the lower left field is lost (left sided quadrantanopia), it can be tough to see the ground. Many patients compensate with looking down, instead of effectively using scanning patterns while walking.

However, this can be troublesome, as it can unfavorable movements can result in strain to both the neck and shoulders. The eyes are also the fastest muscles, and more efficient than other movements. By using efficient scanning patterns, patients don't have to move their head to see. If scanning techniques are used continuously, these patterns can become automated.

Other challenges

Patients with VFDs often have additional eye related problems. Several get sensitive to bright light, caused by a slower and weaker retraction of the pupil. Glasses with a special filter can help those who are most affected by this. However, this can also get better with training.

Vision therapy and rehabilitation

When doing vision therapy, several factors are crucial for the outcome:

- Start as early as possible
- Do it as often as possible
- Continuity of training is necessary

The eyes are the fastest muscle in the body. It is unnatural to walk around and to turn your head to see, as it takes much more time than eye movements. Some doctors claim that it is not possible to rehabilitate your sight, I believe that this is wrong. It is common knowledge that your body can rehabilitate, unfortunately, it is not common knowledge that this also applies to your vision.

Playing piano is a great way to train your vision, and it is also a good cognitive challenge. I have recommended this to my patients, even to patients who-who has not played before. I often see improvements from practicing with a piano.

Observers note: This part of the lecture is clearly motivating for the patients. They get a better understanding of what is wrong with their vision, and what they can do about it. Quotes from the audience "This is really motivating Mahnaz!", "It is so good to hear that it actually helps." and "Doctors keep telling me that it is permanent, this is really uplifting!".

Training at home

The TVI recommends Cogpack for training at home. Cogpack is a computer program created by a pioneer in the field. The program trains concentration, memory, and oculomotor movements in addition to vision therapy. Reflection from the screen and small screen can be challenging with using this program at home. The TVI recommends connecting the computer to the TV, to increase the screen size. Cogpack costs around 2000 NOK and this is not covered by the government.

This is not a scientifically proven, but in my experience people who live in the countryside, and continuously walk in nature, have a faster recovery. I think all the visual stimuli created by the environment is beneficial for improving your vision.

Warm-up exercises

It is important to warm up before starting vision therapy. This activates the oculomotor muscles. If you have a deficit to the right, you warm up with taking more movements to the right side, and opposite if you have a deficit to the left. First, you start with both your eyes, then you can use one eye at the time. If you get tired during vision therapy, you can take a break with warm-up exercises.

Detection of HVFD in health care

Double vision is easy to catch, it is easily noticeable by both the patient and by health personnel. However, visual field deficits are more tricky. It often takes time before the patient gets fully aware that something is wrong. It starts with colliding into objects, and not finding things they are looking for.

TVI and speech terapists

For people who don't have a TVI in their municipality, I recommend getting in touch with a speech therapist to practice reading skills. Some speech therapists can also help with vision therapy, but they have a busy profession, and not all are open for it.

Findings
Patients with VFD have two main problems: reading difficulties and visual orientation problems
Crowded places are stressfull for patients
Right-sided deficit: Don't see where the line ends Left-sided deficit: Don't see where the line starts.
The goal of the therapy is to reduce the dependency on aids.
By practising search strategies, they can be automated
Patients with visual field deficits often have other eye related problems.
Tips for vision therpay: - Start as early as possible - Do it as often as possible - Continuity of training is necessary
Warming up before vision thearpy is important.

C.11 INTERVIEW | TVI ARNE

About the interview

People attending
Arne Tømta (TVI)
Iselin Kanstad (Design Student)
Martinus Ishoel (Design Student)

Method
Interview

Agenda
Questions covering following fields:
- About the field vision thearpy and how TVIs are educated in Norway.
- About patients with HVFDs and their challenges.
- Exercises used for vision therapy and why they work.

Purpose of interview
Getting an overview of vision therapy and how TVIs are educated, a better look at who the average HVFD patient is, and more about why and how vision thearpy works for patients with HVFDs.

Vision therapy is a new domain
This area of expertise has had little attention. In the 80's I met my first two patients. One of them had normal hemi-anopia, and his doctor told him that he was no longer able to see on his left side. When the patient asked what to do, the doctor told him that maybe if he moved his head a little it would help. This was the way it was in Norway before Gunvor started in a job, where she saw that this group was neglected. She has been a pioneer in this field, inspired by Josef Zihl's work.

TVI education
I have three years studying didactics,

one year with special didactics and one year specializing in vision. I know that today both NTNU and Statped Midt in Melhus have courses specializing in vision therapy. In Kongsberg there is a good professional environment for people specializing in vision.

Prioritizing patients below 70 years
This area of expertise has not been a priority, so when Hurdal first started with the courses the response was enormous. This forces us to prioritize, and the choice was to first support the patients below 70 years old. It is not that the elderly does not need the help, but with this group, the need would triple in size. When we have the choice of helping a 25-year-old and an 80-year-old, the 25-year-old gets prioritized. If there are places available, there can also be patients above 70 years old here. The average patient at Hurdal is about 40-70 years old.

Aphasia and neglect is common
Aphasia and neglect are some of the other stroke-related challenges we meet here at Hurdal. It can be difficult to assess whether a person has neglect or a HVFD. It has happened that a patient believed to have a left-sided HVFD, actually has an intact visual field, it is just their attention to that side that is not present.

Misalignment of goals
The big challenge with vision therapy is the misalignment between the patient's and the TVI's goals. Most of the patients who come to Hurdal, come in the hope of retrieving their license. Everything they do is directed at getting their license back. Today it is more difficult to get a dispensation that before. My goal is not to improve patients vision so that they can drive again, but to help them manage their everyday life in a better way. I am glad that it is not up to the TVI to assess whether a patient should get their license back or not.

Regaining field of view
This is a controversial subject. I have heard success stories of patients who after hours of vision therapy have regained some of their visual field. There is a lot of opinions in the scientific field for whether this is possible or not, so I choose not to take a side. My goal with vision therapy is to learn people to manage as best as they can. However, I always try to stimulate the part of the vision that is lost, in a hope of that something is regained.

Exercises used for vision therapy
I rely a lot on the existing computer programs for vision therapy. Programs I use a lot are Cogpack, Vision Builder, Visio Coach and Magnimaster. I now that the other TVI is very creative in the exercises she chooses. She changes exercises a lot and even creates her own methods by using power points.

Vision therapy for reading

The biggest challenge is to get those with reading difficulties to see all the way to the edge. The program Magnimaster I often use to train reading skills. The background is that children with visual impairments reads a lot slower than others, and I want to reduce the gap between children with and without visual impairments. My theory is that two principles will teach them to read faster. One is practicing reading the most commonly used words as fast as possible. This way reading speed will be enhanced. The other is to practice at how long they have to move their gaze - a longer and more precise saccade will enhance reading ability.

Oculomotoric problems and HVFDs

Zihl states that every visual deficit comes with an oculomotoric problem. Not in terms of another visual deficit, but in terms of worsening of oculomotoric techique. Other people, when they for instance read, get a hint at where the line ends, and how far they are supposed to move their gaze. People with HVFDs does not get this hint, and when you do not know how far you have to move your gaze you start struggeling with oculomotoric control. They lack the signals that enables us to use our oculomotoric skills in a sensible way.

Whether to move the head or not

In Norway the standard is to practise vision therapy without moving the head. This principle is not valid in all countries, and I know that in for instance Australia they do the opposite. Here the principle is to move your head as much as possible.

Findings
Vision therapy is a new domain.
Aphasia and neglect are challenging for vision therapy
Problems with oculomotoric control can come as a result of having a HVFD.
Whether patients should move their head or not is debatable, and varies from country to country.

C.12 FOCUS GROUP | PATIENTS WITH HVFD

About the Focus group

Focus group information
Number of people attending: 6
Age range: ~20 - 70 years old
Gender: 3 males and 3 females

Method
Group discussion

Agenda
- Each subject was presented
- Each patients talked about the subject on turn
- Group discussion about the subject

These subjects were discussed:
- Best/worst aspects of vision therapy
- Best/worst methods used in vision therapy
- Best/worst aspects of Merge VR

Purpose of the focus group
Getting the patients to share their thougts about vision therapy. The goal was to spark a discussion among the patients in order to get more and different insight than with a 1-1 interview.

Believing that the therapy is effectfull
Several aspects that motivate patients to conduct vision therapy were mentioned. Believing that therapy has an effect, and to hear what vision therapy improves was repeated by several of the patients as the best part of vision therapy. Training does not have to be fun, as long as I have a belief that it will help me.

Fatigue and exhaustion
Exhaustion and fatigue were mentioned as a demotivational factor for doing vision therapy. A patient stated that exhaustion was the most difficult part of vision therapy and that after only 20/25 minutes of training he had to lie down the entire day. But, he also stated that this was very dependent on the day and level of motivation. Some days the training was so positive that he could continue the entire day.

The importance of progression
The worst part is that therapy progress so slowly, it is very important that you get results and that progress is evident. Some of the patients also stated that seeing that your visual field gets better is extremely motivating.

Best and worst methods
The patients did not always agree on which methods they preferred. But some methods stood out. UFO, see Appendix F.7, was one of these methods that were evidently favored by the patients, and it was mentioned several times. The Ball method, see Appendix F.13, were both mentioned as both the best and worst exercise. Focus area specific exercises were also preferred, and patients mentioned that e.g exercises directed towards reading skills were especially fun. One of the patients stated that none of the exercises were enjoyable or fun and that he did not like any of it.

Aimed at my problems
Several of the patients stated that as long as the exercises are aimed at one of their problems, the exercises are experienced as being fun and motivating.

Training at home
Training at home was deemed both boring and tiresome by most of the patients. The patients stated that it is extremely boring, but the feeling of learning and progression makes it worth it. Except for one patient that stated that he loves to train at home and that he at least train one hour a day. Training at home was also discussed as being more difficult than training with a TVI.

The patients stated that it is difficult to assess whether they cheat or not and that it is very difficult to conduct vision therapy when there is no one there to correct and motivate you. Examples of cheating are moving the paper to make it easier to see or altering head position.

Several benefits of training at home were also mentioned. It is practical as you can do it more often and it is easily accessible, as you do not have to travel to the closest town in order to get access to a TVI. Several of the patients stated that there was no TVI available in their municipality, and that training at home and the courses at Hurdal was what enabled them to do vision therapy. The biggest benfit was mentioned as improving your vision.

The Merge

The patients had both positive and negative opinions of the Merge.

Several positive aspects with the Merge were mentioned. Firstly, patients seem to enjoy the novelty factor of the equipment and stated that it was exciting with new technology. They also liked the headsets sturdiness, that it was easy to apply and that it comfortable to wear. The purple color was also mentioned as a positive factor and the fact that the equipment did not seem threatening.

Several negative aspects with the Merge VR were also discussed. Firstly, that the headset was experienced as heavy and some also mentioned that it was a bit difficult to apply. The look of the headset was also mentioned to be a little to flashy, and that wearing the equipment in public was not an alternative.

Challenges with conducting the focus group

The people in the focus group had a tendency to repeat or enhance what other had said before them, and the patients were highly influenced by the opinions of the others.

Keeping the attention of the patients were challenging. At this point of the stay, the patients were very familiar with each other, and they could suddenly start to mention other subjects than what was discussed. In addition, gathering the patients and getting everybody to talk together, made the patients start to sharing very personal and emotional stories.

Some of the cognitive challenges caused some of the patients to not understand what was discussed. This was experienced as embarrassing and in order to not discomfort the patient, the subject was changed subtly.

Findings
Results and progress is important
Exhaustion and fatigue is demotivating
Belief that the therapy works is essential for motivation
UFO is a preferred exercise
Cheating at home is a problem
Training aimed at the patients problem areas is important

C.13 WORKSHOP I METHOD CREATION

About the workshop

People attending
Volker Solyga (Neurologist)
Jarl Schjerverud (Project Manager)
Stine Tanggard (Attensi AS)
Iselin Kanstad (Design Student)
Martinus Ishoel (Design Student)

Method
Workshop

Agenda
Present the findings up until this point in the project. Use these ideas to create ideas for vision therapy methods. Discuss pros and cons of using VR technology.

Purpose of workshop
A second workshop was held at ØH, to bring all main stakeholders up to speed. Firstly, an elaborative presentation was held, presenting the findings from the stay at Hurdal. Secondly, an idea generation workshop was held, using the findings that were presented in the presentation as a foundation.

Attendants
This workshop had participants from many fields relevant to this project. Firstly, Stine Tanggaard with a Masters in cognitive psychology and cognitive neuroscience. Secondly, Volker Solyga, a specialist in neurology, with experience from patients with HVFDs. Thirdly, Jarl Schjerverud, a lecturer in game design and more than ten years experience as a Lead Game Designer.

Presentation
To begin with, a presentation was held as an introduction to the workshop and to summarize of all finding that was made up to this point in the project. There were several purposes of this presentation. Firstly, it was important to enlighten the team about the target user, their experience with HVFD and vision therapy. Secondly, it was important that the team had an understanding of how vision therapy works, and which key principles vision therapy is based upon. Thirdly, the Merge was presented and sent around for everyone to try.

Idea generation Workshop

The workshop started directly after the presentation and was divided into two phases, creation, and selection phase. Firstly, the creation phase was divided into four phases, based on the vision therapy categories presented in Chapter 4. Here the participants brainstormed ideas for vision therapy methods. Secondly, in the selection phase, the participants presented their ideas and agreed upon which they thought had the biggest potential.

Virtual Reality Workshop

A second workshop was held, focusing on how this project could utilize virtual reality. This was done to find benefits and drawback of using virtual reality equipment. Firstly, all participant were asked to find drawbacks of using virtual reality equipment. Secondly, the same was done for the benefits.

Results

The results from the first workshop were many ideas for vision therapy methods. Some of these are presented in Chapter 6. These were used as a foundation for creating content for the application.

The results from the second workshop was a set of pros and cons with using virtual reality equipment.

Findings
Several ideas for methods to be used for vision therapy. Some of these are presented in Chapter 6.
A overview of potential pros and cons by using VR in this application, which is presented in the list below.

