ARMD®
Regain

PRODUCT report

MASTER'S THESIS | JUNE 2023

Self-training for stroke patients

MSc04-ID4
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Industrial Design, AAU

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MAIN SUPERVISOR Christian Tollestrup
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PAGES 24

Louise Elgaard Christensen

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illu. 01

ABSTRACT

This Master Thesis is made by two Industrial Design students, Regain, at Aalborg University. This catalogue presents ARMD, a tool for arm-rehabilitation for strokepatients, that motivates the patient to do self rehabilitation on the ward through different levels of complexity, progress detection, exciting repetitions and fun, to make the patients forget time and place when exercising.

ARMD consist of a projector part which creates a gameboard at the table in front of the patient. The projector communicates with three different sized cursors, which is the tools the patient has to move around on the gameboard, in order to make the hand lead the arm. All in all to regain functionalities; specifically reach, wrist rotation and the grasp and release function. By enabling progress detection, the patients gets motivated and thereby provides an increase in their independence, so they get to re-enter their everyday lives once again.

ARMD has been developed through ongoing sparring with occupational therapists, physiotherapists, nurses, and stroke patients, who deal with the issue everyday at Neuroenhed Nord in Frederikshavn.

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Regain

PREFACE: a scenario-structured report

The project has been developed and written in collaboration with Neuroenhed Nord in Frederikhavn in the spring of 2023.
This catalogue is targeted at the Danish regional hospitals, the municipal occupational therapy, investors and other stakeholders. This report is structured step by step according to the product usage scenario, so that the reader is guided through the product and its features.

ILLUSTRATIONS

The illustrations *(marked illu. 01-40)* are all of own production, why no external sources can be refered to. Therefore, no list of illustrations will be presented.

illu. 02

STROKE ARM
rehabilitation

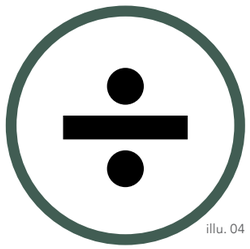
Motivation comes with a ***high price***

Expensive products

illu. 03

No motivational self-training solutions

Childish | Loss of interest



illu. 04

Require ***full attention*** from therapist

Complexity too high | Not alone

illu. 05

current

After a stroke, the connections between the brain and the body needs to be brought back to life. Daily repeats are used to help the brain recall a particular action or activity.

The goal is to prepare for returning to a regular, everyday life. Regaining the ability to use the hands and arms is just as vital as learning to walk once again. Particularly because the brain's flexibility makes time a vital component. The brain is most receptive to long-lasting changes in the first 90 days following a stroke, therefore it is crucial to get started. You need to move it to improve it!

Here, there is a problem with the existing arm rehabilitation solutions. Either they are too expensive and require full attention from the therapist, or the exercise equipment is too childish and fails to keep the users' attention during repetitions; as a result, they lose concentration and stop working out. In arm classes and individual therapy, the patients receive a lot of arm training that evaluates their progression and keeps them motivated to keep going. However, the current self-training solutions fall short of producing an independent, motivating self-training, that provides the essential progress detection.

ARMD® Regain

The answer to the current issues in self rehabilitation is ARMD. The repetitions are made funnier and more motivating through progress detection and gamified principles - and they can be performed on the patient's own in the hospital room. Alone! ARMD consists of an Ultra Short Throw projector that creates the gameboard, 3 different sized cursors and a transport bag.

ARMD is exercising the hand and arm in regaining the functionality to drink a glass of water on their own. With a focus on reach, grasp & release, and wrist rotation this becomes closer to reality.

illu. 06

Gamified approach

illu. 07

Progress detection

illu. 08

Visual ***improvement***

illu. 09

Arm exercises: ***alone***

illu. 10

storage

READY WHEN YOU ARE

ARMD must be stored and placed in the therapy room when it is not in use by a patient. The transport bag fits in between the shelves. The projector, the 3 cursors and the charger are stored in a transport bag, so no dust accumulates at the lens, no risk of it bumping into something and breaking, retention of cursors and tangible buttons. All this, is thanks to the bag!

illu. 11

No dust on the lens | **Protection** of ARMD | **Retention** of cursors | Allows **tangible buttons**

transport

GENTLE HANDLING IN THE BAG

The therapist pick up ARMD from the shelf in the therapy room, grabs the handle and brings it to the patient for the first ARMD session. The transport becomes extremely easy! ARMD is covered in the bag to protect it when being transported to the wards, or even home in private homes.

illu. 12

guidance: first time use

THERAPIST INTRODUCTION

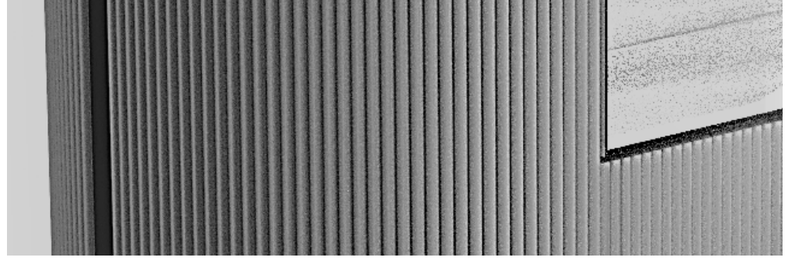
When ARMD is introduced to the patient for the first time, this should be done during an individual therapy-session. Here, the therapist must go through the interface, how to play, how to switch on/off and how they can analyze the data collected when the patient exercises with ARMD. ARMD is the link between the continuous and increasing level of motivation and the visual progress detection that is being offered to the patient - in a fun, motivating and easy way.

When initiating a session, the patient must **press the on/off button**. Hereafter, a 'calibration dot' will appear, see illu. 14. A cursor must be placed here to **calibrate the incorporated IMU**.

illu. 13

illu. 14

>> Press **on/off** button | **Calibration circle** appears | **Place cursor** in the middle

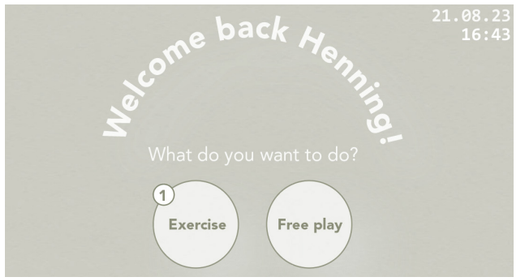


let the exercise begin

PRESS START

illu. 15

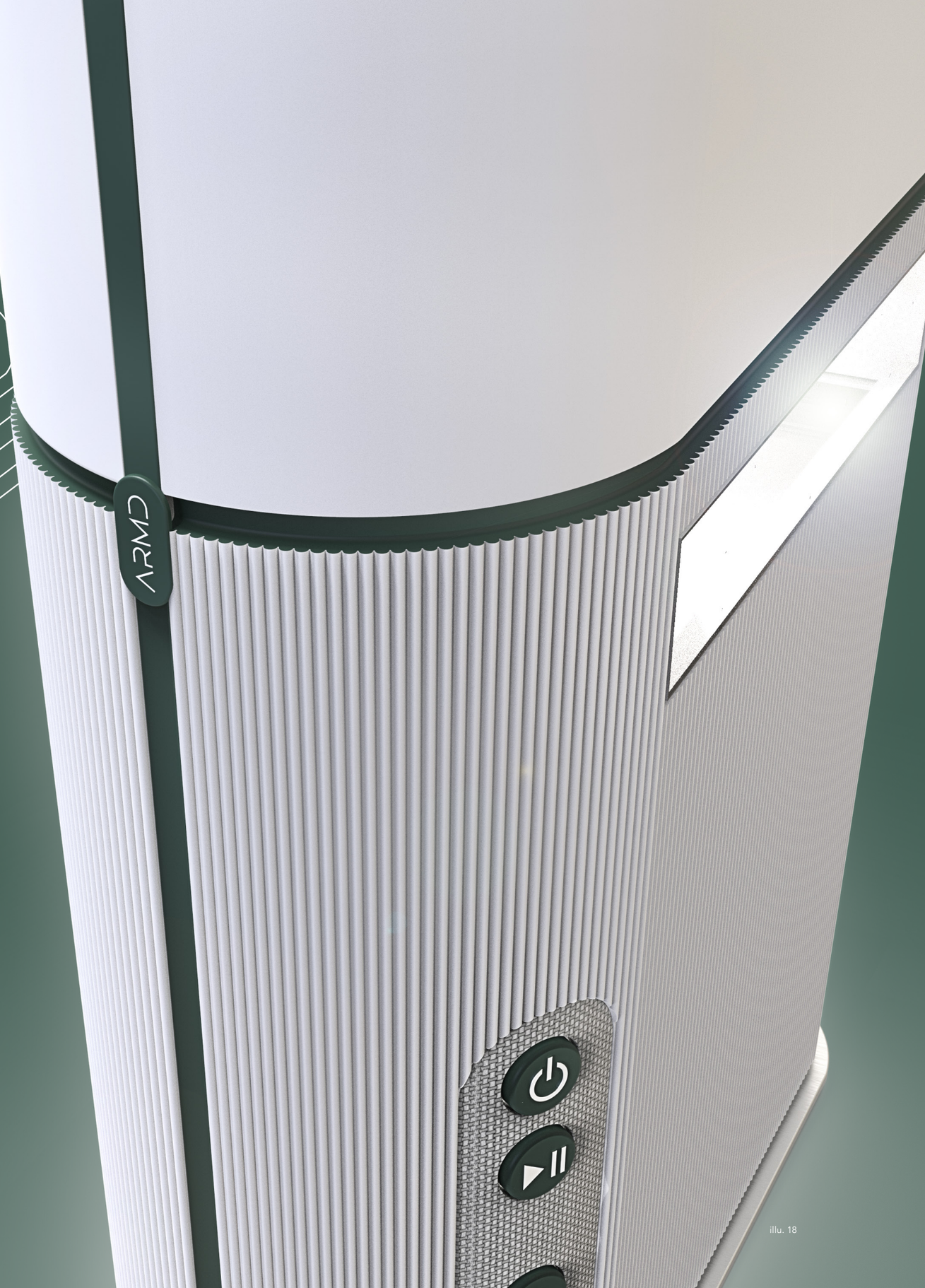
Start the game, that contributes to efficient rehabilitation! Once the calibration have succeeded, the play button must be pressed. A menu will be shown on the projected screen, where the patient either can choose to do the preset exercises or free play, if desired (illu. 16).



illu. 16

The Future of Arm Rehabilitation is here! Be a part of it.

Be ARMD® Regain



illu. 18

2000 ANSI Lumens	**36”** Screen	**LCD** Ultra Short Throw	**1920 x 1080** Resolution

illu. 17

progress detection

right by the hand

illu. 19

illu. 20

DOT GAME | *reaching, grasp & release*

illu. 21

TURNING GAME | *reaching, wrist rotation, grasp & release*

illu. 22

exercises

Different ARMD exercises call for the use of one or more colors. In order to meet the patient at their competence level, the therapist decided on the game type and the quantity of colors to utilize in advance, through the app: they pre-set the session.

It can be difficult to keep focus and remember the days separately when hospitalized. Therefore, feedback is provided up-front, to keep track on the progress. When the game is played, feedback is received in the form of sound when a dot is either hit correctly, the right dot has been missed, and when a new dot appears. Also, visual feedback is provided to help find the dot. The patients can see how many dots are remaining and how many they have hit right, in the corner while playing. When the game is completed, the new high score will be shown.

To access more detailed data, the therapist and the patient can go through the improvements in eg. reaching, shaking and force in the app.

UP-FRONT FEEDBACK | *when the game finishes*

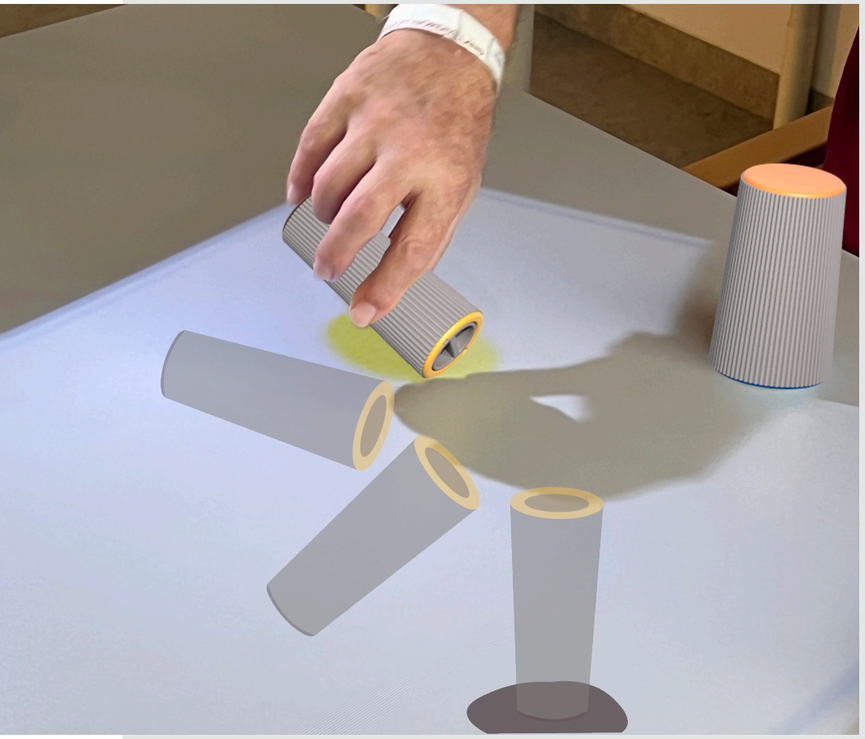
illu. 23

3 cursors
6 colors
A WORLD OF EXERCISES

No stroke case is identical which means that every patient has their own special case and special needs in arm rehabilitation. This is why ARMD is accommodating several patients on their specific arm skill level, providing 3 different sized cursors with 6 different colors in the top and bottom.