VR Pros

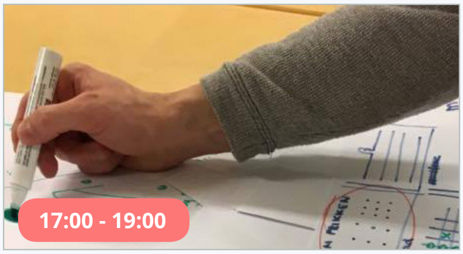
- Equipment can be cheap
- Technology is user-friendly
- Head tracking allows feedback on movements
- Equipment is portable
- Starting mobile VR is quick
- Easy to present 3D visualisations
- Full control of the patients FOV
- Technology can be new and exciting

VR Cons

- Does not cover the entire field of view
- Headset can be difficult to handle for impaired patients
- Technical challenges can arise
- Heavy to wear over time
- Only one person can play at a time
- Technology can be new and frightening
- Eye movement can not be monitored
- Simulation sickness

C.14 INTERVIEW I EVALUATION OF PRICIPLES 1

About the interview



People attending
Arne Tømta (TVI)
Iselin Kanstad (Design Student)
Martinus Ishoel (Design Student)

Method
Interview

Agenda
Evaluation of vision therapy:

- Principles
- Chategories
- Methods

Questions about following fields:

- Vision therapy in general

Purpose of interview
Before the interview, we had complied 4 principles, 3 search strategies and 4 categorize, from our findings from the vision therapy observations. These were brought to the interview, in order to evaluate their correctness and for the TVI to provide feedback.

Grid Exercises
Previous to the current interview, we asked the TVI about vision therapy methods based on grid layouts[17, 20]. After thinking about this, he said that these could potentially be great methods for vision therapy. He said that this would allow the patient to train on consistent saccades, both into the affected and intact visual field. Another advantage was that this could help improve the steering vision, or in other words the oculomotor control that are used for saccades in a specific direction. This could potentially be a great exercises for reading.

Evaluating principles

We presented the four following principle to the TVI; *explore the affected visual field, longer saccades and fewer fixations, use the eyes not the head and be aware of the visual field deficit*. The TVI did approve the first principle, *explore affected visual field*.

The TVI had several objections on the second principle, which were *longer saccades and fewer fixations*. He said that longer saccades was not necessarily a good thing, and suggested to change this to *more precise saccades*. However, he agreed that longer saccades could also be positive, just not in all circumstances. After discussing this, the principle was renamed *longer and more precise saccades and fewer fixations.*

He were also critical to the third principle, which were *use the eyes not the head*. He said that TVIs today, are not in agreement on this topic. TVIs in some countries are training the patients to use their head frequently, while Norwegian TVIs often focuses on keeping the patients head as steady as possible. He said that his way of thinking is that the patient should use their heads similarly to how people with normal vision use theirs. He said that people rarely uses head movements while reading, while most people use their when when crossing the street. However, patients with VFD often uses exaggerated head movements. For this reason we decided to rephrase the principle to; *avoid using unnecessary head movements.*

The TVI meant that the fourth principle, *Awareness that parts of the visual field is defect*, was precise. He expressed that this was important for training, as many patients are not aware of how their VFD affects them. Many misunderstands the impairments, where two examples are that some believes their vision is better than it really is and other that they are blind on only one eye. The TVI meant that this is important, as many do often prefer their intact side, and use most time searching and looking on this side.

Search strategies

When presented the three search strategies, the TVI said that he does not have any strict opinion on which one is better. He said that he mostly uses simple search strategies, where the task is to simply look straight into the affected visual field.

He did not actively use the more complex ones, which we had observed from vision therapy. He said that he mostly used these as a warm-up and for oculomotor training, or for specific scenarios, such as when a patient is looking for something.

In theory there exist infinite search strategies, where different strategies are better for different patients and visual impairments. For patients with homonymous VFDs, he said that he tries to take advantage of the peripheral vision on the intact side, as most information can be seen even if it is not in the central vision.

Similarly to our fourth principle, he emphasised the importance of keeping an overview over the affected side. Most of the search strategies he used, did emphasize this side of the visual field.

Categories

As for the four categories that were presented, he thought that these covered most of vision therapy for patients with VFD. These were therefore not discussed in detail.

The first category, *follow*, were similar to some of the methods frequently used by the TVI. He said that this was a good for exercises warm-up and for oculomotor training. He said that he always uses atleast one method that falls under this category.

As for the three last categories, *detect, saccade* and *search*, he said that he thought these were a precise way of categorizing methods.

Monitoring eye movements

During this interview, we also asked the TVI about the importance of watching the patients eyes during training. He said that even if TVIs are not able to see the shortest saccades and fixations, however they are able to see the fundamental movements of the eyes.

Before arriving at the TVIs office, most patients has had a visual field test, such as the Perimetry Test. However, these test are often wrong, which can often be detected by carefully watching the patients eye. This is both since the TVIs are able to monitor the patients eye over a longer period of time, and simultaneously listen to how the patients experience their impairments. This way the TVIs are able tomap the patients visions to a great detail.

Findings
Methods based on grid layouts can be very effective in vision therapy.
The principles that were presented was good, but needed rephrasing to be more precise.
It can be difficult to find one unifying search strategy.
Search strategies can be multifunctional
The categories which were created were precise.
TVIs are often able to map patients vision to great detail, from observing the patients eyes.

C.15 INTERVIEW I EVALUATION OF PRINCIPLES 2

About the interview

People attending
Eva (TVI)
Iselin Kanstad (Design Student)
Martinus Ishoel (Design Student)

Method
Interview

Agenda
Evaluation of vision therapy:
- Principles
- Chategories
- Methods

Questions about following fields:
- Vision therapy in general

Purpose of interview
After the interview with the TVI Arne, see Appendix C.14, we wanted to get another TVIs evaluation on the priciples, search strategies and categories we had compiled. The new versions were brought to the interview.

Saccades
The TVI was to a great extent in agreement with the comments on the second principle, longer and more precise saccades and fewer fixations, which were made in the previous interview with Arne Tømta. She said that saccades does not necessarily have to be long, and emphasised the precise part of the principle. She also mentioned reading as an example, where saccades are usually short, whereas long saccades are needed for finding the new lines. She stated that these two types of saccades are very different. However, she agreed that the principle were accurate for the target group, but not under all circum-stances. The principle was therefore not changed.

Head movements and body posture

As for the third principle, avoid using unnecessary head movements, she said that she did not care for the movements themselves, but rather the body posture while doing them. She said that patients with HVFD often developed a crooked head position and skewed body posture. This is seen when patients compensates for the impairment by turning their head towards their affected side. The most important aspect of head movements, is to keep an even body posture, and are able to quickly recognize important visual stimuli. However, she did not think that the principle were inaccurate, but rather needed elaboration. The principle was therefore not rephrased.

The follow category

When the first category was mentioned, *follow*, she said that this could be considered a fundamental category of methods. The catgory covers several important elements. Firstly, it is used to make the patient aware of their impairment. If the methods is rendered difficult, this can often be an eye-opener for the patient. Secondly, the TVI is often able to evaluate how the patients use their eyes and body. This method can often be used to uncover bad postures and oculomotor problems. Finally, it is a great warm-up method, as the eye muscles explores the full visual field in a smooth motion. The TVI also mentioned that the importance of warming up the extraocular muscles is depending on the visual skills of the patient. The worse the oculomotor control, the more important the warm-up gets.

The methods in this category does also help to improve oculomotor control and smooth pursuit eye movements. Jagged eye movements can often reduces from practising these methods.

Visual stimuli and variation

The TVI also mentioned sufficient visual stimuli and method variations as important aspects for vision therapy. Too little visual stimuli, can lead to both reduced effect from training and to the patient getting bored. Sufficient visual stimuli can also help the patient filter out unnecessary information and to focus on the important stimuli. Variation in stimuli is also important, an example is to use both numbers and letters, instead of just one. This could help the training get more interesting and diverse for the patient. The TVI was also fond of methods which allowed for several levels of difficulty. These can easily be adopted to the patients level of skill, increasing both the patients effects from the training and the entertainment value.

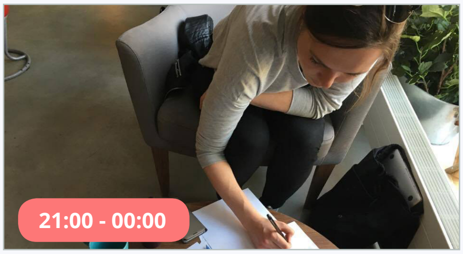
Task comprehension

Task comprehension was also discussed during the interview, as the TVI often include task which are cognitively difficult, in her training sessions. These exercises can often be difficult for those who struggle with language, from impairments such as aphasia. When asked how many of the patients struggles to understand task that they are given, she estimated that about a third of the patients she meets has problems related to task comprehension. However, she were usually able to solve the problem with sufficient explanations and demonstrations, and said that demonstration often were very effective. She also said that she often chose methods based on the patient she was treating.

Findings
Long and short saccades are different, but equally important
Incorrect body and head posture is often seen in patients with HVFD, and important for the patients to correctly compensate for the impairment.
Methods in the "follow"-category can be used to improve awareness, train oculomotor control and be used as a warm-up exercise
Sufficient and varied visual stimuli can help improve the effects from training and the training entertainment value
For patients that struggles with task comprehension, sufficient explanations and demonstrations are important.

C.16 INTERVIEW I ABOUT MOTIVATION

About the interview



People attending
Patient
Iselin Kanstad (Design Student)
Martinus Ishoel (Design Student)

Method
Interview

Agenda
Questions about following fields:
- Living with an HVFD
- Partisipating in vision therapy
- Motivation factors

Purpose of interview
Getting a better understanding of how it is to live with a HVFD and get insight in why patient's train their sight.

Is there any point?
The patient have problems understanding why he is attending the course. He says that he has gotten a better awareness of his HVFD, and that he has learned to use his blind side, but feels that it does not mean much in the big picture. He does not believe he will attend another course. "Is there any point?". During this course he feels that he has not learned that much useful, he has just gotten a little better at using his oculomotor muscles. "Now I don't have any peripheral vision, and I will never get it back either."

Becoming aware
The patient has been to the course before this one. It took the patient two years before he understood how and why he should compensate for his visual field loss. He believes that the courses are very good at creating an awareness of what is wrong with you.

It took about 9-10 months before I realised that something was wrong with my peripheral vision. It was strange walking around not knowing what was wrong. I remember seeing some rabbits running, thinking "Oh, how cute!", then I looked to the right "Oh, shit! There is a fucking fox there!". Before I got to my first course here at Hurdal I thought that I could see everything. But after attending the course I realised that I couldn't see shit. Now I think about it all the time, it is like a virus in the back of my head, I think about it when I am out fishing, at the mall, and in the store.

Finding the balance

The patient thinks that using his oculomotoric muscles is straining. When he is at the course, the TVI tells him to do it the all the time, but in everyday life this is to troublesome to do. It is difficult to find the balance for how often you have to use compensatory techniques. One scenario he always uses compensatory techniques is during long distance biking, this is because he has to.

Findings
It can be demotivation to know that your vision doe not get better nomatter hat wou do.
Results from vision therapy can feel slowly.
Vision therapy courses are great for creating awareness
Vision therapy is very tiering.
It is often easy to forget what you learn.

C.17 DEMONSTRATION | PROTOTYPE 1 ØH

About the Demonstration

Focus group information
Volker Solyga (Neurologist)
Jarl Schjerverud (Project Manager)
Student (Informatics 4th year)
Iselin Kanstad (Design Student)
Martinus Ishoel (Design Student)

Method
Presentation and group discussion

Agenda
The main purpose of the meeting was to inform the stakeholders at ØH about the current progress in the project. Additionally, the aim of the meeting was to get feedback on the first prototype and to brief the informatics student about the project as a whole.

Current state
A short summarizing presentation was held for the attendants, to start the meeting. This was done to inform the stakeholders about our process and main findings. All attendants agreed that the project is heading in the right direction, where both the project manager and the idea owner thought that much of the groundwork was in place.

Next step
The next steps for this thesis and the project as a whole were also discussed during the meeting.

The next step in the project will be to plan how the current prototype and the information that is gathered can be used to create a prototype ready for the pilot test. Attensi and possibly by other contributors such as other students, will be responsible for this. One of the next steps is, therefore, to make sure the work that has been done is understandable and easily accessible.

The plan for this thesis was at this point meant to be educational and inform about the relevant aspects of the project. This is meant to help to make the transition smooth, for those who will work on the project in the future..

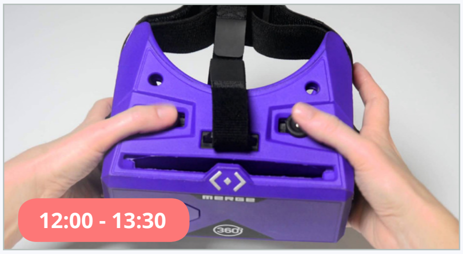
Findings

Presenting our findings in a logical way is important for the next steps in the project.

This thesis could be pursued by another student project. If not, Attensi will continue the development.

C.18 DEMONSTRATION | PROTOTYPE 1 ATTENSI

About the Demonstration



Focus group information
Anne Lise Waal (CO Attensi)
Stine Tanggaard (Attensi AS)
3 employees (Attensi AS)
Iselin Kanstad (Design Student)
Martinus Ishoel (Design Student)

Method
Presentation and group discussion

Agenda
The main goal of the presentation was to prepare the handover of the prototype and development to Attensi.

Next step
One of the goals of this thesis was to create a prototype that is useful for the end user and that Attensi feels confident enough to develop further. In this presentation, it was important to assure the main stakeholders, enlighten them about our reasoning, and make sure that everybody was in agreement. The first prototype was brought to this meeting.

Feedback on prototype
The prototype got good feedback from the audience, and Attensi were pleased with the results. They stated that the framework that was created was a good foundation for them to use for further development.

Including Attensi in the development process
The prototype developed up until now has been in the hands of the students. To take the prototype to the next level, it was important to include the developers from Attensi. During this meeting it was agreed that Attensi would contribute with the rest of the programming, and that the students would provide the specifications of what to implement.

Gamification and next step

After the presentation, there was a discussion about the next steps for the project. This discussion was related to how the application could become motivating to the user, by introducing gamification elements.

Firstly, variation was mentioned as an important factor for motivation. The first prototype 1 is very monotone, but by introducing a level system and new elements as the users play the game, the application would become more varied and lively. Secondly, feedback is important to make the user motivated, and could contribute to increase the user's sense of achievement. The feedback should also be related to the user's problem areas, making the feedback relevant for what the user wants to improve upon. Lastly, traditional gamifications elements could be introduced, to encourage engagement in the users. This could be achieved using elements such as experience points, higescores or leaderboards.

The agreement after this meeting was, therefore, to look into such techniques, in order to make the application more motivating.

Findings

The prototype is possible to use for Attensi when the development phase starts.

In order to make the prototype motivating to use, the plan was to look into gamification techniques.

TESTS

Appendix D | More information on user test.

APPENDIX OVERVIEW

This Appendix provide more information on some of the user tests that has been conducted throughout the project.

D.1 MERGE INPUT TEST

About the test

Test information
Number of people tested: 7
Age: 21-30
Location: NTNU

Number of people tested: 2
Age: 20-70 (rounded)
Location: HSMS

Method
User test with merge

Test set up

- An application with instructions were installed on the phone.
- The test subjects were told to follow the instructions
- The time taken on each input was logged, in addition to counting number of misclicks.

The Merge VR goggles offer two integrated buttons as input to the phone. By using these as individual inputs, it is possible for the user to interact in two different ways, namely; right click and left click. However, we wanted to investigate the possibilities for more inputs and create an assortment of this for use later in the project. This section aims to justify the inputs which were selected.

Choosing input options
The first step in finding suitable inputs was to limit the possibilities by making constraints. Firstly, a decision was to eliminate inputs made from combining other inputs, e.g. double clicks, triple clicks or combining left and right clicks in specific orders. Secondly, an unspecified time limit was made for inputs, meaning that inputs should be possible to do in a reasonable amount of time. Thirdly, the inputs that are chosen should not be confused with each other, meaning that they should not be similar to an extent were they can be not be diversified. These constraints reduced the possible inputs to six, these are listed in the next subsection.

List of Inputs

Left Click: Pushing the left button down, and releasing the button within 1 second

Left Hold: Pushing the left button down, and holding the button down for 1 second

Right click: Pushing the right button down, and releasing the button within 1 second

Right Hold: Pushing the right button down, and holding the button down for 1 second

Both click: Pushing both buttons down, and releasing one of the buttons within 1 second

Both Hold: Pushing both buttons down, and holding the buttons down for 1 second

Input test setup

To validate the decisions that were made in the previous subsection, a test was created. The purpose of this test was to either approve the usability of the six inputs that were chosen, or to further reduce the number of possible input options. This subsection explains how this test was conducted.

The first step for creating a test setup was to make a framework for monitoring the user's inputs. This framework was built in Unity3D, and signals when the users make an input.

An array of all the possible inputs was created, which was then duplicated 6 times. This resulted in an array of 36 inputs, where all the 6 inputs were represented 6 times each. The order of this array was randomized before every test. A scene was then created in unity, with a white panel displayed in front of the user.

During the test, the program automatically iterated though the randomized list of inputs, where the current input was either displayed with text on the panel, read out loud via voice over or both. Any wrong inputs made by the user was registered, along with time spent on making the right input. This was done until the array was empty. Before every test, the users was introduced to each possible input, exactly once.

Student test
A total of 7 students at NTNU participated in the test. These were randomly selected at the school campus. Before the test, the students were briefed on the project and introduced to Merge VR goggles. No further explanation was given about the test.

HVFD patient test
During our stay at Hurdal, two of the course participants wanted to participate in the test. These were introduced to the test and the Merge VR goggles in the same way the students were.

Results
The results from the test is presented in Figure D.1 and D.2. The sample size in this test is low, with only two samples from HVFD patients. While it looks like the students are performing better, the confidence level is low, and the results will not be treated as accurate or quantitative data.

The results show that all test subject spend more time on hold inputs than on click inputs. However, this is expected, as hold inputs will alway take longer to perform than click inputs.

There does not seem to be any evident difference between left, right and both inputs. This suggests that these are treated equally by the test subject.

Findings

Hold inputs takes longer to perform than click inputs.

Left, right and both inputs seems to be treated equally by the test subjectcs.

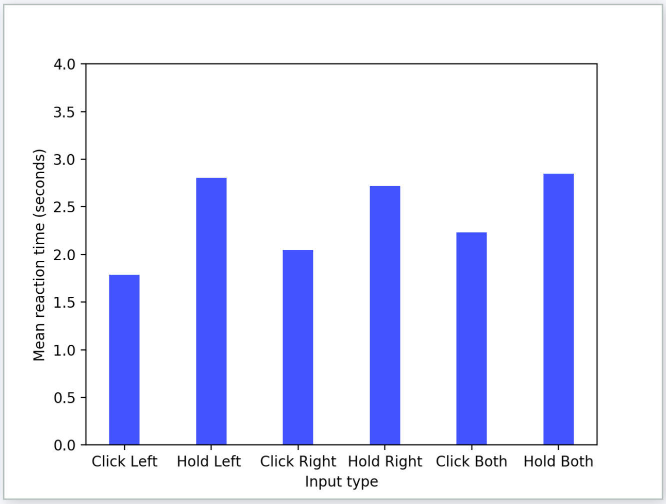


Figure D.1 | Mean reaction time
based on input, students

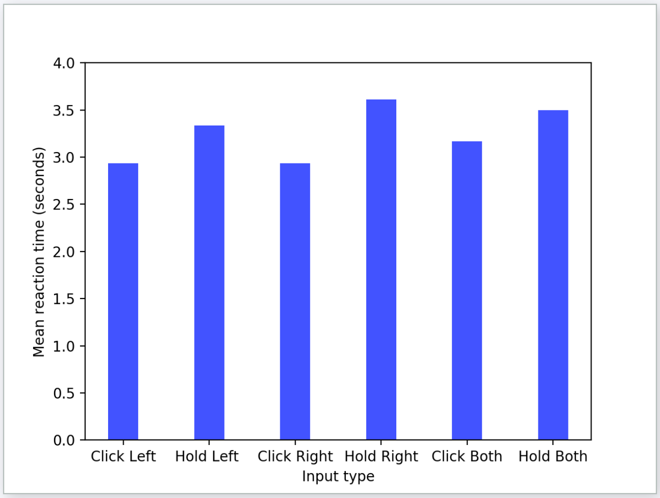
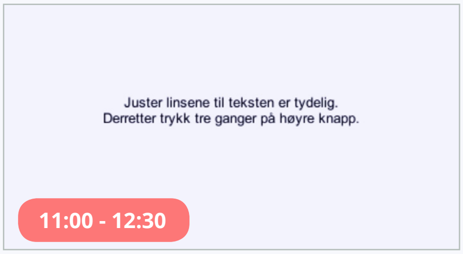


Figure D.2 |Mean reaction time based on
input, HVFD patients

D.2 INSTRUCTION TEST

About the test



Test information

Number of people tested: 7
Age: 21-30
Location: NTNU

Number of people tested: 2
Age: 20-70 (rounded)
Location: HSMS

Method

User test with merge

Test set up

- An application with instructions were installed on the phone.
- The test subjects were told to follow the instructions
- The time taken to react on each instruction were meassured

The instruction test was conducted at the same time and with the same test subjects as in the input test, see Appendix D.1.

The instruction test was based on the same principles and measurements as the input test, namely, reaction time based on instructions. On the other hand was the instruction test a comparison of reaction time, based on instructions to the user.

Choosing instructions

In order to conduct an instruction test, a set of comparable instruction types had to be selected. The instruction types that were assessed prior to the test were; animations, images, text, and audio. Despite wanting to compare all of these, this was considered to take to much time at this stage in the project. While comparing animations and images to text could have provided interesting results, this was assumed to too time-consuming.

A decision was made to compare text and auditory instructions, as both are arbitrary and based on language. Seeing that HVFDs are often associated with reading difficulties, it would be interesting to compare the difference in reaction time between students and patients with HVFDs.

List of instructions

Text instructions: Instructions presented as text, in front of the test subject

Auditory instructions: Instructions presented as sound, out loud for the test subject

Combined instructions: Instructions presented as both text and sound

Instruction test setup
The instruction test was built on the same principles as the input test, see Appedix D.1. A randomized array of instructions was created, with an equal amount of input types and output types. During the test, reaction time based on instructions was measured, along with the number of errors based on input.

Results

The results from the test is presented in Figure D.3 and D.4. The sample size in this test is low, with only two samples from HVFD patients. The confidence level is therefore low, and the results will not be treated as accurate or quantitative data.

The results provide some interesting qualitative results, namely the relationship between the different types of instructions. In both tests, it seems like both test groups performed equally well if the instructions were auditory or auditory and text based. Both from the results alone and from the following interviews, it seemed like if the test subjects are provided with auditory instructions, they want to listen to the full instruction before continuing.

If the instructions were text-based, the difference between the groups are apparent. The HVFD patients spend a significantly longer time on text-based instructions than on the other types of instructions. On the other hand, the students spend less time when the instructions were text-based. This suggests that students would prefer text-based instructions, while HVFD patients would prefer auditory instructions alone or auditory instructions coupled with text-based instructions.

This was also apparent from the following interviews, were most students said they preferred text-based instructions, and HVFD patients said they preferred auditory instructions.

Findings

Results suggests that students perfer text-based instructions.

Results suggest that HVFD patients do not prefer text-based instructions, but auditory instructions.

If auditory instructions are provided, both students and HVFD patients will listen to the full instructions before continuing.

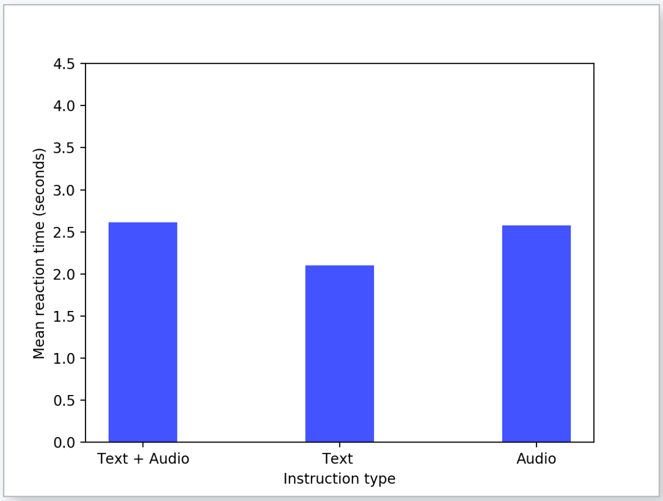


Figure D.3 | Mean reaction time base on instruction, students

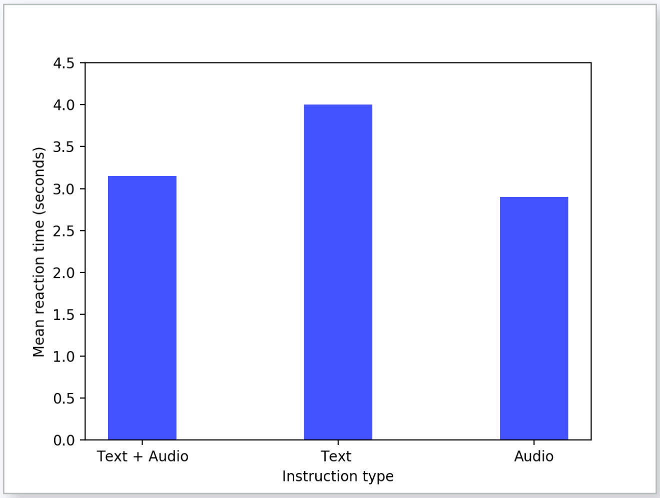
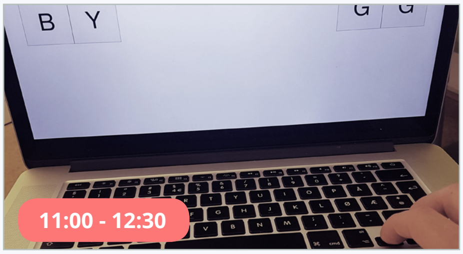


Figure D.4 |Mean reaction time base on instruction, HVFD patients

D.3 GUERILLJA TESTING I PATIENTS WITH HVFD

About the test



Test information
Number of people tested: 3
Age: 20 - 60 (rounded)
Gender: two males and one female

Location: HSMS

Method
Guerillja Testing with computer

Test set up
- Rapid prototypes were created in Adobe XD.
- Patients tested the prototypes.
- Alterations to the prototype were made
- Discussion about the prototypes.

Purpose of test

Using the methods created in the method-creation workshop at ØH, see Appendix C.13, prototypes were rapidly created in order to test them on the patients at HSMS. Based on feedback from the patients, changes on the prototypes were made on the go.

Approach

The guerilla testing is difficult to summarize as the alterations were made on the go, it was tested on different patients and the approach was somewhat unstructured. The results of the testing were mainly small iterations on the existing ideas and an indication on which exercises were favored by the patients.

The prototypes were created by using Experience Design CC, which allowed for a quick and easy setup. The methods which were similar to those commonly used today and the methods that were difficult to prototype were discussed with the patients by using sketches or images. From the testing, some of the game mechanics of the exercises were slightly altered, and new and exciting ideas were brought to light.

Preffered methods

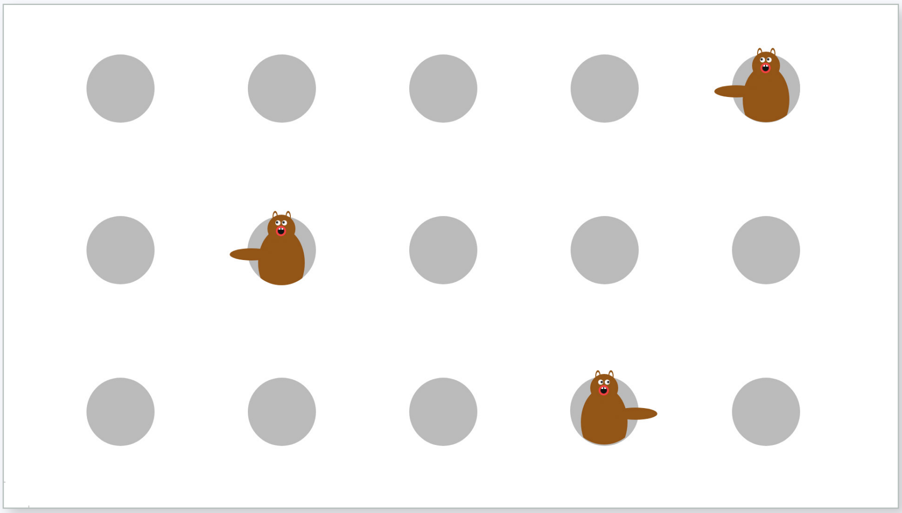
Wack-a-mole and *Word game*, see chapter 6.3 for description, were two of the methods that created encouragement among the patients. This was evident from their behavior, the time they used on the games, and their comments. The game UFO, see Appendix F.7 were not prototyped. Discussing the exercise with patients, resulted in the conclusion that UFO is a motivating exercise which the patients prefer.

Findings

Wack-a-Mole, Word game and UFO are exercises which create encouragement

Figure D.5 | Prototype *Word game.*

Word Game
Figure D.5 shows a prototype created with Experience Design CC. The patients stated “yes” or “no” for whether four letters combined resulted in a word.