LEVEL-UP
When you normally talk about level-ups, you typically refer to an interactive platform in connection with games. ARMD also offers this when playing, but the different cursors contribute with a physical, visual and tangible level-up that can both be seen, felt and provide a sense of success.

Situations and explanations of how patients can use the different cursors, in different skill levels, are shown and exemplified below.



illu. 24

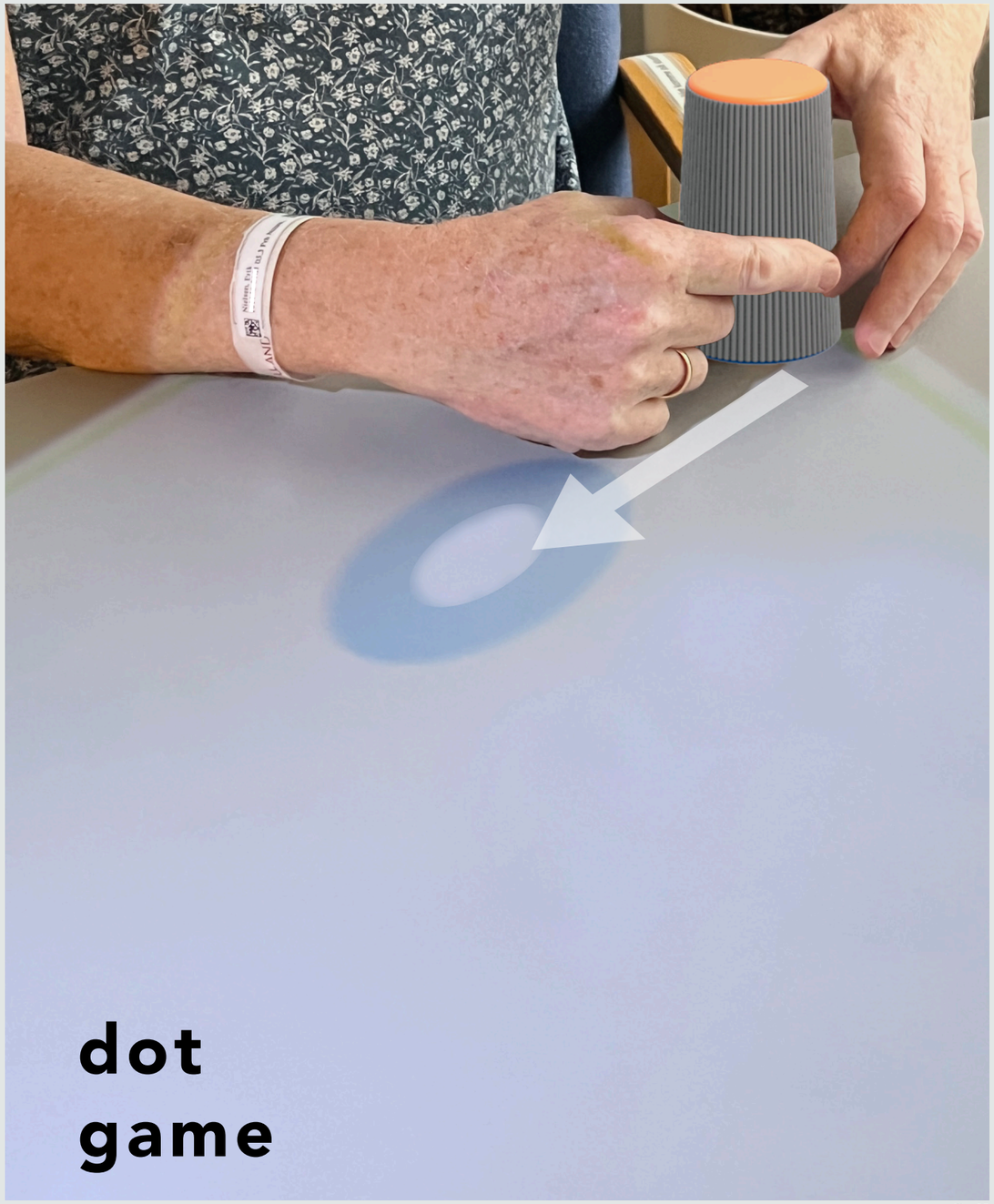
turning game

- √ Reaching
- √ Wrist rotation/turn
- √ Grasp & release

1.
Patient at ***high*** level

This patient has come far in the ability to grasp, release, and wrist rotate so he is tackling the upper levels, that involve all 3 colored cursors, that he has to be aware of when playing the game.

The patient is not just training the arm skills such as grasp, release, reach, and wrist rotation; another level of cognitive training is added as he has to remember the color combinations and therefore keep an eye on all 6 colors.



illu. 25

dot game

2.
Patient at ***lower*** level

- √ Reaching
- Wrist rotation/turn
- Grasp & release

This patient is still struggling with the grasp and release function, which means that he needs to be met at his current level. He is using one cursor and one of the colors to reach the dot on the gameboard. This patient will get tired faster because of the effort that transfers to the arm, when it does not do what he wants. A shorter game is required.

illu. 26

IMU

The IMU is the 'brain' behind the progress data collection and controls if the patient is doing the exercises correctly and does not cheat, consisting of an accelerometer, gyroscope and a magnetometer.

illu. 27

SBC

The small SBC control unit processes the data that the IMU measures to the Motherboard in the projector, creating the game interface.

illu. 28

BATTERY

Allows the cursors to be moved around on the gameboard - wirelessly.

illu. 29

COILS

The coil allows wireless resonance charging, when the cursors are stored in the projector, making sure that the cursors are ready to play, when the patient are.

illu. 30

CURSOR **S**

H: 10 cm
Ø top: 3 cm
Ø bottom: 4 cm
Weight: 100 grams

CURSOR **M**

H: 10 cm
Ø top: 5 cm
Ø bottom: 6 cm
Weight: 200 grams

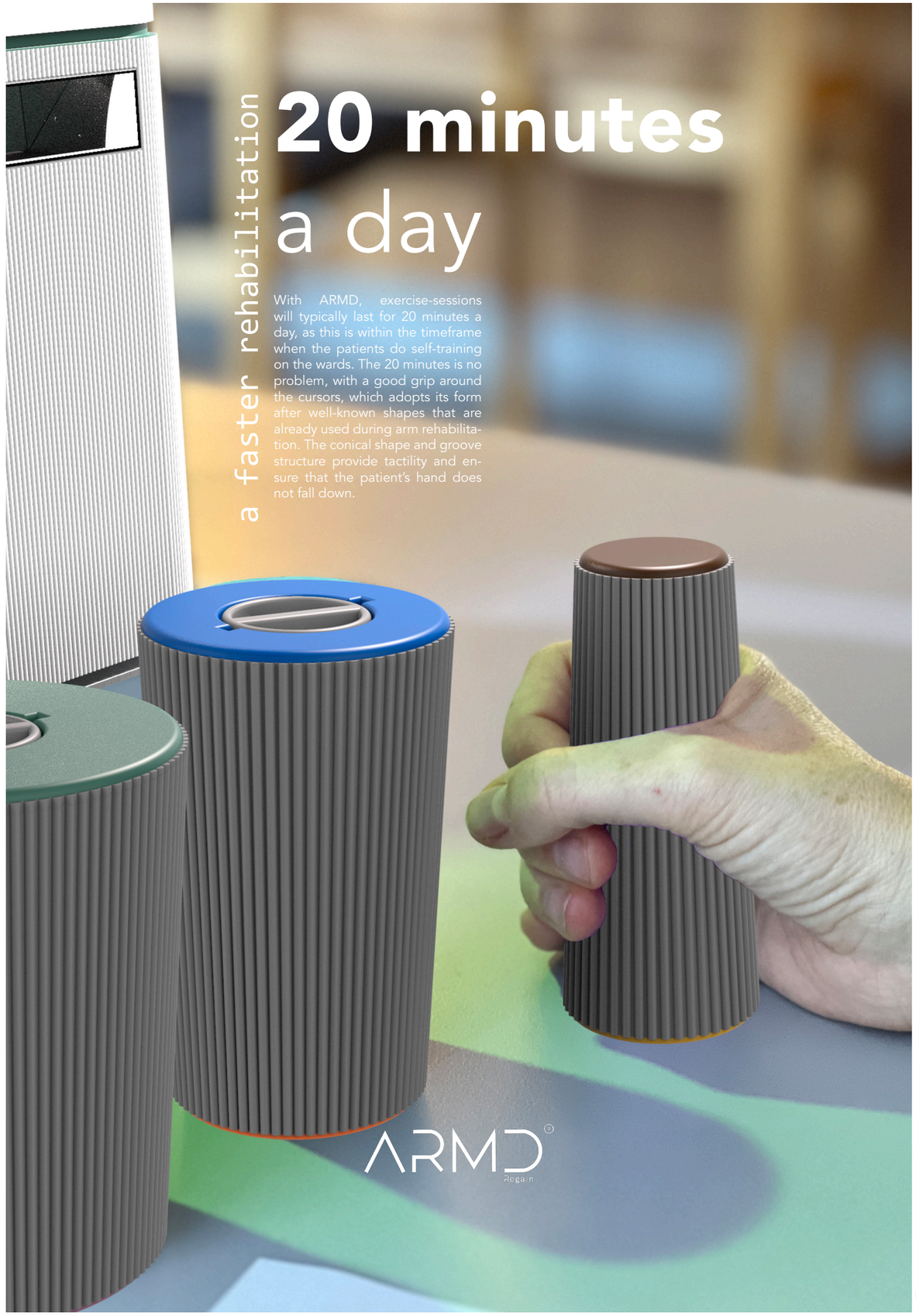
CURSOR **L**

H: 10 cm
Ø top: 7 cm
Ø bottom: 8 cm
Weight: 300 grams

a faster rehabilitation

20 minutes a day

With ARMD, exercise-sessions will typically last for 20 minutes a day, as this is within the timeframe when the patients do self-training on the wards. The 20 minutes is no problem, with a good grip around the cursors, which adopts its form after well-known shapes that are already used during arm rehabilitation. The conical shape and groove structure provide tactility and ensure that the patient's hand does not fall down.



illu. 31

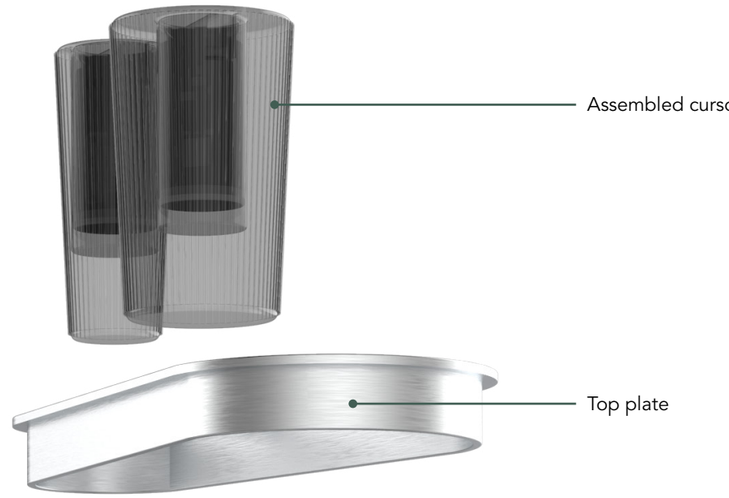
ARMD is using an LCD ultra short throw projector technology to make the gameboard right in front of the patient. The projector communicates with the cursor through Bluetooth to make sure that the exercise is done correctly and to track the individual progression. An IMU inside the cursor is the one that is programmed to understand if the cursor is placed on the right dot, but also the movement of the hand and arm to track the progress over time. Get ready to evolve the patient's true potential!

MATERIALS

The outer shells and the cursors are constructed in plastic material, ASA. This strong material can withstand the cursors' use - also in harsh treatment. It is easy to clean and can be cleaned with alcohol, soap, water, and chlorine.
The shells are held together with screws and a silicone strap is hiding the assembly to add the last finish.
The top, middle, and bottom part is constructed from strong aluminum sheets.
Underneath the bottom, there is a rubber sheet that makes sure that the projector will not move when you are using it and touching the buttons.

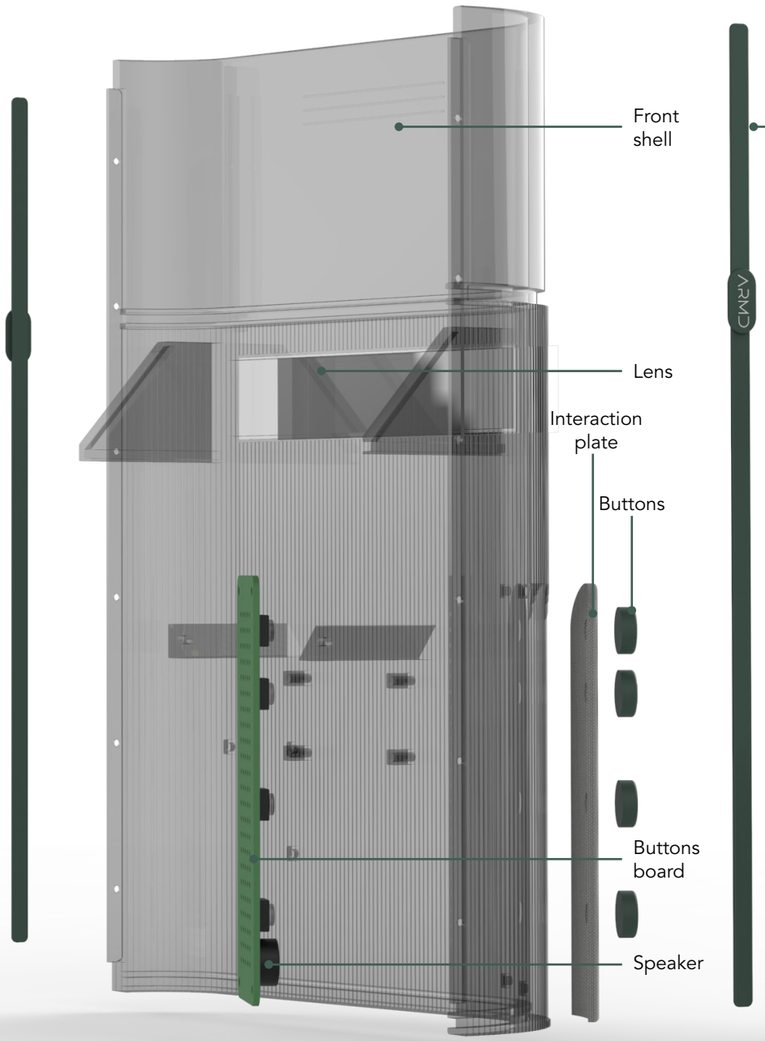
INTERACTION

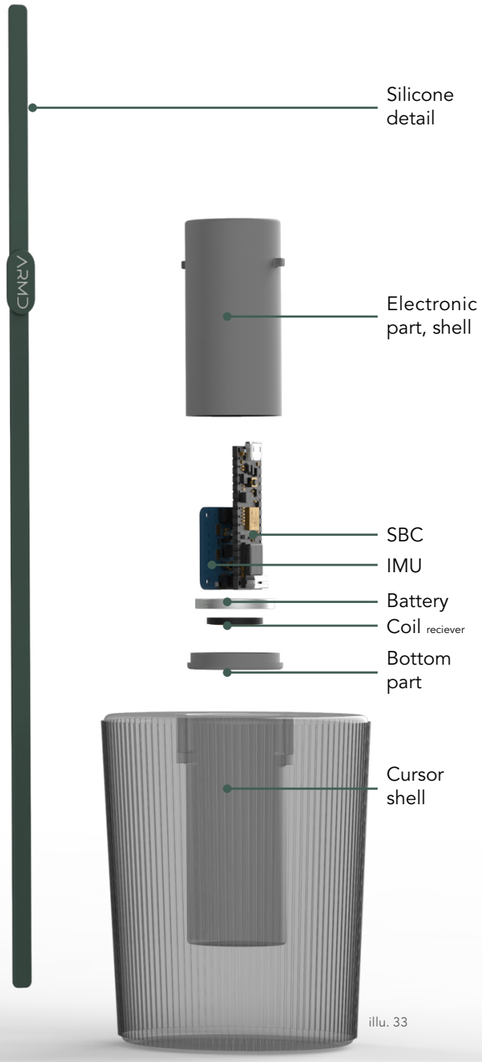
The projector has four buttons to interact with: turn on/off, start/pause the exercise, and turn up or down the sound when playing.



3 kg
Total unit weight, including cursors

illu. 32





illu. 33

the creation of

Value

PATIENT
A more effective self-training in the hospital room, com pared to the current options.
Get the opportunity to combine training with fun games.
Clear, visual, rewarding feedback on your physical progress.

THERAPIST
Specific data on the patients' progress, so that the training and rehabilitation therapy can be utilized and adapted bet-ter to the individual patient.
Provide way more focused training.
More accurate data, so the rehabilitation offered is of a high-er quality; you get happier patients.

REHABILITATION FACILITIES
Faster and more efficient treatment and rehabilitation of stroke patients equals a minimization of the department's workload and makes rehabilitation cheaper.
Better rehabilitation conditions in Denmark, with patients who get out faster and contribute to society again.

UNIT PRICE
With ARMD, you receive the projector, three different sized cursors, a charger, a carrying bag and hours of motivational self-training. It is all included in the pricing. It is obvious to have numerous pieces of ARMD ready for your disposal, so that each arm patient has their own for self-motivating training on the wards. All of this, you can get for a unit price of;

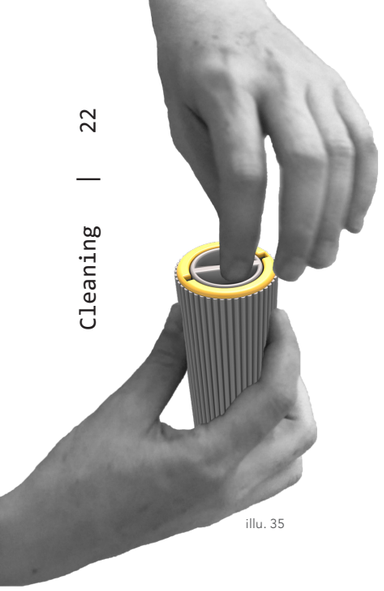
6500
DKK

RENTAL PRICE
Regain provides a rental option to the municipally owned occupational therapy clinics, the hospitals and other stake-holders, if the patient wishes to keep using ARMD at home after hospital discharge. A 20% commission will be paid to the trained staff member who recommends ARMD to the patient. Rent ARMD **per month for;**

750
DKK

WIRELESS CHARGING
ARMD is connected to a power source when exercising, but the cursors are wireless. These are charged when they are on top of the projector. With a transmitter coil in the projector and receiver coils in each cursor, it allows for resonance wireless charging. You should never think about charging the cursors - it is simply done through the daily routine.

illu. 34



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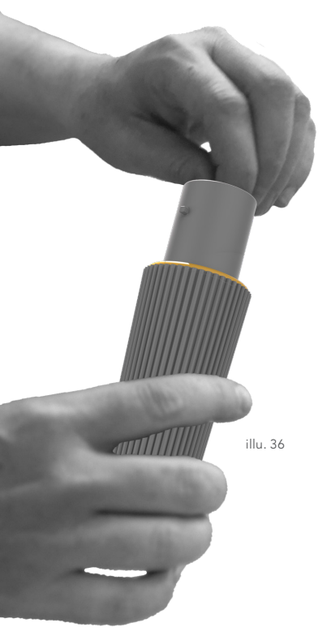


illu. 36

illu. 37

cleaning

EASY CURSOR HYGIENE

The everyday hand touch, heavy use of the cursors and shifting players, require cleaning. The outer part that the patient interacts with, and the electrical component of the cursor are both easily removable, as shown to the left. The outer part can tolerate heat, water, alcohol, soap, chlorine, and other chemicals, thus it can withstand regular use in a hospital and dishwasher. So whenever ARMD meets a new training-buddy, traces of the previous player cannot be seen, accommodating the requirements the hospitals have for hygeine.

Ready. Set. Play!

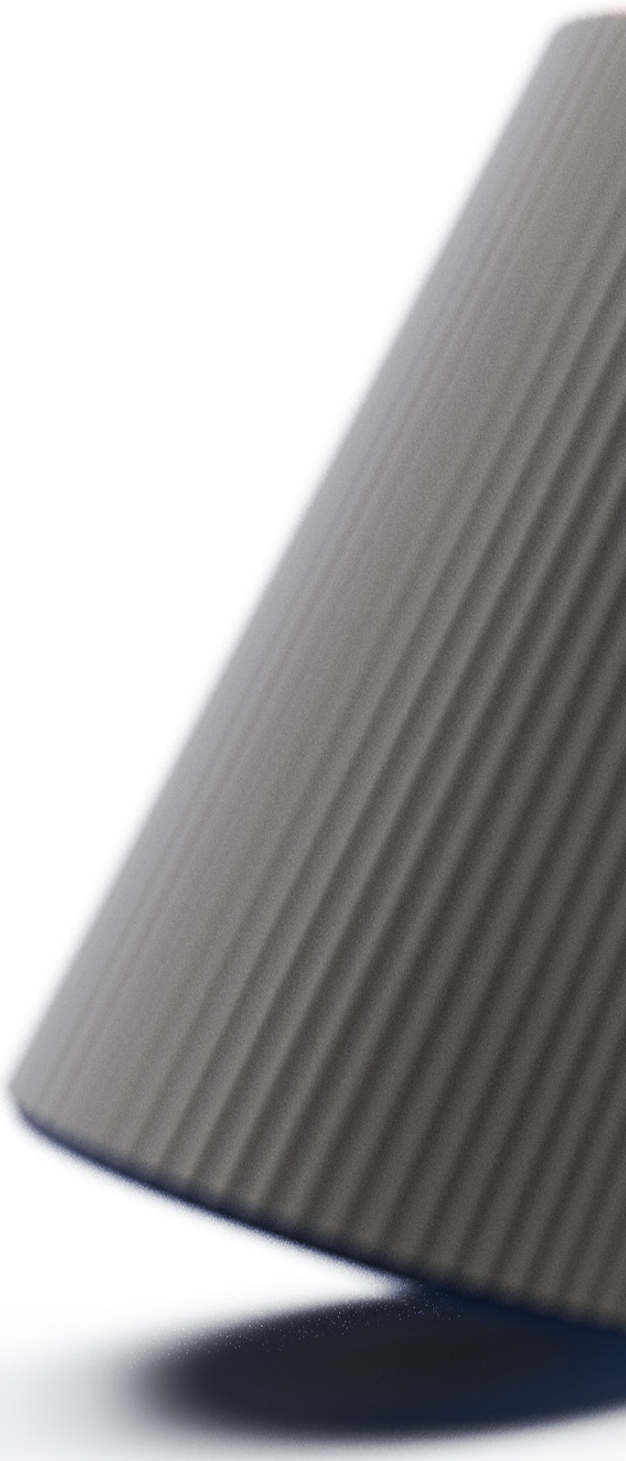
illu. 38

Dishwasher
cleaning

illu. 39

Resistant
to chemicals

illu. 40



AALBORG
UNIVERSITY

ARMD®
Regain

PROCESS report

MASTER'S THESIS | JUNE 2023

Self-training for stroke patients

MSc04-ID4
Louise Elgaard Christensen & Marie Sørig Toft Petersen
Industrial Design, AAU

illu. 1

There is a life

BEFORE

...

& there is a life

AFTER

TITLE PAGE

TITLE ARMD by Regain - PROCESS REPORT

THEME Master Thesis: Self-training for Stroke patients

PROJECT TEAM MA4-ID4

PROJECT START February 1, 2023

SUBMISSION May 31, 2023

MAIN SUPERVISOR Christian Tollestrup

CO-SUPERVISOR Anderson de Souza Castelo Oliveira

PAGES 112

Marie Sørig Toft Petersen

Louise Elgaard Christensen

MEET THE
designers

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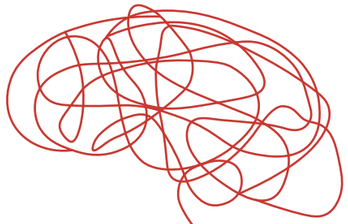


This Master Thesis examines how motivation can be achieved in stroke arm-rehabilitation and presents the design process behind the product proposal ARMD: A tool for arm stroke rehabilitations that motivates the patient to do self rehabilitation on the ward through different level of complexity, progress detection, exciting repetitions and fun to make the patients forget time and place when exercising.