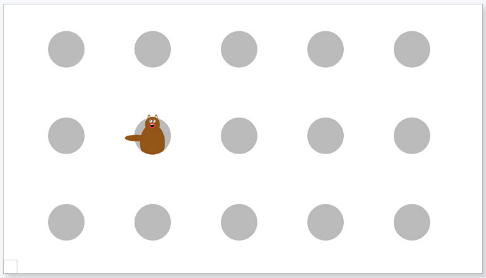


Figure D.6| Prototype *Wack-A-Mole*

Wack-A-Mole

D.6 shows a prototype created with Adobe XD. The patients stated “right” or “left” for whether majority of the moles pointed to the left or the right. This prototype was testen on several different levels, advancing in number of moles and speed of the exercise.

D.4 TEST PROTOTYPE 1 | STUDENTS AND PROFESSORS

About the test

Test information
Number of people tested: 5
Age: 25 - 53
Gender: 1 female and 4 males
Location: NTNU

Method
Usability Test

Test set up
Subjects were given the Merge, with a Samsung Galazy S7. The phone had the prototype installed, and running.

They sat down during the whole test, and were asked to talk out loud about what they did and thought when using the application.

This section summarizes the results from the user tests on students and professors. Two schemes were used during the test. The first was a system usability scale and the second was created specifically for the test.

SUS scheme
The SUS scheme [32] consisted of 10 statements, which all were in Norwegian.

The user had to rate each statement on how much they agree with it, where 1 represents strongly disagree, and 5 represents strongly agree.

Enjoyment scale
The scale which was created specifically for the test was meant to assess how enjoyable each of the minigames was. Additionally, this was an assessment of what the users thought about the menu system, controller, and headset. 7 questions were asked, where the users were asked to rate what they thought on a scale from 1 to 6, where 6 is the most enjoyable.

	User 1 Score	User 2 Score	User 3 Score	User 4 Score	User 5 Score	Average
Statement 1	2	1	0	0	0	0.6
Statement 2	4	3	4	4	4	3.8
Statement 3	4	3	4	2	4	3.4
Statement 4	4	4	4	4	4	4
Statement 5	4	4	2	3	3.5	3.3
Statement 6	4	3	2	4	4	3.4
Statement 7	3	4	4	4	4	3.8
Statement 8	4	4	3	4	4	3.8
Statement 9	3	3	4	4	4	3.6
Statement 10	4	4	4	4	4	4
SUS score	90	82.5	77.5	82.5	88.75	84.25

Table D.1 |Test results from SUS scheme

SUS scheme Statements(Norwegian)

1. Jeg kunne tenke meg å bruke dette systemet ofte.
2. Jeg synes systemet var unødvendig komplisert.
3. Jeg synes systemet var lett å bruke.
4. Jeg tror jeg vil måtte trenge hjelp fra en person med teknisk kunnskap for å kunne bruke dette systemet.
5. Jeg syntes at de forskjellige delene av systemet hang godt sammen.
6. Jeg syntes det var for mye inkonsistens i systemet. (Det virket "ulogisk")
7. Jeg vil anta at folk flest kan lære seg dette systemet veldig raskt.
8. Jeg synes systemet var veldig vanskelig å bruke
9. Jeg følte meg sikker da jeg brukte systemet.
10. Jeg trenger å lære meg mye før jeg kan komme i gang med å bruke dette systemet på egen hånd.

SUS results

The results from the SUS scheme can be seen in Table D.1.

Average score: 84.25
Ranging from: 77 - 90

These results indicate that *People love your product and will recommend it to their friends* [32]. However, for this project, it suggests that the users though it was user-friendly and easy to use.

It should be noted that Statement 1, i would, *I think that I would like to use this system frequently*, got a very low score by all users.

Question	User A	User B	User C	User D	User E	Average
Hva syns du om OPPVARMING?	1	4	2	5	2	3
Hva syns du om METEORREGN?	6	6	4	5	3	5
Hva syns du om MØNSTER?	2	2	4	1	1	2
Hva syns du om TVILLING?	5	4	5	4	2	4
Hvordan var MENYEN?	6	5	6	6	3	5
Hvordan var KONTROLLEN?	4	4	2	1	6	3
Hvordan var BRILLENE?	6	2	5	4	5	4

Table D.2 | Test results from Enjoyment scale

Enjoyment scale results

The results from the Enjoyment Scale can be seen in Table D.1.

Meteor Shower and *Twin* both got a high score, and was enjoyable to the user. *Warm-up* got a medium score, which indicates that this game was neither entertaining or boring. However, *Pattern* got a low score, which means that the users did not enjoy this game.

Most user enjoyd both the menu and the headset. However, the controller got various feedback.

Findings
The application is user friendly and easy to use.
Warm up is neither enjoyable or boring.
Meteor shower very enjoyable.
Twin is enjoyable.
Pattern is very boring.
The user like the menu.
The controller recieved variable feedback.
The user like the menu.

D.5 TEST PROTOTYPE 1 | TVI

About the Presentation

Focus group information
Kristin Lundberg (TVI)
Iselin Kanstad (Design Student)
Martinus Ishoel (Design Student)

Method
Presentation and group discussion

Agenda
The purpose of the meeting was to get an evaluation of the prototype from a TVI, in addition to getting access to new patients for testing the prototype. A short summary of the project was presented, highlighting the reasoning behind the prototype

Visualization of performance and results
The TVI stated that getting an image of what the patient sees within the glasses would be very beneficial when used together with a TVI. This would enable the TVI to easier evaluate and help the patient during training.

It is important that this device shows how a patient evolves, so that the TVI can use these results during vision therapy sessions both for motivation and evaluation. Computer applications in training are a great way to show progress, as the results are very visible for the patient.

Creating awareness
Creating awareness is one of the most important parts of vision therapy. To get a patient to fully understand the extent of the visual field loss it is important to show them how they are affected. Showing patients how they are affected works as a huge motivational factor for conducting vision therapy. It is important to remind them every now and then, it is not enough to show it to them once.

Difficulty
An aspect which was discussed during the meeting, was how the application could be adjusted based on the patient's level of skill. As the patient's level of skill is very different, they should be able to play at different difficulties. For a patient with severe impairments after stroke, which

is just learning how to use the app, the difficulty should probably be significantly lower than for a patient who has used the application every day for two months.

The TVI said that the minigames “Twin” and “Pattern” were more difficult than the two others, and would be too difficult for some of the patients. For these games, an even simpler version could be valuable for some patients. The conclusion from the discussion was that all games would benefit from being scalable, to fit all patients level of skill.

The TVI stated that it would be beneficial to be able too adjust the difficulty of the games before they are given to patients.

Access to patients

The TVI said that this application was something she did not have any problems with showing to patients. She had two possible patients that could help during the test phase, and would contact them to schedule a meeting.

Findings

If the TVI could see what’s inside the headset, this would be beneficial when the concept is introduced to the patients

Better feedback on where the patient’s struggles, could help increase awareness of their deficit.

Pattern and Twin are more difficult to understand than Warm-Up and Meteor shower, which could be problematic for severely impaired patients.

The prototype was sufficient enough for the TVI to test it with a patient.

HURDAL

Appendix E | Summary of the stay and findings at Hurdal

APPENDIX OVERVIEW

During this master thesis, two weeks was spent at the Hurdal Syns- og Mestrings-senter. This Appendix summarizes the findings from this stay.

E.1 HURDAL INTRODUCTION

Figure E.1 | Hurdal Syns- og Mestringssenter

Hurdal Syns- og Mestringssenter
Hurdal Syns- og Mestringssenter(HSMS), is a center directed by the Norwegian Association of the Blind and Partially Sighted. This center offers courses for people which are blind and partially sighted, and aims to help these to live normal lives.

Course Patients
The course which was attended, focus on stroke patients in their working age, mainly patients below the age of 70 years old. Vision therapy has been a neglected subject in Norway for a long time, and since Hurdal started with their courses 20 years ago, they have gotten many referrals from patients who want to attend. Therefore, they have to prioritize. If there is enough capacity, they help older patients as well, but mainly Patients with HVFD at Hurdal are in the age range of 40-70 years old.

About the course we attended

During this thesis, two weeks were spent at HSMS. The course lasted the whole day, starting around 08.00 and ending around 23.00. We followed a course for attendants who have attended previous courses before.

The course consisted of six participants, which each had from one to two vision therapy sessions a day. We were allowed to attend these sessions, and the following sections presents some our findings from attending the course and observing these sessions.

E.2 GENERAL OBSERVATIONS

Neglect and HVFD is difficult to differentiate
Some of the patients have neglect, others a combination of hemianopia and neglect. It is often difficult to say whether a situation is caused by one or the other.

HVFD is a hidden impairment
The participant's vision impairments are not immediately evident and are not noticeable when observing behavior and movement. There is a big difference between this group and other patients on the facility. This group is not reliant on available vision aids, e.g. markings on the floor, railings across the walls, white canes or vision assistants.

Being able to drive again is important
A common goal of many of the course attendees is to be able to drive again. This topic is frequently mentioned during training, meals, and coffee breaks.

Driving is not realistic, reading skills improve
Talking with mobility instructor: Getting their driver's license is a goal many of the participants here want to achieve, however, most will never be able to. In the last seven years, he only remembers 2 or 3 patients who got their permit again. Reading, on the other hand, has improved for almost every patient.

Cognitive difficulties
Several of the attendees had cognitive difficulties. Fatigue, tiredness and concentration problems are apparent during the course activities. Some are less obvious, and it is often difficult to say whether it is a result of their stroke or just regular behavior.

Physical impairments
Every morning there was a morning exercise. This was a set of different dance-like movements, which lasted for about 15 minutes. During these exercises, several physical impairments became visible. Some participants had troubles with complex movements, and some patients were not confident when doing the movements, and skipped the exercise or left the room temporarily. Most of the patients had good balance and mobility, but some struggled with hand movement. These were more difficult, especially for those with one impaired arm. Finger movements were especially hard. Several of the patients struggeled with this.

Busy public places can be difficult
One patient mentioned that busy public places such as airports and terminals could be challenging and stressful. These are places he would have liked to get help, if possible.

Recognizing people can be difficult
One patient said that he has a difficult time recognizing people when in public, especially of the appear on his affected side. People he knows has often called him arrogant, which he knows is meant humorously, but it is still uncomfortable to hear.

Ignoring objects on the blind side
A patient asked after one of the course participants when he had been sitting across the table to the left of the patient for about 15 minutes. Another patient did not find the ketchup bottle next to him. Incidences like these, happened almost every day of the stay.

E.3 VISION THERAPY | SESSION 1

Driver licence is a motivational factor
The patient says that he started to train his vision with the hope of regaining his driver's license. When he started to realize that this would never happen, he lost hope and motivation. He also states that there is to little documentation and feedback on his training. All this combined makes the patient wonder whether he should train his vision at all.

Cognitive difficulties prevents effect of therapy
The TVI says that this patient's cognitive difficulties are significant and that he most likely won't get any benefit from training. He might get better during practice, but when he gets home, he will most likely go back to his old ways. The TVI believes that the main reason for the patient's stay is the social aspect.

Loosing concentration
During the TVI session, the patient repeatedly loses concentration and starts talking about other subjects. He often stops in the middle of exercises to tell a joke or a story, and the TVI struggles to keep him focused.

Computer games are motivating
The methods used in this session where cards, UFO, Find the number and missing number. This is the first time the patient has trained his vision using a computer. His remarks imply that the games are motivating. Statements like "This was a funny exercise, well, not funny funny, but funny", "This was a good exercise" and "I could play this all night." gives the indication of this. Also, he is more focused than in the other tasks, and his concentration issues are less evident.

Keeping the head still is challenging
The patient struggles with keeping his head still and often corrects himself. The TVI has to hold his head still and look at his eyes to see that he moves them correctly.

Cheating the game is demotivating
The patient states that he feels that "he can see through the program.", meaning that he manages to analyze where the next ball will appear in UFO. Whether this is correct or not, is difficult to analyze, but it is evident that this troubles the patient.

Embarrasing to not be able to do the exercises
Find the number is not a successful exercise and is way above the patient's level. When the TVI changes the exercise, the patient responds "it is quite embarrassing to change exercise, guess I was not good enough.".

E.4 VISION THERAPY | SESSION 2

Experiencing progress
The patient fixates very often, has short saccades and has a relatively slow reaction time. The patient has experienced significant progress since the accident.

Negative to vision therapy
The patient is negative to Vision therapy. This is not because he doesn't think it helps, but because it makes him very tired. He is already tired from the training he did the day before and is not looking forward to today's training. He was told by the TVI to prioritize his stay at Hurdal and to save more energy for the Vision therapy sessions.

Does not like computers
The patient also tells about his dislike for screen-based technology. He does not want to live a square life and does not own a computer. Nevertheless, the TVI did manage to convince him to try a program named CogPack.

The method UFO shows the extent of the deficit
The exercise UFO gave an overview of the extent of the deficit when the patient were not allowed to move the eyes. The exercise revealed a total homonymous hemianopia, as the patient did not notice the UFOs before they entered the left visual field. This seemed to be bothersome for the patient, as he sometimes knew that the UFO was to the right of his functioning visual FOV, but was not allowed to search for it. This rendered the task tedious and boring. The patient mentioned that this felt unrewarding, as it only seemed to reveal his visual deficit.

Exhausted after few exercises
Later, the patient was allowed to use his eyes to search for the UFOs. This made the task more efficient and made the reaction time between the left and right a lot less noticeable. After this method was finished. The patient was evidently exhausted.

Stopping the session
The next method which was used was called eye witness. This task required the patient to observe a computer generated scene. After the observation, the patient was asked to recall details about the scene. This was not pure visual therapy, but rather cognitive therapy. After this test, the patient expressed that he did not want to continue with more vision therapy. The patient's body language expressed that he was very tired.

E.5 VISION THERAPY | SESSION 3

Motivated patient
The patient is highly motivated, trains hard and is very focused on his training. He is diagnosed with quadrantanopia in the lower half of his eye.

Regaining the driver license
The patient's main goal is to regain the driver licence. "To be able to drive again is very important for me, of course I want to improve on the other stuff too, but I can do that eventually." Says he has driven before, and that there is no problem since driving only requires the bottom half of the visual field. This statement is not supported by the TVI.

Awareness training for driving
Most important training for drivers license: Awareness training.
Driving license test: split awareness, speed, and perception is tested.

Judged unfairly because of his aphasia
He also claimed that the communication between health personnel is bad and that the person testing him in driving, were not aware of his other stroke-related challenges. He felt he should be able to drive, and that since his other challenges were neglected, that the judgment was unfair. Besides, he also feels it embarrassing to rely on another person while driving.

Almost no one regains their license
An important observation is that almost no one of the patients at Hurdal reclaims their driver's license after rehabilitation. Still, most of the patients in this course, especially this one, has one big goal, to be able to drive again.

Lived with a HVFD without knowing what was wrong
"Why didn't anyone tell me this before?" - Claims he had to live with a visual deficit, noticing that something was off, without anyone telling him what was wrong.