ARMD consist of a projector part which creates a gameboard at the table in front of the patient. The projector communicates with three different sized cursors, which is the tools the patient has to move around on the gameboard, in order to make the hand lead the arm. All in all to regain functionalities; specifically reach, wrist rotation and the grasp and release function. By enabling progress detection, the patients gets motivated and thereby provides an increase in their independence, so they get to re-enter their everyday lives once again.

The design process is characterized by a main focus, using the design teams own competences in concept development and testing, combined with ongoing sparring with therapists and patients from the real world, who deals with the issuse everyday at Neuroenhed Nord in Frederikshavn.

ABSTRACT

PREFACE & ACKNOWLEDGEMENTS

This Thesis has been developed and written by two Masters students through the 10th semester of the Industrial Design studies at Aalborg University, from February 1 to May 31, 2023.

The Design Team would like to thank everyone who have been involved in the design driven process:

Main supervisor Christian Tollestrup and co-supervisor Anderson de Souza Castelo Oliveira.

Nurse Rikke Brorholt and Occupational Therapist Pernille Aaen from Neuroenhed Nord, Fredershavn Hospital.

Main user Henning Nielsen & hospitalized patients at Neuroenhed Nord, Flemming Byrgesen and André Kristensen, who have been involved in testing & interviews.

Maja Klamer Løhr from Hjernesagen & all individual, recovered stroke-patiens who have acommodated us and shared their stories with us. Thank you so much!

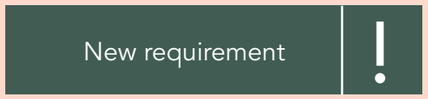
READING GUIDE

The Thesis is presented through four reports:
A Product Report, that presents the final product proposal.
A Process Report, that presents the design process.
Technical Drawings, that illustrates the product and how to produce it.
Appendix, that provides additional information if needed.

It is highly recommended to read the reports in the order, presented above.

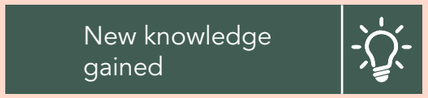
The Process Report is divided into six phases: Research, Framing, Concept Development, Product Development, Maturation and Epilogue. Each phase will in the end present a Design Brief and continuously reflect on how to achieve 'Motivation'.

Through the Process Report, different sum-up boxes will occur, when relevant knowledge has been gained. The meaning of each can be seen below. Furthermore, QR codes will appear. It is recommended to scan them through the camera on the phone (for iPhones). They will show videos from tests, that might be essential for the understanding.



illu. 3

illu. 4



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References through the report are specified by the Harvard method, (Author, Year). Illustrations are numbered after their occurrence. Worksheets are referred to as, ex. [WS 17], meaning Worksheet 17 in the Appendix.

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02 PROJECT FRAMING

03 CONCEPT DEVELOPMENT

04 PRODUCT DEVELOPMENT

05 MATURATION

06 EPILOGUE

Visit at Caspershus, Frederikshavn
February 3th, 2023
Interview with Tanja Larsen, Leading Nurse

Visit at Neuroenhed Nord, Frederikshavn
February 3th, 2023
Interview with Rikke Brorholt, Leading Nurse

Meeting with Stroke-patient
February 3th, 2023
Interview with Flemming Byrgesen,
stroke-patient since 2018

Teams Meeting with Stroke-patient
February 6th, 2023
Interview with André Kristensen,
2-time-stroke-patient

Visit at Apopleksiafsnit 6Ø, Aalborg Universitetshospital
February 8th, 2023
Interview with Tine Rasmussen, Leading Nurse

Teams Meeting with Hjernesagen
February 9th, 2023
Interview with Maja Klamer Løhr,
Strokeadviser

Visit at Neuroenhed Nord, Frederikshavn
February 13th, 2023
Interview with Rikke Brorholt, Leading Nurse
Invited to join the "Arm Class"

Framing

Joining "Arm Class", Neuroenhed Nord, Frederikshavn
February 17th, 2023
Interview with Pernille Aaen, Occupational Therapist & Henning Larsen, Strokepatient

Concept development

TEST

Visit at Neuroenhed Nord, Frederikshavn
February 27th, 2023
1st concept-testing with main user Henning Larsen, Strokepatient with arm-issues
Follow-up interview with secondary user, Occupational therapist, Pernille Aaen

TEST

Visit at Neuroenhed Nord, Frederikshavn
March 13th, 2023
2nd concept-testing with main user Henning Larsen & Erik, Strokepatients with arm-issues

Product development

Meeting with 'Idéklinikken', Aalborg Universitetshospital
March 28th, 2023
Sparring with Maria Kristensen
& Cristoffer Høg
Industrial Designers at Idéklinikken

TEST

Visit at Neuroenhed Nord, Frederikshavn
April 20th, 2023
Technology-testing with patients and sparring with Occupational Therapist Pernille Aaen

Interface development

illu. 6

The Masters Thesis have been directed by the Stakeholders. Experts have been used to point the project in a sceintific direction and a main user have been used to test conceptideas.

STAKEHOLDERS

REGION NORDJYLLAND
– i gode hænder illu. 7

illu. 8

Henning Nielsen
Stroke-patient
Hospitalized at Neuroenhed Nord,
Frederikshavn

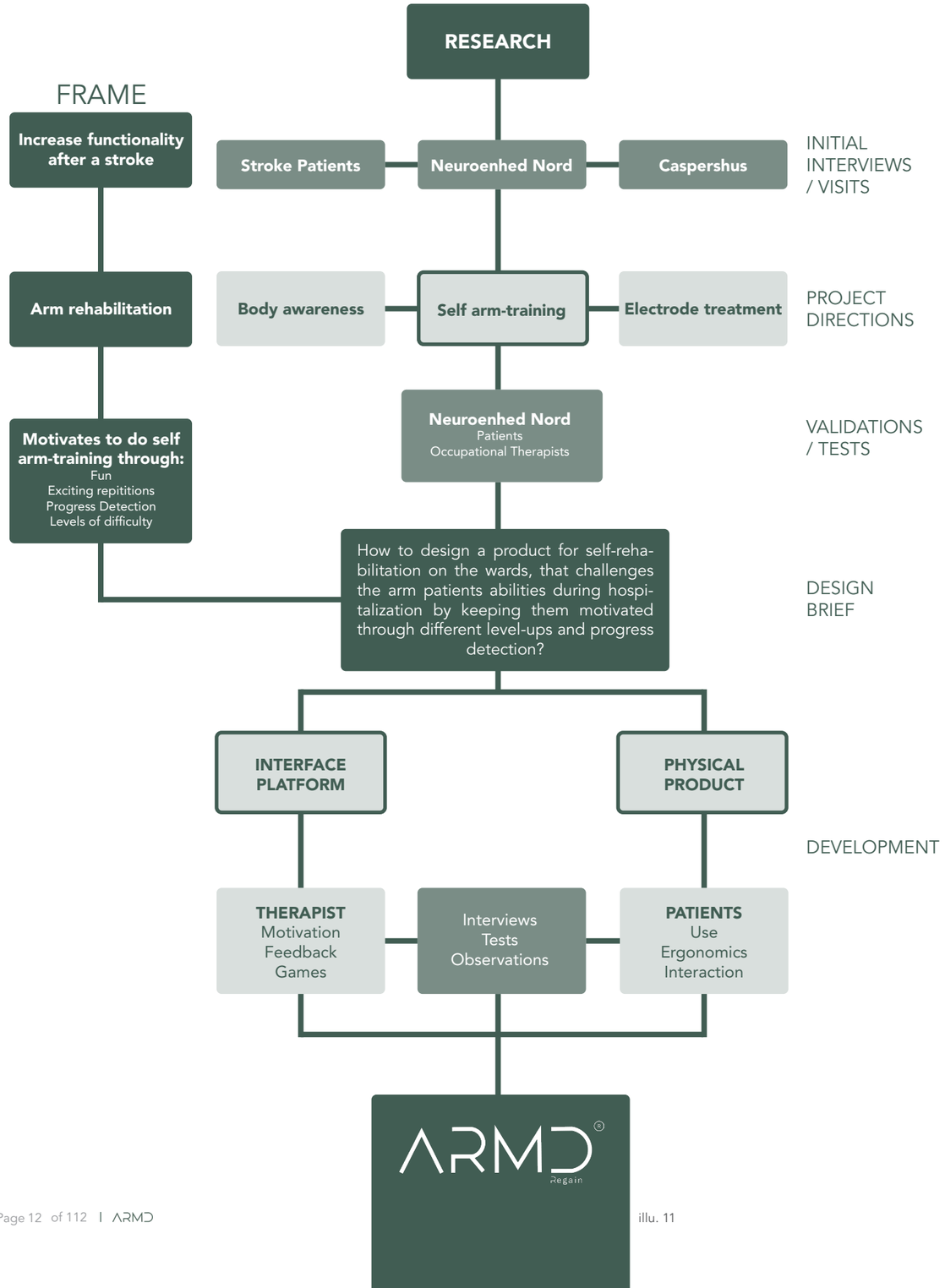
illu. 9

Pernille Pallisgaard Aaen
Occupational Therapist
Neuroenhed Nord,
Frederikshavn

illu. 10

Rikke Brorholt
Leading Nurse
Neuroenhed Nord,
Frederikshavn

PROCESS OVERVIEW



illu. 11

illu. 12

INTRODUCTION

A stroke is not a thing you can be prepared for. Life will change in a second and things that was easy before, now becomes difficult. No stroke incident results in the same disabilities, but they all have in common that there was a life before, and now you have to deal with the life after a stroke. In Denmark, there are 12.000 new stroke cases happening every year - 50% of these will experience a loss in their armfunctions and have to undergo arm rehabilitation at one of the country's hospitals.

Though, a general problem in rehabilitation is the decreasing level of motivation over time. These patients have cognitive and mental barriers that requires that the rehabilitation period is giving them motivation. They are not able to keep themselves motivated because the damaged brain gets tired and they are not able to detect their progress in their physical abilities.

After a stroke the connections between the brain and the body needs to be brought back to life. This is done by daily repetitions to make the brain remember the specific task or movement. Here, time is a crucial factor due to the plasticity of the brain. Within the first 90 days after a stroke, the brain is most responsive to changes that will last.

This create the interest of a complex design problem, that has to deal with people that has experienced a huge change in life. People, who have experienced the ultimate setback in their lives. People, whose brains are not working on full speed and need motivation to progress and regain their independence - but time is against them, in order to gain as much lost functionality, as possible.

// RESEARCH

01

In this phase, the subject 'Stroke' is examined and unfolded. This is done to understand what happens in the body of the patients and also what happens during rehabilitation in order to eventually create an entrypoint.

METHODS

Desktop research
Semi-structured interviews
User-centered observations
Mapping

illu. 13

INITIAL MEETING WITH STAKEHOLDERS

In order to obtain relevant knowledge and find an approach to deal with the theme of Stroke (apoplexy), experts and patients were contacted.

From the start, there was a nervousness that it would not be possible to enter the hospital's stroke wards and that it would be a major task to find patients who were open to articulate their illness as it was known in advance, that a case of apoplexy in many cases also affects the psyche.

Instead, it turned out that both hospitals and patients were open and very willing to collaborate and learn from each other.
In order to get a nuanced picture of a stroke case, the procedures and what happens purely anatomically, the nursing home 'Caspershus, Frederikshavn' [WS 3], 'Neuroenhed Nord, Frederikshavn Hospital' [WS 5] and 'Apopleksiafsnit 6Ø, Aalborg Universitetshospital' [WS 8] were visited. To supplement the initial information, knowledge was obtained from the association 'Hjernesagen' [WS 9], followed by two interviews with various apoplexy patients who had been discharged from the hospital and returned to life outside the four walls of the hospital [WS 4 & 6].

After this initial process, 'Neuroenhed Nord, Frederikshavn Hospital' was chosen as the primary go-to, as the place houses both patients, nurses, occupational therapists, and physiotherapists who, through the design process, could contribute with expert knowledge, insights, and good test facilities in both context and user availability. Furthermore, there was a mutual interest and passion where the design team could come and go as needed.

illu. 14

what is a STROKE?

A stroke is the overall term for a blood clot or hemorrhage in the brain, this is also called apoplexy. A stroke is life-threatening but with fast acute treatment it is possible to survive and with rehabilitation it is possible to come back to a life close to "normal" with few permanent injuries, but it will never be the same.

The treatment in the acute phase should take place in the first 4,5 hours to increase the chance of getting a life without or only with limited disability. A stroke will always set a footprint in the brain. A stroke will change the patient and the family's life from one moment to another without any preparation time.

Stroke is the most frequent reason for adults having a disability and the fourth most frequent cause of death.

• 50% will get their physical skills back close to normal.

• 20-25% will live with smaller physical disabilities and might need help in daily life.

• 25-30% live with disabilities that require help with personal treatment and need aid in their own home or at care homes.

(Madsen, 2021)

Treatment must take place within the first

4.5 hours

after a stroke

(Madsen, 2021)

90.000

people are living with the diagnosis 'Stroke' in Denmark

(Madsen, 2021)

12.000

people gets a Stroke every year in Denmark

(Madsen, 2021)

85%

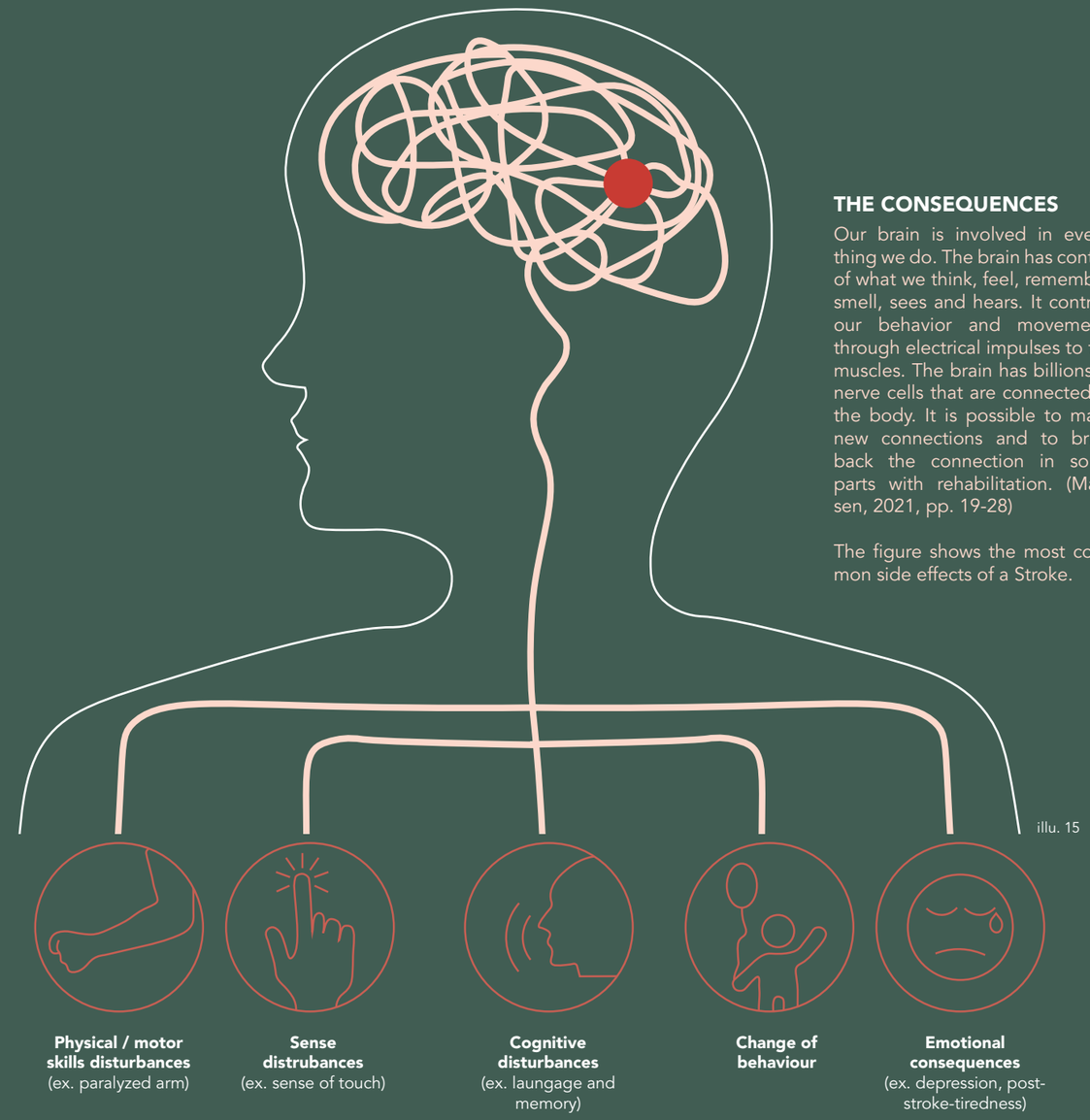
are caused by a blood clot

(Madsen, 2021)

15%

are caused by brain hemorrhage

(Madsen, 2021)



illu. 15

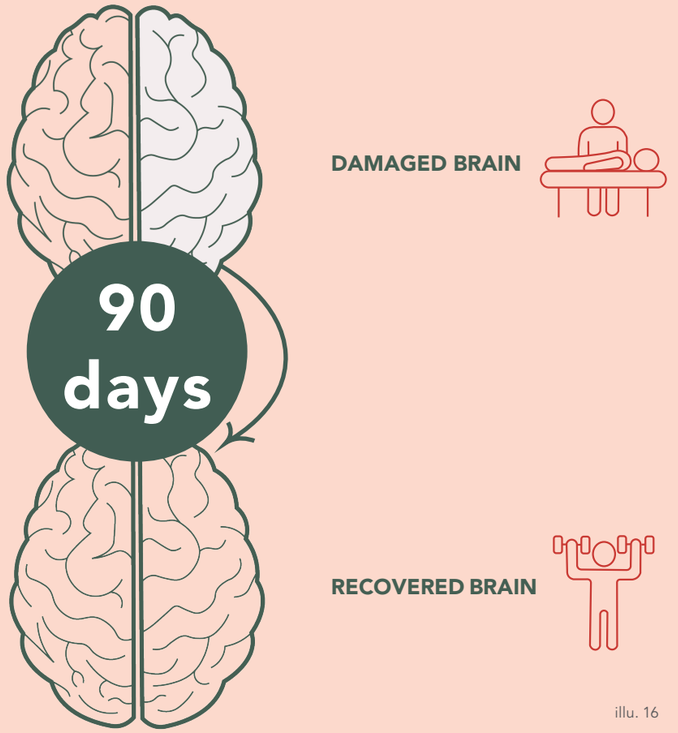
THE CONSEQUENCES

Our brain is involved in everything we do. The brain has control of what we think, feel, remember, smell, sees and hears. It controls our behavior and movements through electrical impulses to the muscles. The brain has billions of nerve cells that are connected to the body. It is possible to make new connections and to bring back the connection in some parts with rehabilitation. (Madsen, 2021, pp. 19-28)

The figure shows the most common side effects of a Stroke.

THE PLASTICITY OF THE BRAIN

In order to dive deeper into the functionality and importance of the brain, a key term turned out to be the plasticity of the brain. In this section, knowledge of the plasticity of the brain are based on statements and information provided by expert Stakeholders in the field: leading nurses and occopational therapists.



illu. 16

Brain plasticity is the ability for the brain to repair its connections or re-wire itself. It is important to understand that with stroke patients the connection between the brain and the body is intact. It is the message from the brain to that body that has to wake up again. This is the opposite of a motorbike accident where you became paralyzed from the neck and down. The brain works but the connections are lost and cannot come back.

90 DAYS TO IMPROVE THE MOST

For a stroke patient rehabilitation from day one is important. Rehabilitation is about working with the whole human and how you best get back to a normal everyday life. The first three months of rehabilitation (90 days) is the most important because here the brain is most responsive to changes that will last.

300 REPITITIONS A DAY

The rehabilitation should take care of some parts in the beginning and slowly add on when the patient becomes better. The brain needs 300 repetitions a day of a specific movement before the connection functional again and get used to it. It is not possible to work with everything at the same time, the brain needs time to recover and becomes more tired than usual. It is a balance to train, and it cannot be "run-away" as some say with a sports injury.
(Rikke, Nurse in charge Neuroenhed Nord, Frederikshavn)

The controversial truth is that new physical functions becomes harder to regain after the first 3 months. **It is all about starting the rehabilitation as soon as possible, why rehabilitation can be said to be the focal point of the project.**

Rehabilitation is defined as:

"a set of interventions designed to optimize functioning and reduce disability in individuals with health conditions in interaction with their environment".

(WHO, 2023)

illu. 17

THE REHABILITATION PROCESS

With rehabilitation now set as the focal point, the objective is to dive deeper into what it consists of, what it means to rehabilitate and what it does over time to the injured brain. This is done to understand strategies and what the patients gets provided.

illu. 18

CLARIFICATION OF THE PROBLEMS

One of the first steps in rehabilitation, is to examine what the individual's issues are. This can be reduced ability to speak, paralysis in parts of the body or lack of structure/overview, which is why the rest of the rehabilitation must be adapted accordingly.

illu. 19

COGNITIVE EXERCISES

The rehabilitation can also consist of training the patients in awareness and attention, as many are seen to be extremely distracted. This can be memory exercises or conversations with a psychologist. The art of being present and attentive has just as much value as being physically in top shape.

illu. 20

PHYSICAL EXERCISES

Functional training
This type of exercises are more related to everyday exercises, chores and are often goal-based. These exercises must be repeated 20-30 minutes a day, and if not, they lose the function again shortly after. So in general, they must be performed daily with a variety in difficulty, combined with goals.

Cardio training
Cardio training cannot be used alone to rehabilitate stroke patients. If they do not perform this type of training, they will not be able to do everyday tasks after a few months.

Strength training
In the first timeperiod, the patients will experience a decrease of their muscle structure. In order to master any other everyday-challenge, strength training must be incorporated.

Must increase functionality after a stroke

TIMELINE
// facilities

A phase overview has been constructed with main focus on the patient's logistics within the different types of facilities, which has been made to gain a better understanding of the complex process and exactly what these patients go through in their time during hospitalization and rehabilitation.

This overview has been made by collaborating with nurses from Neuroenhed Nord at Frederikshavn [WS 5], Nursing home 'Caspershus' in Frederikshavn [WS 3] and Apopleksiafsnit 6Ø at Aalborg Universitetshospital [WS 8]. It is extremely relevant as each patient's case are different from each other.

It is seen that stage 1 includes hospitalization in the acute phase; here comes the apoplexy patient (in North Jutland) at Aalborg Universitetshospital, where a potential assessment is made; must the patient be sent on to stage 2 or sent directly home. The patient stays here for 2.8 days on average.

Stage 2 includes the rehabilitation sites located in Hammel, Thisted, Frederikshavn and Brønderslev (in North Jutland). They are here for an average of 17 days doing rehabilitation exercises in Frederikshavn.
According to the progress made, the patients are either sent home (4) or sent to a private nursing home (3), doing exercises and getting help for basic chores.

CONCLUSION

Stage 1 and 2 are highly relevant in this project, as most rehabilitation must happen within the first three months after the stroke. This is the most important period due to the brains plasticity, meaning that this is the period when the brain is most receptive to learning to walk again, talk and use the arms.
This is where a meaningful design-problem can be developed and where all the relevant people are located (nurses, patients, therapists), creating an outstanding opportunity for information collection and testfacilities.

Apoplesiafsnit 6Ø, Aalborg Uviversitetshospital

3500 patients per year

50% of patients have a paralyzed arm

2.8 days of hospitalization on average

22 beds

1 Hammel
(tough case of Apoplexy)

2 Brønderslev
(moderate/tough case of Apoplexy)

3 Frederikshavn
(mild/moderate case of Apoplexy)

4 Straight home

Own home

Visits: physio- and occupational therapists

Caspershus, Frederikshavn

3 month stay with exercises and own home

Caspershus, Frederikshavn

Offer of exercises 2 times a week

illu. 21

Emergency phase — **1**

Rehabilitation during hospitalization — **2**

Rehabilitation after discharge — **3**

Phase of maintenance — **4**

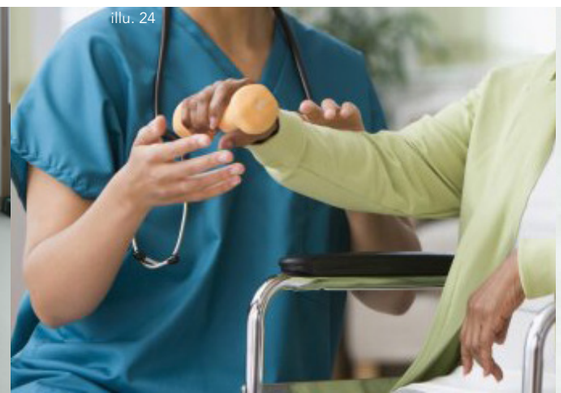
The hospital's responsibility
Doctors
Nurses
Fypioterateauts
Occupational therapists
Neuropsychologists

The municipality's responsibility
Physiotherapists
Occupational therapists
Associations / advisors

! Must be used for 17 days when hospitalized


illu. 22


illu. 23


illu. 24


illu. 25

PHYSICAL DISABILITIES

// caused by a stroke

When a person has had a stroke, some of the brain cells die. These brain cells normally send signals to the body's muscles, but this connection is disrupted by the stroke. This results in permanent weakening of the affected parts of the body [Dignity Health, 2019]. The damage is in most cases on the opposite side of the body to the side where the brain damage occurred. If the brain damage occurs on the left side of the brain, the signal to parts of the right side will be weakened [WS5].