Doctors stopped caring after diagnosing him with a HVFD
In addition, he felt that the doctors stopped caring about him after he was diagnosed a visual field deficit. "There's nothing we can do!". They didn't tell him what to do next, and this was experienced as very frustrating. Hurdal on the other hand is better to take care of the patient as a whole, and he really appreciates this opportunity.

Forcing the eyes to move first
The TVI explains what his difficulties are: *Waving her hands on each side of the head* - When I sit like this, I get a visual signal, which you won't get since you have a problem with seeing on one side. A person without a visual deficit will cast a quick glance, before turning the head. Your goal is to turn off the autopilot and force the eyes to move first.

Small changes in exercises can cause problems with executing the exercise
The patient was confident during the domino exercise, and had little problem carrying it out with a reasonable speed. He did not move his head, and it was not noticeable that he has quadrantopia. The patient had done this test before, and advanced to adding the numbers together, before the TVI recommended it. When the TVI later on wanted to advance to a stage even more difficult (adding the numbers + adding one), the patient experienced more cognitive problems. This test was new for the patient, and the difference between the two levels were huge.

Task comprehension can be difficult
The patient has little problem with performing the tasks given, when he understand what he has to do. The TVI uses a lot of time explaining the exercises, without the patient understanding.

Performing well in an exercise is motivating
The patient has done this tasks many times at home, which is evident in his fast execution. The TVI is clearly surprised by his efficiency, and the task take almost no time to finish. The patient clearly prefers the computer game, and says it is better when he knows the tasks he has to perform.

Training unrelated to his focus area is unrewarding
When the TVI suggests to place him closer to the screen, to give him a bigger challenge, he doesn't see the point. "When I'm driving I don't have to look at that angle, so why should I practise on that situation?" - this and other statements, gives an indication that this patient is very focused on transferring training results to real life.

Too easy exercises are boring
The game appears to be tiresome and repetitive. And do not appear to give the patient enough of a challenge.

Lack of feedback on the patients progress in relation to his focus area
Although the patient repeatedly mentions driving, he gets no indication of how good he have to get in order to be able to drive again. On the other hand, the TVI starts with telling him how the methods are connected to driving, before initiating the different methods.

E.6 VISION THERAPY | SESSION 4

Compensating by throwing a longer look
Uses dominos as a warm up exercise. At the right side, the patient has problems with registering the dot in the upper corner on the domino piece. He is told to concentrate on throwing a longer look to the right.

The exercise cards is good for training at home
The first exercise was a method using cards, he starts on level 2 and goes through each level up until level 4. The TVI recommends the cards exercise, see Appendix F.5, for training at home.

Learning new tasks is difficult
Learning new tasks is difficult, either perception, understanding or his aphasia causes him to struggle with understanding the instructions given. An example is when the TVI asks him to look for an even/odd number, and he uses a long time to understanding what this means. Counting 2-4-6-8-10- before falling off and starting to say odd numbers again.

Repeating the same information is not effectfull
Afterward, he went over to cogpack on a computer. He tested two games, cogpack-saccade and cogpack-prefer vision, see Appendix F.8 and F.9. During cogpack-perifer vision the patient struggles with pressing the arrows. It looks like this is due to an understanding problem, he awaits to press the arrow until the number appears, even though the TVI repeatedly says press several arrows and press the arrows faster.

Showing exercises to the municipality
Then he plays the two last levels of UFO. He excelled in this task and performs well above average. The patient states "It is evident that my head is ok when I do tasks like this! I wish the municipality could see me perform this task!."

Refuse to take breaks
The patient refuses to take breaks, he doesn't have time. He states that he has been a hard worker his entire life and that he does not need breaks. When it is time for lunch, he says that he would rather train more and that he only needs ten minutes for eating anyway.

Aphasia can give the impression that the HVFDs is bigger
The patient himself keeps telling the TVI that if he doesn't manage a task it is because of his Aphasia not his visual field deficit. As soon as he understands what he is supposed to do, he performs the exercise with ease.

Tested in linguistic skills rather than visual
The patient is also highly focused on regaining his drivers licence, and repeatedly talks about it between the different exercises. In order to regain his

drivers licence he has to pass a visual awareness test at the ergotherapist. If a patient fails this test, they have to apply for a new one at the municipality. At the test the patient got many new and unfamiliar exercises, and had problems understanding what to do. The patient himself felt misunderstood, feeling that he got tested in linguistic skills rather than visual. He felt neglected by the test responsible, who according to him showed no understanding of his other stroke related difficulties. It should be noted that afasi patients are allowed to drive.

The patient struggles with understanding that he is not fit to drive

The municipality won't allow him to retake the test, which he feels is unfair. He wants to show to the doctors that he is capable! By either taking a practical driving test or by showing his results from Cogpack.He says that if he is a danger to anyone else, he does not want to drive. But he feels that his results from training is not taken seriously and that he is more than qualified to drive a car.

Lack insight about the full range of his cognitive difficulties

The TVI on the other hand does not believe that he ever will be able to regain his drivers licence. Patients with visual field deficits will almost never be able to drive again. In one year only a total of five people in Norway with VFD has qualified for a dispensation. The drivers test is a though test, and the TVI says that if everyone had to take this test, many would not have had a drivers licence today. He lacks insight about the full range of his cognitive difficulties. It would be beneficial to let him try a car game, to show that it is not safe for him to drive.

Not cheating is important for the patient

During the exercises the patient is careful not to cheat, and asks the TVI to change the numbers so he does not rely on memory, only on vision.

E.7 VISION THERAPY | SESSION 5

Trouble with oculomotor functions
The patient has had HVFD on both sides. He has had a total homonymous hemianopia on the left side, and scotoma on the right side. He has had a lot of troubles with oculomotor functions and has still problems with flickering while fixating.

Focus on reading
The patient expressed a desire to get better at reading, during the initial talk. The TVI said that reading could be the main topic for the Vision therapy during his stay in Hurdal. The reason for choosing reading as the main focus area was based on the patient's struggles with reading in everyday life.

Difficulties with reading
The TVI started the training by testing the patients reading skills. A text with words of different lengths and complexity was used. The TVI measured the patients reading speed, along with reading technique. The patient had apparent problems with reading. He skipped lines and short words while spending a lot of effort on long and complex words. He did also have a habit of guessing before he had read the full word.

The letter and word method, see Appendix F.14 and F.15, was also used. During these exercises, the patient struggles with reading and recognizing letters. This was a distinct improvement from the reading test. The TVI concluded that the patient did not have any problem with reading words, but rather with the reading technique seen as a whole.

TVI advises the patient to change aid
The patient said during the initial talk, that he uses a magnifier to read. This was ultimately the wrong tool for the patient, based on the TVIs assessment. The magnifier helps the patient to easier read individual words, which is not the difficult part for the patient.

Fatigue decrease reading ability
During the last exercises the patient gets noticeably worse at reading. He does not at any time complain but is on many occasions very fatigued. This contributes to making the long and complex words difficult to read. The patient does also frequently close his eyes to take short breaks, both on recommendations from the TVI and his own initiative.

E.8 VISION THERAPY I SESSION 6

Great progress related to vision
The patient suffered from right homonymous hemianopia. This HVFD is now reduced to a scotoma located to the upper right area of the central vision. This patient has experienced great progress in vision, especially in terms of oculomotor functions. The therapy session quickly proceeded to the therapy.

Tired after a short period of time
The first part of the Visual therapy session was composed of several similar methods, which was used quickly and alternately. These were the letter, word and ball method.The patients seemed to master these methods well, as the session was conducted in a swift and efficient manner. However, was the patient was clearly tired from the therapy when this method was concluded.

Assessing the extent of the HVFD
To asses the size of the scotoma, two methods were used. The first one was using a colored sheet of paper, which was held up in front of the patient. The patient was asked to fixate straight ahead while describing the color and location of the paper. The patient was able to locate the paper's location correctly but struggled to see in when inside the location of the scotoma. Both color and appearance became difficult to describe when in this area.

The second method used a digital overhead, where the TVI arranged a set of different shapes in different colors on the overhead. The images were shown on a monitor in front of the patient. The same aspect was apparent as with the paper method, where shape and color became invisible in the affected area. In some instances the patient was not able to see the shape at all, even in the shape was distinct and the color clearly stood out from the background.

Fatigue affects visual performance
It was apparent that the patient saw less and less as more therapy was conducted. This was due to the patient getting tired and fatigued.

E.9 VISION THERAPY | SESSION 7

This observation was conducted during day two at Hurdal. The observation was of a TVI having about one hour of time both training and assessing patients vision. The patient has a VFD on the left side and has a history of neglect.

Progress and test results

Only a few minutes was spent talking about the patient's history, where the patient's progress was emphasized. Previous test results were also mentioned during this initial talk.

Training with computer at home

The patient mentioned his current training program, which consists of using two computer programs on a regular basis. However, the patient did not use one of the two programs. The patient did, however, talk enthusiastically about the program Cogpack, which was used for several exercises.

Training with one eye

The patient mentioned that he only trained using both eyes, while he was also supposed to train using one eye at a time. The TVI said that to get the wanted effect, the full exercise had to be done. However, the patient stated that he had experienced a lot of progress using this program.

Tricks for getting help with vision therapy

The patient also mentions several tricks for getting help with vision training. The first was using a speech therapist to get help learning how to read, even though speech therapists are usually offered to those who struggle with speech, in terms of either wording or pronunciation. The patient was also able to get access to rehabilitation, by joining a union which works with stroke.

Observing eye and head movements

The first one was the ball test, which was used to test the patient's oculomotor skills. During the test, the TVI was observing the patient's eye, looking for unnatural or faulty eye movements. The patient was asked to not move the head and was told to correct their position immediately if he made a head movement. The exercise was done using both eyes and each eye individually. The patient moved his head periodically, and his eyes moved faultily in the upper left quadrant of his vision.

The TVI corrects the patients

During the exercise First and Last Word and First and Last Letter, see Appendix F.16 and F.17, the patient struggled with missing the first letter in each row. In some instances, this was detected by the patient himself but was most often corrected by the TVI.

TVI changes training program based on how exercises are performed

The patient was also asked to read the first and last letter in each row. This resulted in a higher pace, but a higher frequency of errors. This was apparently caused by flickering or misalignment between the eyes. Based on this observation, the TVI made plans for more fixation training.

Troubles with memory

At the end of the session the method described in F.18 was used. The patient was asked to scan the hart charts in a specific order, while the TVI was monitoring the patient's saccades and fixations. Making long saccades and rapid fixations, was the task given by the TVI. The patient had a hard time remembering the order of which he was told to scan the hart charts, as the sequence seemed to be long and confusing. As this was at the end of the session, the patient was exhausted from the previous exercises.

E.10 MAPPING OF FINDINGS FROM HURDAL

Trello was used to get an overview of the observations done at Hurdal. This made it easier to know which findings to focus on, as they could be moved around and sorted after priority. The findings that were noted are presented in this section.

- Physical impairments (One hand)
- Reading difficulties
- Perception and concentration issues
- Fatigue and tiredness issues
- Transferability: The task has to correspond with the real world.
- Some uses head motions, in order to see
- Most thinks it is difficult to adopt an artificial search strategy
- Using special scanning techniques are difficult, if it is not part of a spesific task
- Some does not like Visual Therapy.
- Patients often close their eyes, when resting between excersises
- The patients thinks VT is fatiguing
- The vision impairement is not evident from observing

- Most patients have had a severe stroke (paralysis, Afasi etc). This is not evident anymore!
- Many patients have other sight related problems (light sensitivity, flickering, fixation problems etc)
- TVIs uses different methods
- The patient contributes to decide what their training is about.
- Goal: Drivers licence
- The patient should not move their head during vision therapy
- VFD is often linked with memory problems
- Vision therapy can improve other cognitive issues, such as memory and concentration
- The patients does often move their head during Therapy, if they are not reminded not to

Patients lack documentation on their results

Patients wish the municipality could see their game results

the TVI and patient often have different version of the patients abilities and goals

Computer games are motivating and funnier than regular exercises

Several have severe concentration issues, and constantly interrupts training sessions

The TVIs does often have to monitor eye movement.

Changing exercise because it's to difficult is embarrasing

Important to train rapid switch of focus

Saying the numbers/task out loud gives patients a better understanding

The earlier training starts after getting a VFD, the more efficient

Patients often feel neglected by their doctors, "there is nothing we can do with HVFDs!"

A patients visual impairment are often misjudged because of other cognitive problems (lack of understanding, speech difficulties, concentration issues etc)

It is important to train awareness of two different incidences

Many of the patients have cogpack installed at home

Some patients don't see the neccessity to train on methods that don't directly link to getting their licence back

How good a patient performs on a test is not linked to everyday life. (some have reached the highest level of the game - without being good enough to take the licence)

Visual deficits affects perception, concentration and memory.

The drivers test is tough

Several of the patients use a speech therapist for vision therapy

The TVI uses varying amounts methods during each session

Many of the patients are familiar with each other.

Some experiences that vision gets worse as they get tired

One of the TVI sperate between using one and one eye, and both at the same time

Many of the patients are familiar with the TVIs

The TVIs make up their own methods based on basic principles

The patients work towards unrealistic goals (getting their drivers licence back)

a feeling of "cheating" the game is demotivating

Most has aids, such as magnifiers, special glasses, reading TVs, walking stick, special rulers

Some does not actively use their blind side. Most did not use that side in the beginning

Thinks buzy public places are disorienting and stressfull

Some thinks orientation is a big problem

Busy places such as airport terminals and malls can be difficult and stressful.

Difficult to recognize people in public, especially if they appear on the affected side.