The injury affects the activities of daily life: both chores, but also the relatives, as some injuries can change the patient's entire way of being or require extra help for various daily tasks [Ackerman, et al., 2009]. **The complexity here lies in the fact that no patients are affected in the same way; the damage caused by stroke varies from person to person.**

Therefore, frequent physical disabilities are mapped in order to understand the challenges that the individual patient may face in the transition from acute treatment (phase 1) to rehabilitation (phase 2) and in the everyday life in terms of chores.

BRAIN FATTIGUE

The fatigue can suddenly overwhelm the patient, and many experience it without prior warning. This can occur after simple daily tasks or after the training patients receive while in hospital. This often happens because the patient has to think about every single movement they make (for example in conjunction with paralysis). [Hjernesagen, n.d]

COGNITIVE CHALLENGES

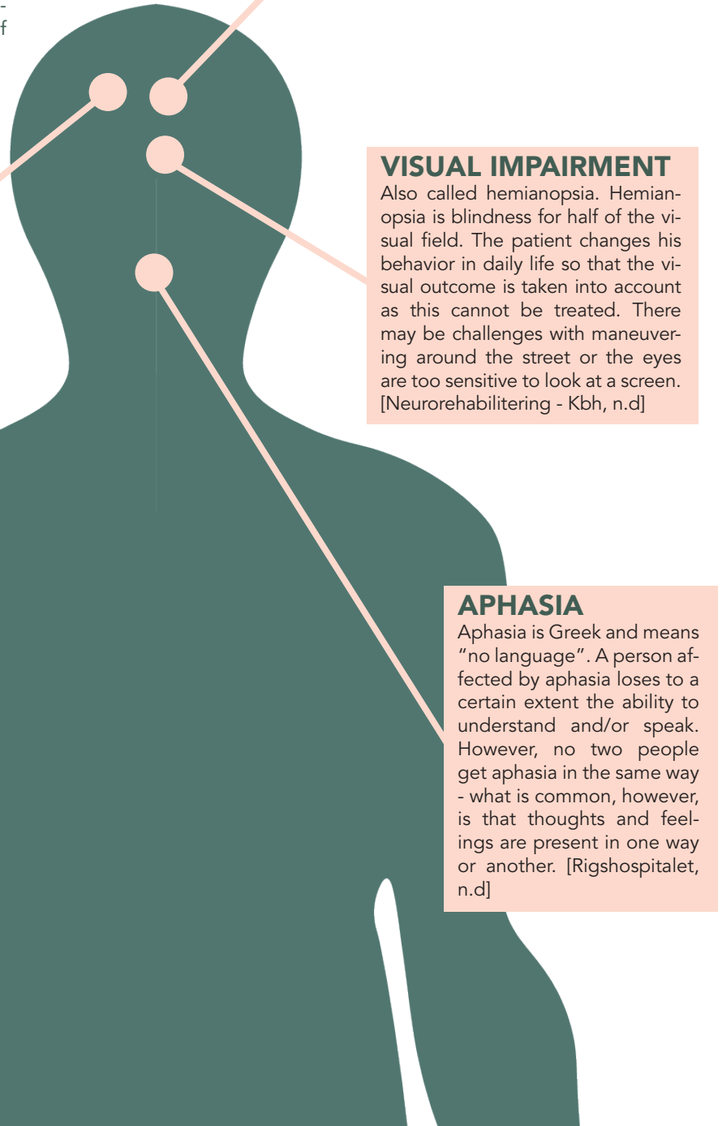
Difficulties with memory, concentration, planning and problem solving are just some of the cognitive challenges the patient may face. In the course of daily life, these difficulties can cause a lot of frustration - both for the patient, the therapists and the relatives. [Stroke Association, 2018]

VISUAL IMPAIRMENT

Also called hemianopsia. Hemianopsia is blindness for half of the visual field. The patient changes his behavior in daily life so that the visual outcome is taken into account as this cannot be treated. There may be challenges with maneuvering around the street or the eyes are too sensitive to look at a screen. [Neurorehabilitering - Kbh, n.d]

APHASIA

Aphasia is Greek and means "no language". A person affected by aphasia loses to a certain extent the ability to understand and/or speak. However, no two people get aphasia in the same way - what is common, however, is that thoughts and feelings are present in one way or another. [Rigshospitalet, n.d]



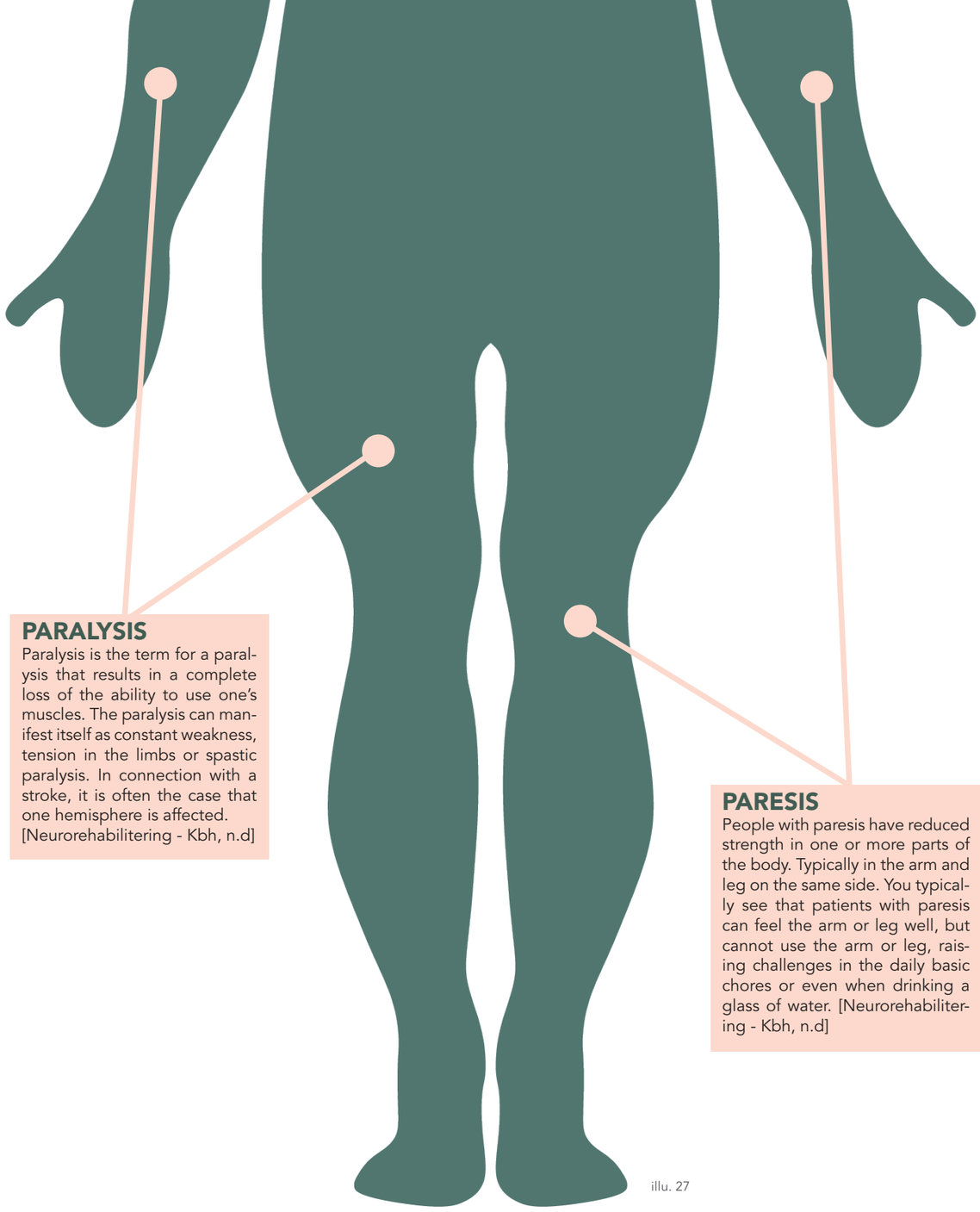
illu. 26

PARALYSIS

Paralysis is the term for a paralysis that results in a complete loss of the ability to use one's muscles. The paralysis can manifest itself as constant weakness, tension in the limbs or spastic paralysis. In connection with a stroke, it is often the case that one hemisphere is affected. [Neurorehabilitering - Kbh, n.d]

PARESIS

People with paresis have reduced strength in one or more parts of the body. Typically in the arm and leg on the same side. You typically see that patients with paresis can feel the arm or leg well, but cannot use the arm or leg, raising challenges in the daily basic chores or even when drinking a glass of water. [Neurorehabilitering - Kbh, n.d]



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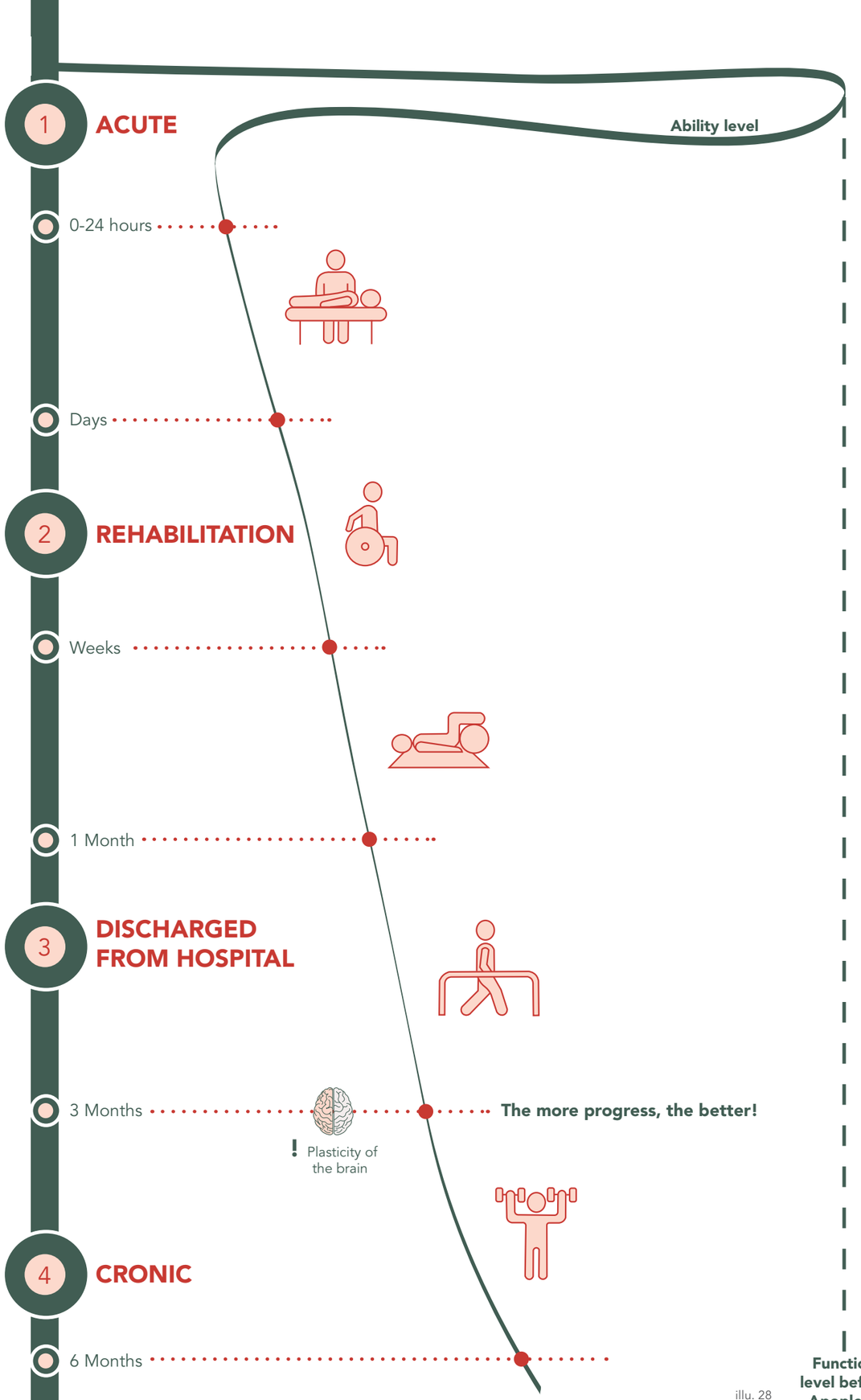
CONCLUSION

An understanding has emerged of how - and how different - a stroke can affect.
This research has raised **interest in paresis or paralysis** for further project work, as it is assessed that factors such as brain fatigue and the general cognitive challenges can be difficult to design for: these cannot be measured or tested in the future, though aspects can be incorporated later in the process.

Every case is different: flexibility is needed



illu. 28

REHABILITATION ROADMAP

// patient's focus

With the logistical timeline mapped out, it is relevant to know exactly what patients go through during the various stages of rehabilitation. Therefore, in collaboration with nurses and therapists, the patients' chores and exercises can be mapped out, in order to eventually achieve independence and take back control over their body and life.

1: ACTUTE STAGE

When a person has a stroke, the person here in North Jutland is taken to Apopleksiafsnit 6Ø at Aalborg Universitetshospital, where each patient is hospitalized for an average of 2.8 days. While the person is in the ambulance, the condition is assessed and blood-thinning medication is given. During hospitalization, the person receives intensive treatment, of which the focus is quickly on re-establishing the nerve impulses to the brain. This may be the first attempt to stand up, sit up, which depends on the degree of the braininjury.
The rehabilitation itself in the acute stage is very different, which is why a potential assessment is made of the individual patient. Some patients can be sent home directly, and others, depending on the level of the brain injury, can be sent to Hammel, Thisted, Brønderslev or Frederikshavn where further rehabilitation takes place.

2: REHABILITATION STAGE

Once the patient has been assessed for potential, he/she is sent to one of the regions. For example, Hammel is for the severely injured and Frederikshavn is for the better, which has been identified in the "Timeline-section".

PHYSICAL EXERCISE

However, regardless of the condition, the patient receives intensive training: both morning, noon and evening. Psychologists and speech therapists will also be involved during this phase, as in many cases depression develops among the patients.
The physical training focuses on the individual's needs and position. In addition, the patients also participate in group training; for example, there is an 'arm team' where patients who suffer with their arm can receive rehabilitation. Large parts of this physical training focus on solving everyday tasks; holding a piece of cutlery, fetching the coffee yourself, etc. In addition, there are also cardio classes such as a spinning class, which gets the legs moving.
Trainings range from 30 minutes to 60 minutes: both in individual sessions and group sessions. In Frederikshavn, there are trainings every single day, to get started on as many functions as possible before the first 3 months are up.

3: DISCHARGE FROM HOSPITAL STAGE

When the therapists assess that there has been enough improvement during the previous stage, the patients are only sent home at the weekend, and are in the hospital on weekdays. When the patients are so far advanced that they can solve various everyday tasks (such as drinking from a glass of water, holding cutlery or going to the toilet themselves), they are sent home to their own home, after which care in the municipality takes over.

4: CRONIC STAGE

As previously mentioned in the "brain's plasticity"-section, both patients and therapists struggle against brain plasticity. The chronic phase occurs after 3 months, when the brain stops being receptive to physical improvements. However, small improvements can occur for some patients, but generally it is seen that they come very slowly.

If a patient still struggles to get some functions up and running, a therapist (physiotherapist or occupational therapist) from the municipality is assigned, who comes to the person's home in their private home. Here the rehabilitation is continued with the hope of seeing improvements.

REFLECTION

As previously concluded, Stages 1 and 2 are extremely relevant, as this is where a design proposal can be developed with the greatest impact due to the plasticity of the brain.

However, this can be tightened further. On the part of the hospitals, the biggest focus is on the training and the actual rehabilitation in stage 2, so this is therefore seen as an opportunity in that the frequency of the training and its importance are emphasized enormously.
Neuroenhed Nord, Frederikshavn, can be used as the main go-to as it houses patients, nurses and therapists.

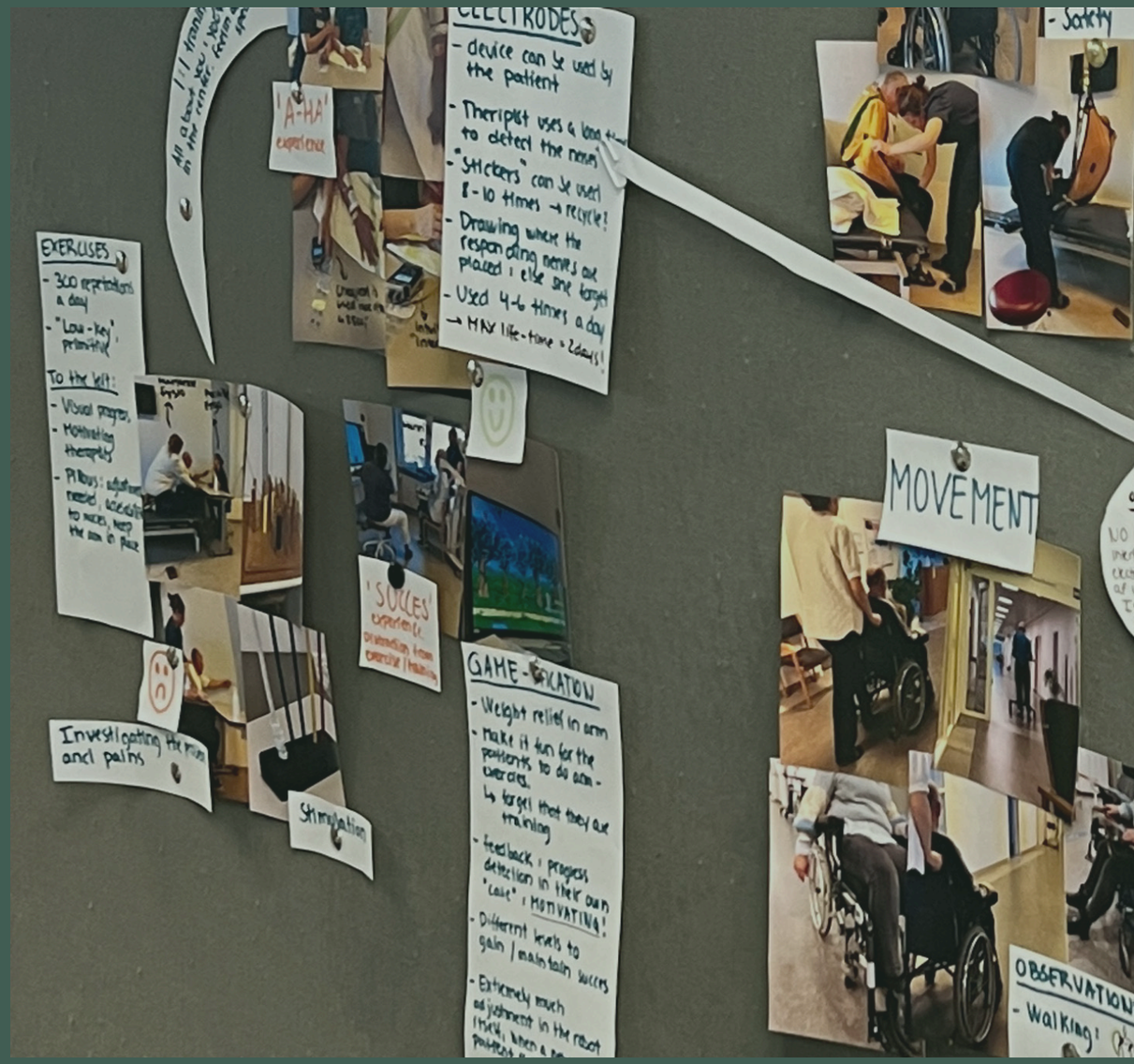
// FRAMING

02

In this phase, work is done to understand the opportunities and the challenges involved in rehabilitation after a stroke. This is done in order to frame and gain an understanding of the relevant insights that are needed to be able to develop a specific design problem. This will finally be summed-up and evaluated by Design Brief 1.0.

METHODS

Interviews (user and therapists)
Observations (user and therapists)
Act out testing
Casestudy
Market-analysis



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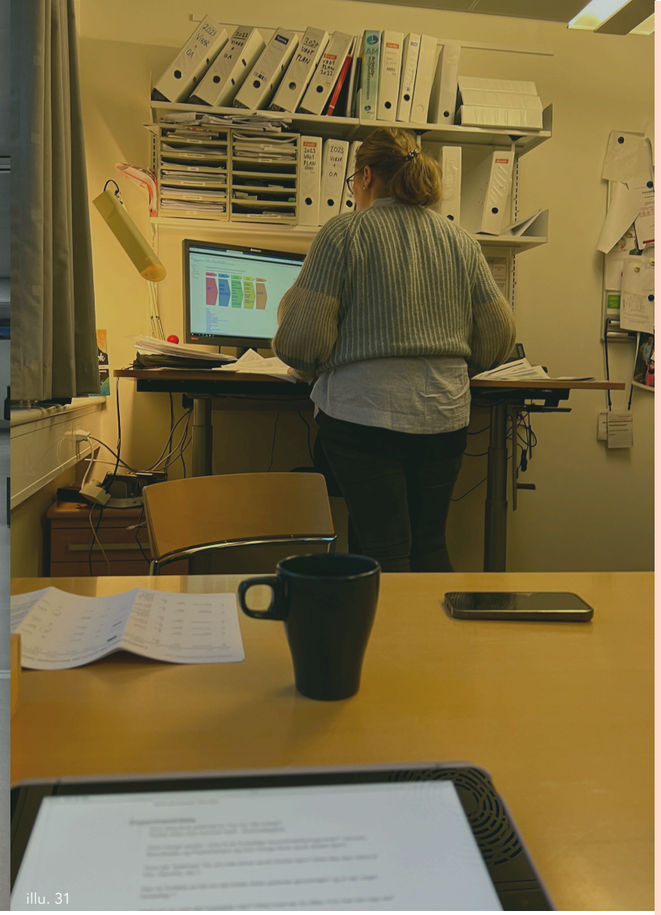
illu. 30



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APOPLEKSIAFSNIT 6Ø

// interview in the acute stage

There was a need for a specific project focus, as it soon became apparent that 'stroke' causes many different injuries, each of which leads to different needs and micro-scenarios.
Therefore, a meeting was arranged with the leading nurse at Apopleksiafsnit 6Ø, Aalborg Universitetshospital, who takes care of, treats and assesses the patient's potential in the acute phase 1 [WS 8].
It turns out that around 50% of the patients who are sent on to the rehabilitation centers in North Jutland (phase 2) from 6Ø, has injuries concerning the arm: either paresis or paralysis. This is roughly 6,000 patients in Denmark per year.
As the percentage is so high, it was chosen to look more closely into the rehabilitation of the arm as this direction would have an impact for a broad group of stroke patients.

6000

new arm-cases per year in Denmark illu. 32

	Must be for arm-rehabilitation
!	Product must be able to be used by single-handed patients

ARM REHABILITATION

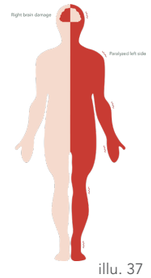
interviews illu. 33 observation illu. 34 expert knowledge illu. 35

With knowledge and data from the acute phase, the way therapists and nurses does arm rehabilitation was looked into in order to specify further and understand how it is done at the rehabilitation facilities in phase 2 of the timeline. To obtain knowledge, interviews were done with nurses and occupational therapists, the team observed through the visits at the hospital and the association 'Hjernesagen' was contacted to obtain knowledge from an outside expert who counsels patients on an everyday basis.

PARALYZED ARM: FALLING DOWN

Arms are complex and need a lot of rehabilitation. Firstly, the team were working on the problem of having a paralyzed arm that the patient is not aware of. Here the team were told by multiple nurses that there is a problem that the arm falls down from the wheelchair and the patients do not notice it and keep doing what they were doing. This has a lot of side effects such as hand gets stuck in the wheel, crooked back, pain in the shoulder and overcompensation of the "functional side" [WS 10 & 11].

illu. 36



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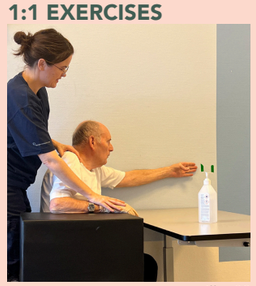
ARM SESSIONS

// observation

ARM-CLASS

illu. 38

1:1 EXERCISES



illu. 39

1:1 ELECTRODE THERAPY

illu. 40

PARESIS: CHANGE OF FOCUS

The team followed therapy sessions at the hospital and observed everyday life at the hospital and never saw the problem of 'the paralyzed arm falling down' for ourselves - with our own eyes, so the team changed to **working with patients with a weak/ limited arm instead: paresis.**

Several therapy sessions were followed including an "arm-class" where all the arm patients exercise in the same room with a focus on their own skills and have one therapist that helps them. On illu. 38, the patient got caught up in the exercise, and totally forgot time and place. The team also followed two 1:1 therapy sessions with exercises (illu. 39) and the use of electrodes (illu. 40). Potential was seen in working with the arm paresis patients that have to do self-training on the hospital wards as well. There was a need for hygiene and a lot of single-use items were used. [WS 12]

SUM UP

After watching these 3 kinds of therapy sessions, it got to the team's attention that the patients also do self-training on the wards in the afternoon hours. Since the therapist is present during therapy sessions, they praise, guide and inform the patient about the progress, which are parameters the patient do not get when doing training alone. **That is why self-training on the wards has been chosen to look further into.**

	Must be for self-arm-rehabilitation
!	Must be easy to clean

CHALLENGES
// in arm rehabilitation

DEPRIORITIZATION OF ARM FUNCTIONS
Through an interview with Maja from 'Hjernesagen' [WS 9], a Danish association for brain-damaged people, she stated that in hospitals there is a tendency to prioritize the function of the legs first and thus get the patients up and walking.
Therefore, the function of the arms is de-prioritised. Maja communicates with discharged patients who would have liked the therapy plan to focus more on regaining the functions of the arms.