Hearing that vision therapy can improve the visual field is as a motivation boost

Many of the patients use computer programs at home for training

Aphasi patients are allowed to drive

Most patients use smart phones

- Morning practice is not suited for stroke patients
- Several skips morning training
- Most has physical impairments
- "When you come to a certain age you know what is best for you, and do it"
- Most of the initial TVI training is not directly linked to HVFD
- The impaired hand is difficult to raise over shoulder level
- The group has a light and joyful mood
- Finger movements are especially difficult. (clenched together or moving slow and staccato)
- Most of the patients experience great trouble with reading
- Several have oculomotor problems
- warm up before visual therapy is good for the occolutmotor muscles

- Several have experienced visual improvements
- Visual impairments are not apparent to the observer
- A focus area is chosen for therapy; Mobility, ADL, Reading,etc
- Some does not look at their HVFD as a big problem
- They get a lot of information about preventing stroke at the course.
- Many computer games are repetetive and boring
- None of the patients have their license
- Patients care about preventing stroke (exercising before breakfast, eating extremly healthy etc)
- Hand movements are difficult. Many struggle with impairment in one arm
- "11 days is a little bit to long to be away from home"

- Stroke patients are usually divided in young and old
- Most patients have been to Hurdal several times before
- Most patients have been to Sunnaas rehabilitation facility
- Gets motivated by hearing that their HVFD will improve by training
- Patients in this group are younger than expected.
- Visual impairments become obvious during vision therapy
- Goal of elderly stroke patients (67+) : Get back to everyday life
- Goal young stroke patients (Working age): Get back to work and family obligations
- General balance and mobility is good for most of the patients

- Several of the patients have neglect
- Several have cognitive difficulties
- It is difficult to say whether an incidence is caused by a cognitive difficulty or just human behavior.
- The group is not reliant on vision aids (railings, markings on floor etc.)
- Reading improves for nearly everyone after therapy
- Almost no one with HVFD gets their license back
- Most have trouble reading
- Patients think Cogpack is great
- Patients have little surplus of energy during the stay at Hurdal
- The patients in this group had stroke several years ago (2-10).
- Hurdal is not specialized for stroke patients. It is a facility for people who struggle with sight

METHODS FOR VISION THERAPY

Appendix F | Literature review and summary of vision therapy methods.

APPENDIX OVERVIEW

This Appendix covers some literature reviews, which was part of the preliminary insight phase in this project. These literature reviews are of studies and methods for vision therapy.

The last part of the Appendix is a summary of vision therapy methods which has been observed at Hurdal syn- og mestringssenter.

F.1 LITERATURE REVIEW I VISION THERAPY

Methods for vision therapy are vast. These range from pencil push-up therapy, which is a cheap, simple and effective method [37], to more complex computerized trainers such as the Sanet Vision Integrator[38]. This Appendix focuses on vision therapy in terms of compensatory visual field training(CVT), which has proven to have a positive effect for people suffering from VFDs[7,15,16,17].

Helsedirektoratet does not provide a recommended method for vision therapy[13]. The aim of this literature review it therefore to explore existing methods, and to find methods that are relevant for this project.

Visual Scanning Training

Visual Scanning Training (VST), also called Explorative Saccade Training(EST), is a method where patients are systematically or randomly scanning and identifying objects which are displayed in both their blind and seeing field of view. This usually involves a screen or board which displays LEDs, letters, numbers or shapes. The goal of this therapy is to decrease time spent searching for objects and to improve the search strategy used by the patients.

An example of VST is seen in a study by de Haan et al. [39], see Figure F.1. In the study, three different methods are used; the dot counting test, parallel search test and serial search test. The dot counting test was based on counting dots and was evaluated based on counting accuracy and time spent searching. The parallel search test was based on checking whether an object was present among distractors or not, and was evaluated based on reaction time. The serial search test measured time spent finding an object among distractors. The study did not find any evidence for changes in performance. However, patients did report having less difficulty performing certain ADLs after training.

Figure F.1 | HVFD exercises from a study by de Haan et al.[39], p 8.

Audio-Visual Scanning Training

Audio-Visual Scanning Training (AViST) is similar to VST in terms of purpose and procedure. However, this method includes auditory stimuli along with the visual stimuli.

AViST was used in a study by Keller and Lefin-Rank[22], to compare the method with VST. A board with a 3x16 grid of LED lights and speakers was used for this assessment. During the test, the patients were supposed to click a response button as fast as possible after detecting the presence of a visual target. During the test, the visual targets were supported with auditory stimuli. Tests were also conducted without sound. The results of the test suggested that the addition of auditory stimuli provided faster reaction times.

F.2 LITERATURE REVIEW | PROMISING STUDIES

Nelles method

Nelles et al.[16] did a study of a method (Nelles method) using a large training board, See Figure F.2, which was made to enhance the detection of and reaction to visual stimuli. The finding from this study supports that this training method helps patients that suffer from homonymous hemianopia, to compensate for the visual field that is lost. The training resulted in both improved reaction time and detection of visual stimuli. These findings are assumed to be a result of more efficient saccades.

Keller method

A similar method (Keller method) was used in a study by Keller and Lefin-Ran [22], see Figure F.3. This study was done on stroke patients suffering from lesions in the occipital lobe and claims that the method helps to improve eye movement behavior. The results from this were an improved performance for the patients in a variety of ADLs.

Similarities

Both methods are based on intensive training of saccadic eye movements into the part of the visual field that is lost. They are based on a matrix of LEDs, which light up in different patterns. The patients are then supposed to detect either single visual stimuli or patterns of visual stimuli. When the correct stimuli are detected, the patient presses a button and their reaction times are measured.

Time-consuming

The methods are also very time-consuming. During the Keller study [22], each of the patients trained for a total of 56 hours; 4 hours daily for two weeks. During the Nelles study [16], the patients received a total of 28 training hours; 30 minutes two times a day for four weeks. However, compared to other methods such as VRT, can this be considered to be a small amount of training time[40].

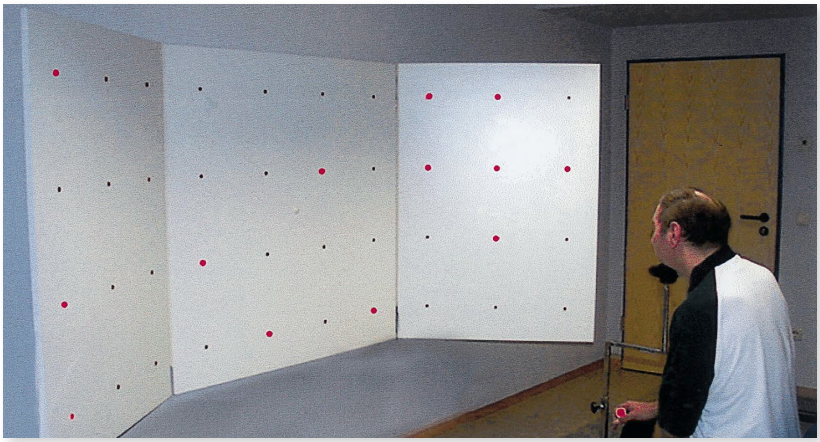


Figure F.2 | Apparatus for HVFD exercises from a study by Nelles et al.[16], p 190.

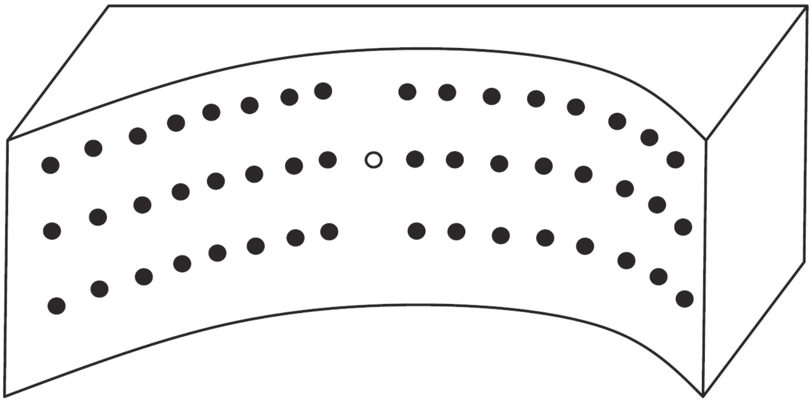


Figure F.3 | Apparatus for HVFD exercises from a study by Keller and Lefin-Rank[22], p 688.

F.3 LITERATURE REVIEW | MOBILE APPLICATIONS

There exist several mobile applications that are created for vision therapy. A quick search on the App Store or Google Play Store provides many Apps which claims to provide better vision.

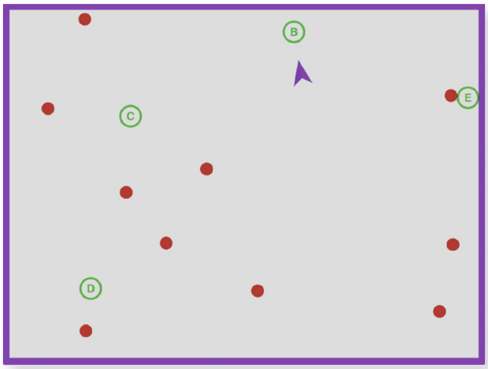


Figure F.4 | Image of example game from Vision Tap [36]

Vision Tap
One of the Apps available for the iPad is Vision Tap[36], see Figure F.4. The App is a collection of 13 exercises that is used in vision therapy, which is adapted to the iPad form factor. This App was mentioned in an interview with a TVI, see Appendix C.8, which said that this is actively used by patients and TVIs around the country. The fact that Vision Tap is used by patients and TVIs today supports the validity of the app. However, there is no available research available to provide any documented effect. While Vision Tap is not specifically targeting patients with Homonymous Hemianopia, the App provide an overview of the fundamentals of vision therapy.

Vision Therapy by Cerevrum INC
Vision Therapy by Cevevrum [41] is another mobile application for vision therapy, see Figure F.5. This app utilizes virtual reality technology and provides some of the same fundamental exercises as Vision Tap but in a much simpler way. This app automatically goes through 5 different exercises in approximately 2.5 minutes, with no possibility for customization or overview of progress. No research was found, who suggest any effect from using the app.

Similarities
The two apps are similar, as they are built on the same principles. They are however very different in the ability to adjust the program to fit the user. Vision Tap offers a complete package which allows the user to customize training and track their progress. On the other hand is Vision Therapy by Cevevrum a static run through of methods. Neither is solely meant for patients with Hemianopia but contributes to show how Apps for people with visual impairments can be made.

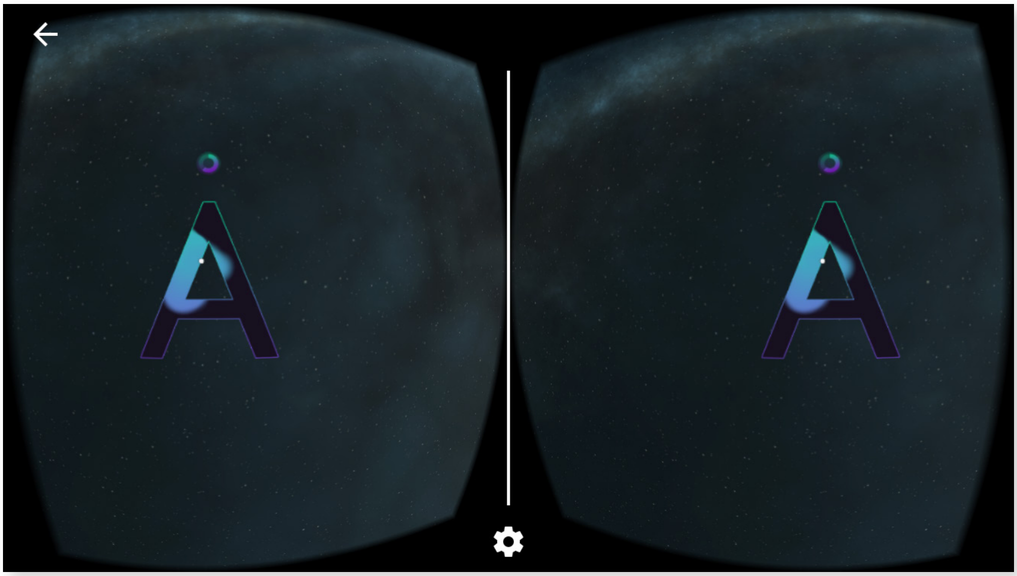


Figure F.5 | Screenshot from Vision Therapy by Cerevrum [41].

F.4 DOMINOS

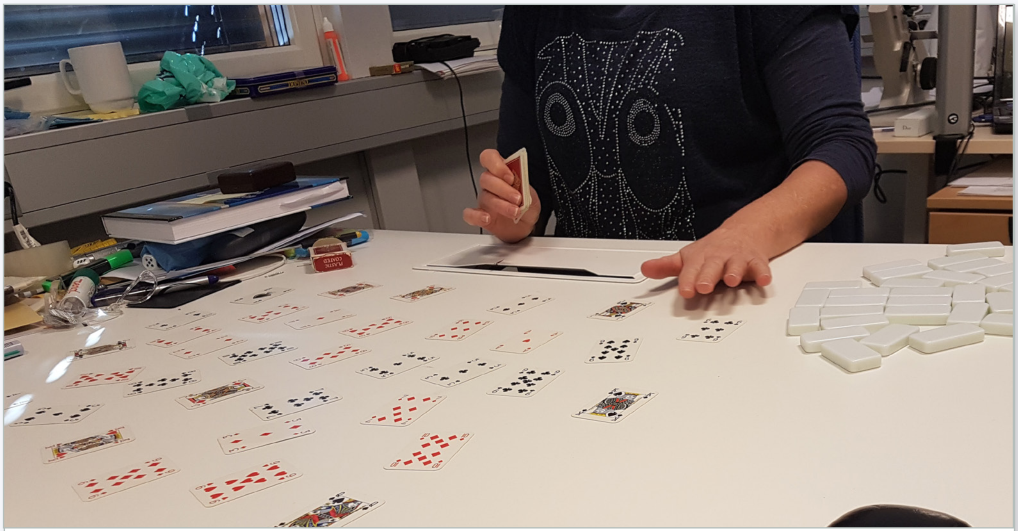
Procedure
The patient and the TVI sits across a table. Several dominoes are spread on the table. The TVI takes one and one domino and shows it to the patient, varying the placement of the domino. This exercise varies in speed based on the patient's performance.

Levels
Level 1: Say the two numbers on the domino piece out loud.

Level 2: Add the numbers on the domino and say it out loud.

Level 3: Add the numbers on the domino, then add one and say the number out loud.

F.5 CARDS



Procedure
The patient and the TVI sits across a table. All the cards in the deck are placed face-up on the table. The patient is asked to locate and point on a specific card/series of cards.

Levels
Level 1: Find a specific card. (Find number 6)

Level 2: Find all cards with a number the TVI says out loud (find all cards with number 6 on them)

Level 3: Find all cards in one suit and point on them in order. (find all hearts from 2 to ace)

Level 4: Point on cards in order, alternate the suit.

F.6 POST-ITS

Procedure
In this method the patient sits on a chair in front of a wall, looking at one point at the wall. Around the point, there are several post-its with numbers ranging from 1-10 in the color blue or green. The patient sits with a laser pen in his arm, which he uses to perform the tasks given. The range of the numbers and number of colors varies according to the patient's performance.

Levels
Level 1: Point on a specific post-it

Level 2: Point on post-its from 1-10 in order in the same color

Level 3: Point on post-its from 1-10 in order, alternate between the colors.

Level 4: Point on post-its backwards from 10-1 in the same color.

Level 5: Point on post-its backwards from 10 - 1, alternate between the colors.

F.7 COGPACK | UFO

Procedure
The patient sits in front of a large screen. In this exercise the patient has to look at a focus point in the middle of the screen. Round balls fly in to the center of the screen from different angles. The patient has to localize the balls as early as possible. The patient uses the mouse to click on the appearing balls. If this is to challenging, the patient can notify the TVI when a ball is seen, and the TVI uses the mouse to click on the balls for the patient.

Levels
Level 1: slow and big

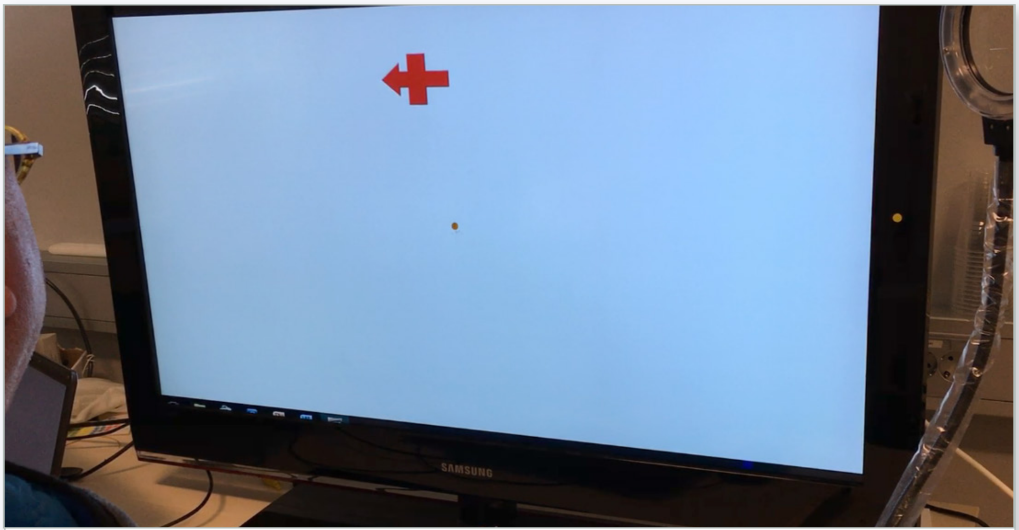
Level 2: Smaller and faster

Level 3: Super fast

Level 4: Hyper fast

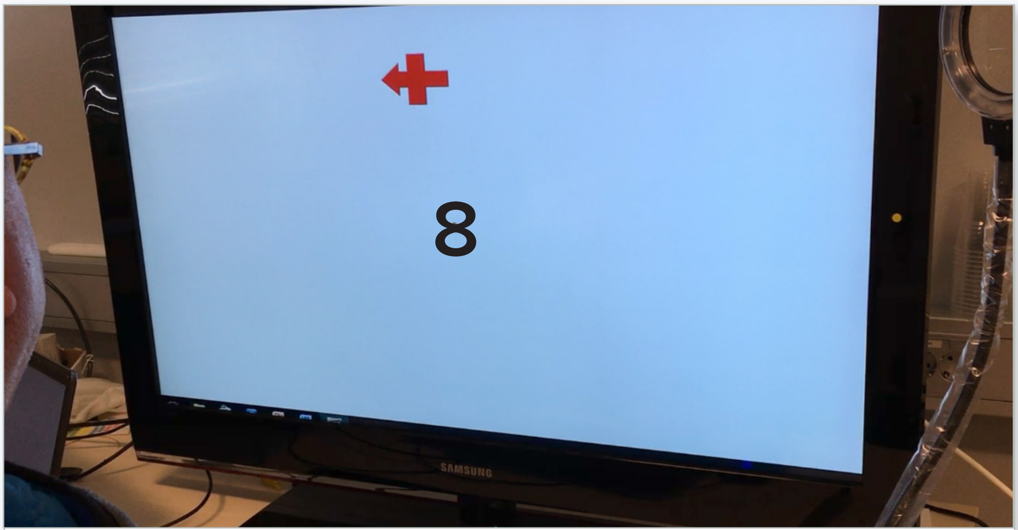
Level 5: Permanent adaptive (adjusts to the patient's level)

F.8 COGPACK I SACCADE



Procedure
The patient sits in front of a large screen. A left or a right arrow appears on the screen, and the patient has to press the corresponding arrow on the keyboard.

F.9 COGPACK | PERIFER VISION

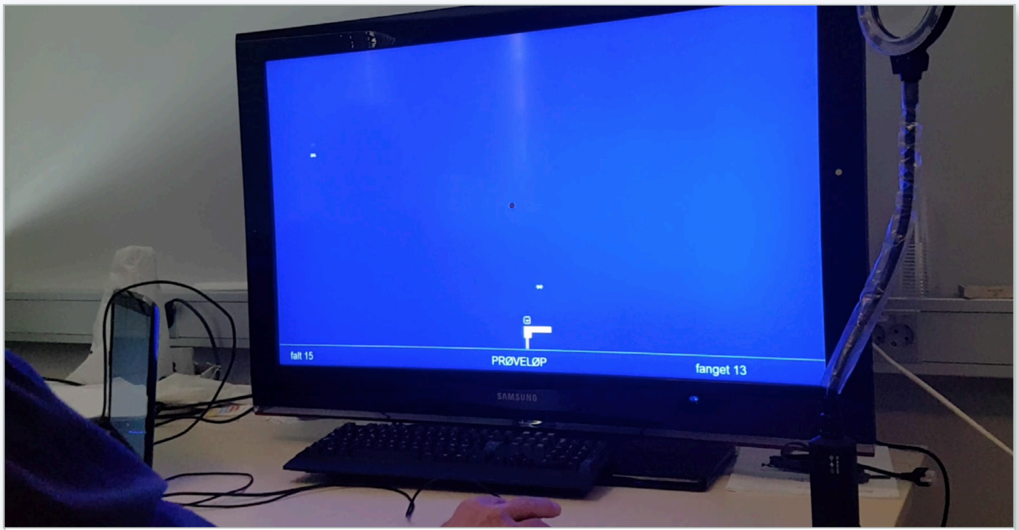


Procedure

The patient sits in front of a large screen. In this exercise, the patient has to do two things simultaneously. It is an advanced version of *Cogpack* | *Saccade*. A number appears in the middle of the screen, and the patient has to say the number out loud. At the same time, arrows appear in a faster speed, and the patient has to press the corresponding arrow on the keyboard as fast as possible.

This is a good preparation test for taking the driving test.

F.10 COGPACK I STAR FALL



Procedure
Stars fall from the sky. The goal is to collect as many as possible by moving an object to the right and to the left. This object is moved by using the arrows on the computer, or by moving the computer mouse from left to right. Increasing the difficulty results in more stars falling at a faster speed.

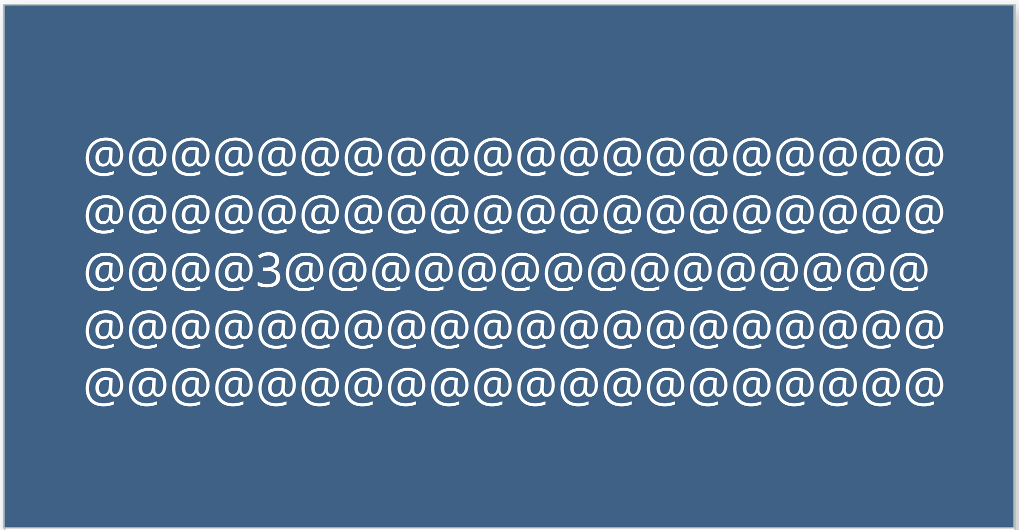
Levels
Level 1: Easy

Level 2: Medium

Level 3: Hard

Level 4: Adaptive

F.11 LOCATE THE NUMBER



The image is a recreation of the method observed at HSMS

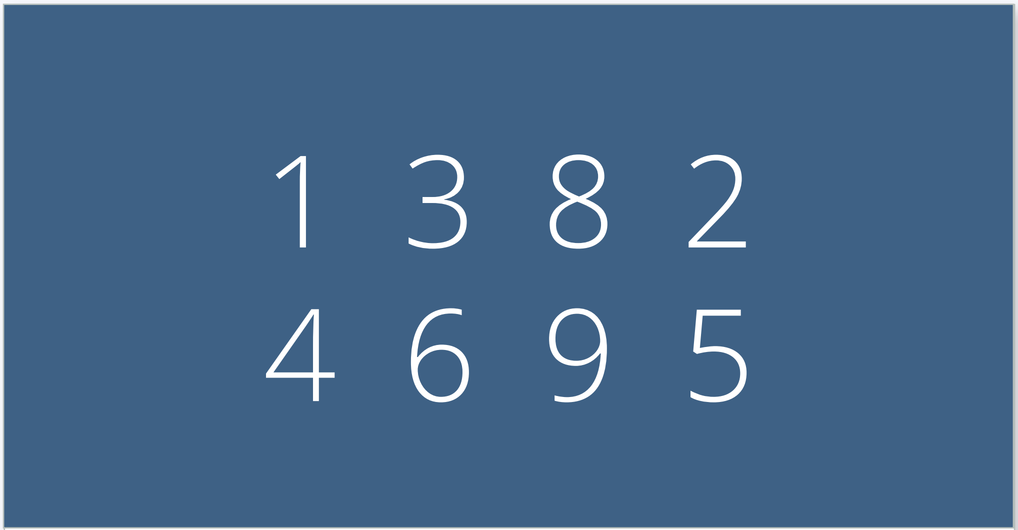
Procedure

The patient sits in front of a large screen. In this exercise, the patient has to locate a number in a series of commercial-at-signs and click on it. There are 5 rows with 20 signs in each row. There is no space between the signs.

This method teaches the patient how to scan efficiently.

NB! Since the patient is using the mouse to click, it is common to start using the mouse to trace the different lines. This is not allowed.

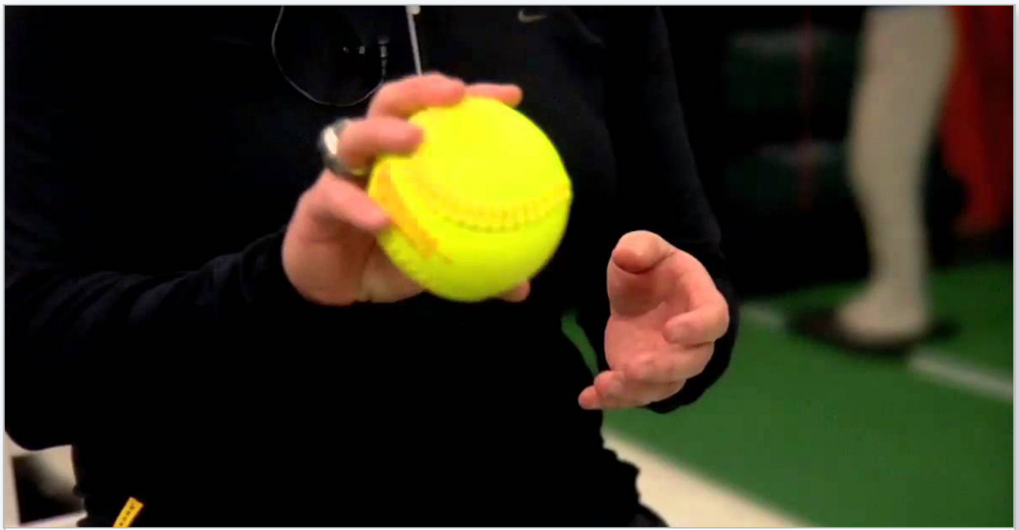
F.12 MISSING NUMBER



The image is a recreation of the method observed at HSMS

Procedure
The patient sits in front of a large screen. In this exercise, the patient is shown 8 big numbers, range 1-9, in a random order. The patient has to find the missing number and click on it.

F.13 BALL METHOD



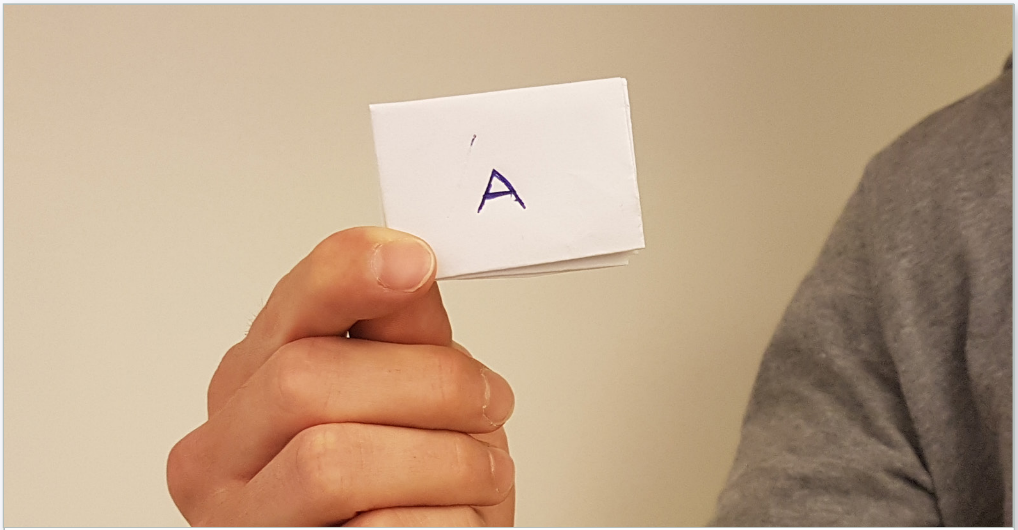
Procedure

The TVI uses a simple colored ball, which is held in different positions relative to the patient's head. The ball always starts in the center of the patients FOV and is moved outwards at different distances and with different speeds.

During the test, the TVI observes the patient's eyes and looks for unnatural or faulty eye movements.

The patient is asked to not move the head and is told to correct their position immediately if they make a head movement. The exercise can be done using the eyes individually or both eyes simultaneously.

F.14 LETTER METHOD



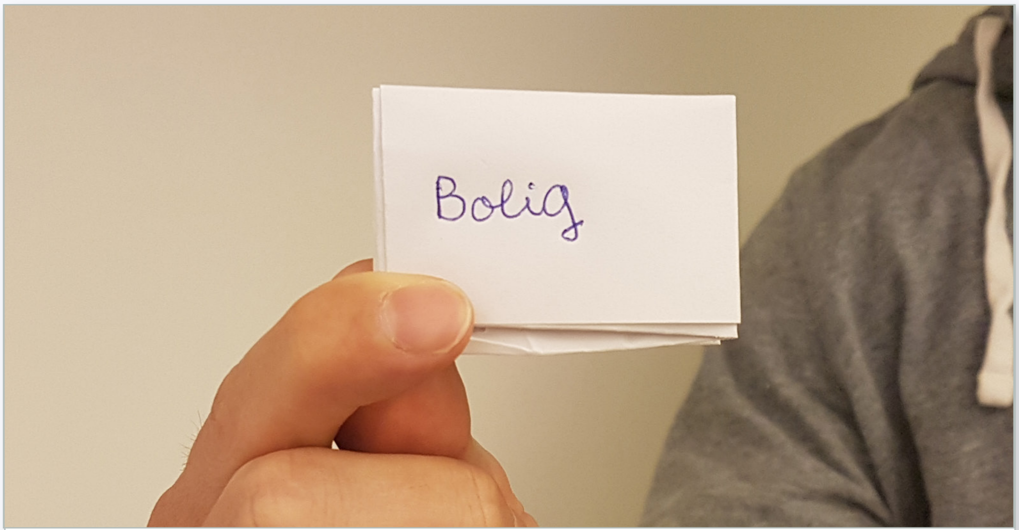
Procedure
This method utilizes a deck of cards, which has a letter written on them. These cards could be similar in terms of font families, font sizes, font weights, and orientations, but could also differ.

These cards are held up in front of the patient, one after the other. The position and distance of the cards which are held up are changed for each card.

The TVI judges where the cards are held up, based on the HVFD of the patient and their oculomotor control.

The patient is told to read each letter out loud as the cards are switched out. The frequency of the cards is based on the patient's ability to interpret and say the letters.

F.15 WORD METHOD



Procedure

The Word method work similarly to the *Letter Method*. However, this method uses full words, instead of isolated letters. This method can also utilize a variety of fonts families, font sizes, font weights, and orientations, in order to make the task more difficult.

F.16 FIRST AND LAST WORD

Hest	Gutt	Lompe	Fiolin	Barn
Katt	Kone	Appelsin	Te	Kjole
Hund	Kopp	Lommebok	Kaffe	Paraply
Hus	Kar	Krus	Sekk	Regn
Hytte	Papir	Bok	Lapp	Sol
Sau	Blyant	Avis	Klut	Stjerne
Kyr	Bamse	Mark	Vask	Blomst
Mobil	Såpe	Genser	Pute	Bilde

Procedure

This method is used in order to improve the patient's ability to recognize words and to train saccades into the blind field. A sheet of paper is used, which contains 8 rows, with 5 words in each row. The patient is asked to keep their head steady and to read the first and last word in every row. The TVI is checking whether the correct word is read, and notifies the patient if they move their head or makes an error.

F.17 FIRST AND LAST LETTER

Hest	Gutt	Lompe	Fiolin	Barn
Katt	Kone	Appelsin	Te	Kjole
Hund	Kopp	Lommebok	Kaffe	Paraply
Hus	Kar	Krus	Sekk	Regn
Hytte	Papir	Bok	Lapp	Sol
Sau	Blyant	Avis	Klut	Stjerne
Kyr	Bamse	Mark	Vask	Blomst
Mobil	Såpe	Genser	Pute	Bilde

Procedure

This method is very similar to the *First and last word* method. The same prop and procedure are used, but the patient is asked to read the first and last letter in every row, instead of the whole word.

F.18 FOUR HART CHARTS

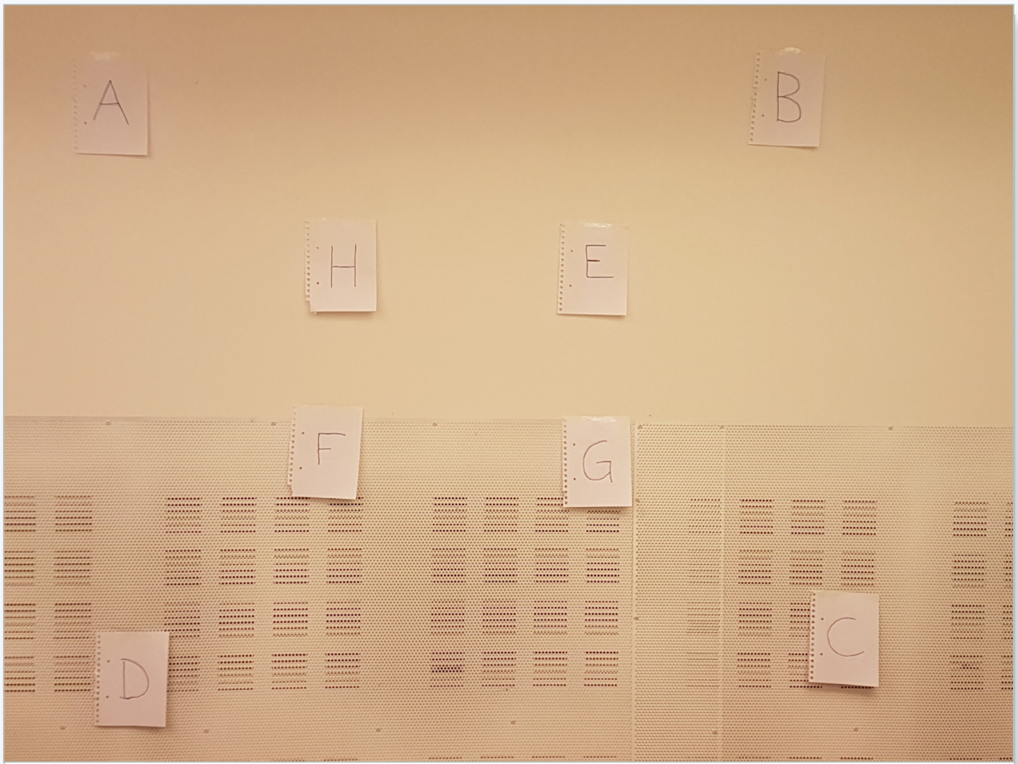
The image is a recreation of the method observed at HSMS

Procedure
This method is meant to train scanning techniques and search strategy. Four Hart Charts, namely paper sheets with a list of words, are placed on the wall. These are placed in a rectangular shape.

The patients are asked to scan these Hart Charts in a specific order. This order of fixations is; upper left, upper right, lower right, lower left, upper left, lower right, lower left, upper right. By scanning in this order, most of the patient's peripheral vision and central vision is covered.

During this method, the TVI monitors the patient's eye movements and order of fixations. The patient is sometimes allowed to point while doing the task. The goal of this exercise is for the patient to learn this scanning technique. The exercise also helps the patient to get a more efficient search strategy, by making longer saccades and more rapid fixations.

F.19 LETTER CHARTS



Procedure

This method is meant to train scanning techniques and search strategy. It is very similar to *Hart Charts*. but is a much easier version. Using a big wall, four papers with the letters A, B, C, D are placed in the four corners. Inside, in a smaller square papers with the letters E, F, G, H are placed. Then the patient is asked to use the eyes to follow the letters from A to H, teaching them a search pattern. This method was also used in the hallway. The TVI brought the patient out to the hallway, walking beside the patient, while the patient used this scanning technique. The TVI continuously asked the patient question about the surrounding elements, to see if the patient was paying attention.

COMPLETE TASK DESCRIPTION

Appendix G | Task description ØH Innovation project

APPENDIX OVERVIEW

This Appendix provides the translated version of the task description for the ØH innovation project. This task description covers the full project description, a project overview and the purpose and goal of the project.

G.1 PROJECT DESCRIPTION

Project title
Virtual reality rehabilitation of patients with hemanopsia/quadrantanopia

The solution
The goal is to conceptualize and develop a prototype where VR - glasses is used as a training tool for patients suffering from visual field deficits post stroke. With VR-glasses it is possible to control the content displayed in a patients field of view, and it gives the patient the opportunity to administer their own equipment.

The need for this solution
Today there are limited rehabilitation possibilities for patients with visual field deficits. The awareness of having a visual deficit and learning how to live with it, is important for managing everyday life.

Project/ Innovation activities
The activities are divided in 4 phases: planning, concept development, application development, and testing and evaluation in close collaboration with supplier, professionals from hospital and rehabilitation institutions and patients/users.

The effect the project is expected to provide
The purpose of this project is to examine whether VR - technology could be a new, effective tool in the rehabilitation of patients suffering from visual field deficits after a stroke.

The technology is accessible and user friendly, and can be administered by the patient themselves. This project will contribute to an increased use/focus on self-service technology as a rehabilitation option. It will also give this patient group a new possibility for rehabilitation, and provide the patient with an increased feeling of independency.

Describe the implementation of the solution in the health sector and/or commercial benefits
As there are few options for rehabilitation of patients with visual deficits, this product/tool will be of interest for hospitals and institutions who work with this patient group. The solution can be easily implemented in health care since it is based on available technology combined with using existing knowledge and expertise. Protocols can be shared across regional health authorities/ institutions, standardizing the different treatments. Sharing of licenses outside of regional health authorities can be considered based on development cost and the complexity of the developed methods.

G.2 PROJECT OVERVIEW

In Norway, approximately 15 000 people suffers fromstroke every year. Up to 60% of these have visual field deficits post stroke. Having a reduced field of view can be critical in everyday life. Our sight is important for our mobility, reading skills, visual orientation and activities of daily living (ADL). Visual field deficits after stroke is as the visual function involves large parts of the brain.

Damages to parts of the optic tract can result in visual field loss to the sides (hemianopia) or loss of the top or bottomcorner of the visual field (quandrantanopia). Spontaneous recovery of the visual field can occur during the first 2-3 months after stroke. Research has concluded that rehabilitation is possible. Rehabilitation of visual field deficits is divided into two fundamental paradigms: compensation and recovery. Existing treatment methods is divided into three different groups: Visual Scanning Training (VST), Audio-Visual Scanning Training (AViST) and Vision Restoration Training (VRT). VST and AViST are compensatory training techniques that focus on the scanning patterns of the eyes, while VRT aims to increase the patients residual function by training on light detection and discrimination of visual stimuli. Both paradigms, compensation and recovery, have positive effects on cognitive functions. Some patients are unaware of their visual field loss, which is a partial explanation for why this area is often neglected in the rehabilitation process. Patients with hemianopia lack the ability to register objects on their affected side, and often collide with doorframes, cabinets and people. Many also experience reading difficulties.

A complete recovery of hemianopia rarely occur, but compensatory improvement in functionally relevant visual skills is achievable for most patients. Rehabilitation of sight should start immedialtely after the patients' condition stabilizes and amapping of the visual field deficit can be conducted. This will create the foundation for a custom training-and rehabilitation program, adapted to each patient. But it should be noted that it is possible to achieve results fromtraining even if the rehabilitation starts at a later stage. Visual deficits post stroke is often neglected in today's society. This is unfortunate since reduced field of view is associated with a higher risk of falling and reduced performance in ADL.

Patients are rarely offered sight rehabilitation, and only a few patients are referenced to diagnostics and treatment. It has previously been discussed that focus on Visual field deficits should increase among Norwegian therapists working with stroke. Today patientswith visual field deficits are treated with the help of TVI and sight rehabilitation. Through a variety of different training methods, granting of aids (reading-PC, audio books, etc) and adaption training, the patient learns to live with their current sight. Psychological support is included in sight rehabilitation, here the patient learns to accept a new and challenging life situation. The goal of TVI training is to make the patient as self-reliant as possible. The goal of sight training is to increase visual function and performance ability. Motoric training of the eye, stimulation of the affected field and making patients aware of their deficit are key elemets of sight training. Software and computers are often used in rehabilitation exercises, and do sometimes even have implemented eye-tracking. These systems often require the guidance and support of a therapist (e.g TVI), but some can also be used by the patient in their own home. VR is a technology that lets a user affect and be affected by a data created environment that emulates reality. Most environments in VR include both visual and sound as sensory outputs and is either displayed on a screen or through a special stereoscopic apparatus.

The technology, which is already readily available from manufacturers like Oculus Rift (Facebook), Vive (HTC / Valve), Prometheus (Sony) and Hololens (Microsoft), is relatively untested in hospitals in Norway. The goal of this project is to conceptualize and develop a prototype where VR - glasses is used as a tool for visual training by stroke patients with visual field deficits. VR glasses-makes it possible to precisely control the content displayed in a patient's field of view, and may be a more effective training tool than what is offered today.

G.3 PURPOSE AND GOAL

The project intends to investigate whether VR technology can be a new effective tool in the rehabilitation of patients who end up with visual field deficits after stroke. Specifically, it aims to use VR-glasses, which will contribute to an increased use of self-service technology, as the patient can manage the equipment and stand for a lot of the training themselves.

One can envision, for example, that the patient begins rehabilitation of the visual field in cooperation with a therapist, and then continue on their own at home. This is possible when the technology is available, mobile and user-friendly. In addition to enhancing visual performance, this equipment will provide effects such as an increased feeling of independency and an increased belief of being able to manage on their own. VR-glasses as a training tool will increase the quality of rehabilitation, and provide new possibilities for a patient group who currently have a very limited offer.

In this project the end goal is to conceptualise and develop a prototype thatwill be tested during the project period. The project will also examine to which extent mid-range VR equipment, such as Gear VR, works as a rehabilitation tool for patients, both in health care and at home, in a cooperation with municipal health services and the patient group.

Internationally, VR-glasses has been used in therapeutic contexts several times, examples are pain relief associated with burns, post traumatic stress syndromes, war trauma, phobias etc. Common in all the projects we have looked into are good results, reduced drug use and high patient satisfaction. Benefits suggests that VR technology will streamline time and provide faster and more lasting results than traditional treatment. No studies were found connected to the use of VR-glasses in vision therapy after stroke.

SØ has an ongoing innovation project that tests the use of VR-glasses in mental health services. The project is conducted in close cooperation with professionals within the field and Attensi AS. This project has given and gives us an enhanced confidence and competence that this technology is useful in a treatment context. Here existing knowledge and experience is combined with VR-technology. The intention is to show that eye scanning training in short intervals, will result in effective motoric search strategies, that will be useful for patients in their everyday life, and give them a feeling of improvement. The visual training is short (one month), cheap, and can be performed by the patient themselves, in their own home, without direct assistance from a therapist.

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