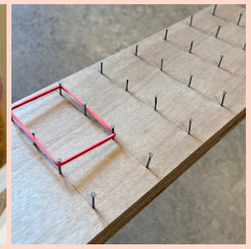
PRICE: TOO EXPENSIVE
If the market is filtered for products that only focus on the arm, the price for these products starts at DKK 59,000. Since the hospitals are public institutions and thus have minimal resources, it cannot be justified to purchase these products nor design one like these. Exactly the same applies to private individuals.

CHILDISH
The moment you enter the physiotherapists' and occupational therapists' training room at the hospital, you spot colors and training products that look like they can be purchased in children's rental shops. They are too simple and raise dilemmas for the patient such as dignity.

LACK OF MOTIVATION
Due to the nature of the primitive exercises and the patient's state of mind, patients experience a lack of progress detection and lack of motivation. When this happens, it will have an negative impact on the repetitions of the exercises, which are key to the improvement.

COPING STRATEGIES


illu. 41


illu. 42

Through the visits at the hospital, it was seen that the therapists creates simple homemade equipment, exemplified in the illustrations to the left.
These coping strategies are mainly done due to the lack of equipment for the arm patients and the training generally takes place in a very low-practice manner with everyday objects, such as a knife, fork, disinfection bottles and water glasses. Therapists (physiotherapists and occupational therapists) currently have no other available options than trying to master these strategies.

1

The therapists make workstations on the wards to motivate the patients to do self-training, but stroke patients often have lack of initiative and ownership of their own progress.
// MOTIVATION

2

// DETECTION
The therapists need to detect why they did not do their exercise: either because the exercises are too difficult, or patients forget it.

Key-insights
// from visits

illu. 43

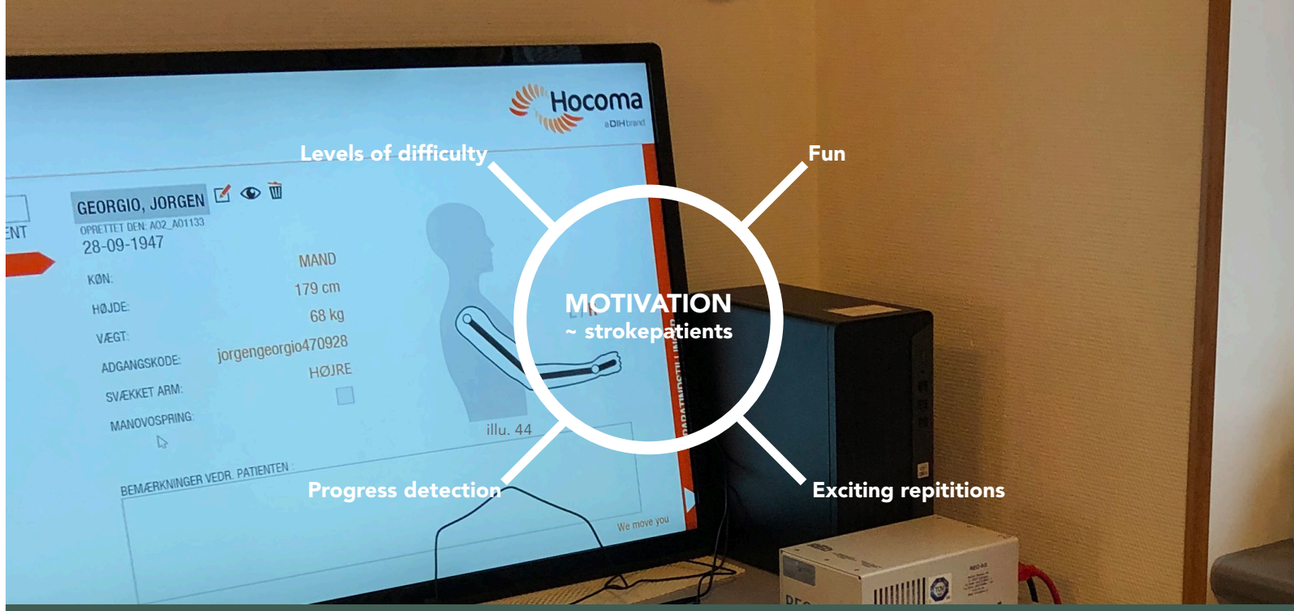
3

300 repetitions a day is required, related to the brain's plasticity.
// REPETITIONS

4

When the patients are training with therapists, they are being motivated because the therapists guide and praise them and tell them about their progress - something they are missing when they are on their own on the wards.
// GUIDANCE

Must provide progress detection, repititions & guidance



THE SCOPE OF **MOTIVATION**
// in stroke rehabilitation

As parts of the key insights from the several visits at the hospital have shown, motivation is key. In order to understand what is motivating, provide some guidance and a goal to design for, the term 'motivation' is investigated.

DEFINITION OF MOTIVATION
The word motivation comes from the Latin "movere", which means to move. Motivating is a process which creates and maintains a purposeful behavior that must ultimately result in a person performing something specific. One's motivation is influenced by both external and internal factors [Susanne Sørensen, 2010]

MOTIVATION-SCOPE IN PROCESS
When defining 'motivation' in relation to this project, two opposite poles can be presented, as it has been observed, that some patients overexert themselves when using the 'Hocoma' robot [WS12]. See illu. 44)

In order to meet the patients' individual needs for motivation in conjunction with the government's therapy plans, a balance must be found in which they do not let the negative thoughts take over, but at the same time do not overexert themselves finding so much motivation that they do nothing but exercise all day long.

A purposeful behavior has to be created through the desired design proposal at 90%. Here the patients are motivated enough to maintain focus and the energy level, but not committed so much that they cannot stop exercising.

CONCLUSION
These factors form the framework for the further work and design process in order to nudge the user to forget time and place, and do not pick up on the numbers of iterations that is being made. By striving to gain motivation - a parameter that cannot be measured - these tangible principles can help to do testing and specify even further.

WHY ARE THEY NOT MOTIVATED?
You might wonder, why these patients are not motivated to make an effort to return to their normal life, as this is something 'healthy' persons would want. The brain has damage and does not work like it did before, something we as normal persons cannot imagine. The problem is that these patients easier lose their focus, get distracted and the brain gets tired. This is why they have problems taking the initiative themselves. They are set back so much that it is hard to see any improvement. Therefore, progress detection is key to maintain the motivation.

illu. 45

Motivates to do self-arm-training when alone on the wards

MARKET
// self-arm-rehabilitation

In order to get a realistic picture of a possible market gap, the rehabilitation-market for an arm with paresis is examined. A reasoning can thus be created and a wall to lean on in the further concept development. As the context is rehabilitation under regional auspices, it is examined with a particular focus on price and the lack of motivation factor among the hospitalized patients.

In general, it is seen that motivational products are very expensive - a price, that the public institutions cannot participate in financially. Neuroenhed Nord in Frederikshavn got the ability to buy the Hocoma Armeo Spring (the machine in the upper right corner at ilu. XX) because of foundations.

Existing products and solutions are mapped in a price/motivation relationship, of which a gap is seen in the market for something that is motivating, at a low price - precisely a place where a great need is seen among patients and hospitals.

POSSIBLE OPPORTUNITY
They can have several in the hospital so that the product can be brought into the rooms. The patients can then take some of the matter into their own hands, in a motivating way and thus rehabilitate themselves, by achieving ownership and independence. In addition, the therapists' workload can also be minimized.

REFLECTION: WHY TARGET FOR HOSPITAL USE?
This is due to the plasticity of the brain - if the arm does not work after the first 3 months - i.e. the months you are typically hospitalized. Though the brain is active and responsive to new development the whole life, it is in the first three months the biggest potential for improvements are placed. When the patients are home again, everyday tasks as making food, put on cloth and brushing teeth keep the abilities in the arm maintained. Therefore, it does not make sense to sell the product as a consumer product after they have returned to their own home. The patients have typically been discharged because their potential has been enhanced. Though, it might make sense to arrange some kind of rental business, because the patients gets familiar with the product at the hospital and might want to keep exercising when they get home. This exercise continuation can be created by the 'motivating' aspect.

Prices less than 10.00 DKK and rental price less than 5000 DKK in a 3,5 month period.

HOCOMA
ARMEO SPRING
// casestudy

When participating in the "arm-class", the Hocoma Armeo Spring device was spotted. This product quickly came to the team's attention, as it has a huge potential in arm-rehabilitation and the product contains some qualities, that the team can learn from, adapt or even downscale. The qualities are shown on illu. 61.

The Hocoma Armeo Spring is a new investment for Neuroenhed Nord in Frederikshavn. It can help the patient to exercise different parts of the arm in a gamified way. The patients enjoy playing games with the Armeo Spring attached to them. They simply forget the time and place because they are having fun playing the various gametypes. They even do much more repetitions than in other exercises. It keeps being motivational because of the progress detection and the ability to "level-up" and beat your own record.

QUESTION IS..
How can a product be made that has the same motivational factor (p. 31) as the Armeo Spring, just in a smaller scale to use during self-rehabilitation?

REFLECTION: HOCOMA
Hocoma has a high price point, but the Wii adapts the same technology. Hocoma's strategic move in terms of pricing means that they are perceived as the absolute most advanced on the market. How to design something at a low cost that is still perceived as a credible, 'professional' product?

- Fun to use
- Credible, professional aesthetics

THE USER

In order to be able to design a solution for the target group and understand what **user-centered parameters are key if they were to do self-training**, it is important to understand them and their needs and pains. This target group is extremely interesting because they **compare the life before the stroke with the new life they have - involuntarily - got after the stroke.** 90% of all stroke patients are over the age of 60 (Sundhed.dk, 2019), therefore the target group is chosen to be 60 + years old.

// overall

60+ years old | **Arm parasis** | **Can walk**

// specific user insights

Motivation: During the exercises, patients try to cheat - either they become too committed or they are too tired and cannot overcome the therapist's challenges for 'next time' or next session.

Amazed by technology: This age group grew up without mobile phones, tablets, streaming services, games and robots. The user has a big smile when it works.

Had an active life and is now hospitalized: This sudden change has caused the patient to cry a lot and often and starts the morning with an anti-depressant pill.

Has a good sense of humor: Good interaction and chemistry with the staff.

illu. 64

Attention: The patient is easily distracted.

// Henning Nielsen
80 years old

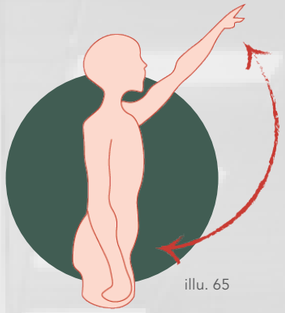
Working intensively to get arm function up and running: The patient is walking, yet still struggles with arm-functions and balance.

Lack of initiative: Needs therapists to remind him to do the exercises.

Must be intuituve to patients over the age of 60

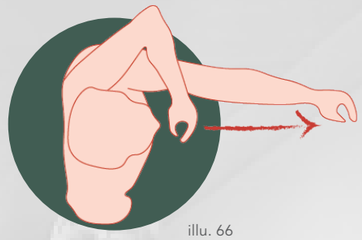
MAPPING OF THE MAIN EXERCISES

Because the arm is being worked on, it is important to understand exactly which exercises are done with the patients during rehabilitation. By breaking down the arm exercises in this way, an overview can be generated, so that in the future it can be specified and referred to, with a view to incorporating these exercises into a design proposal.



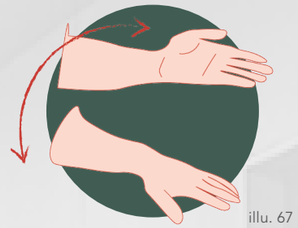
illu. 65

// Lifting arm



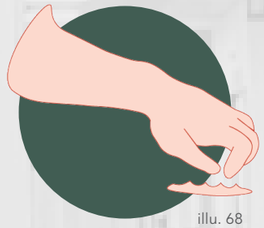
illu. 66

// Reaching



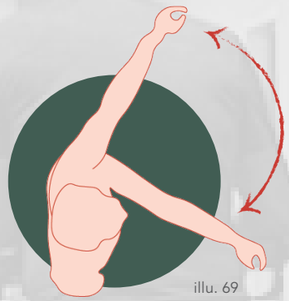
illu. 67

// Wrist rotation



illu. 68

// Fine motor skills



illu. 69

// Shoulder rotation

illu. 70

// Grasp & release

// Main user's arm challenges

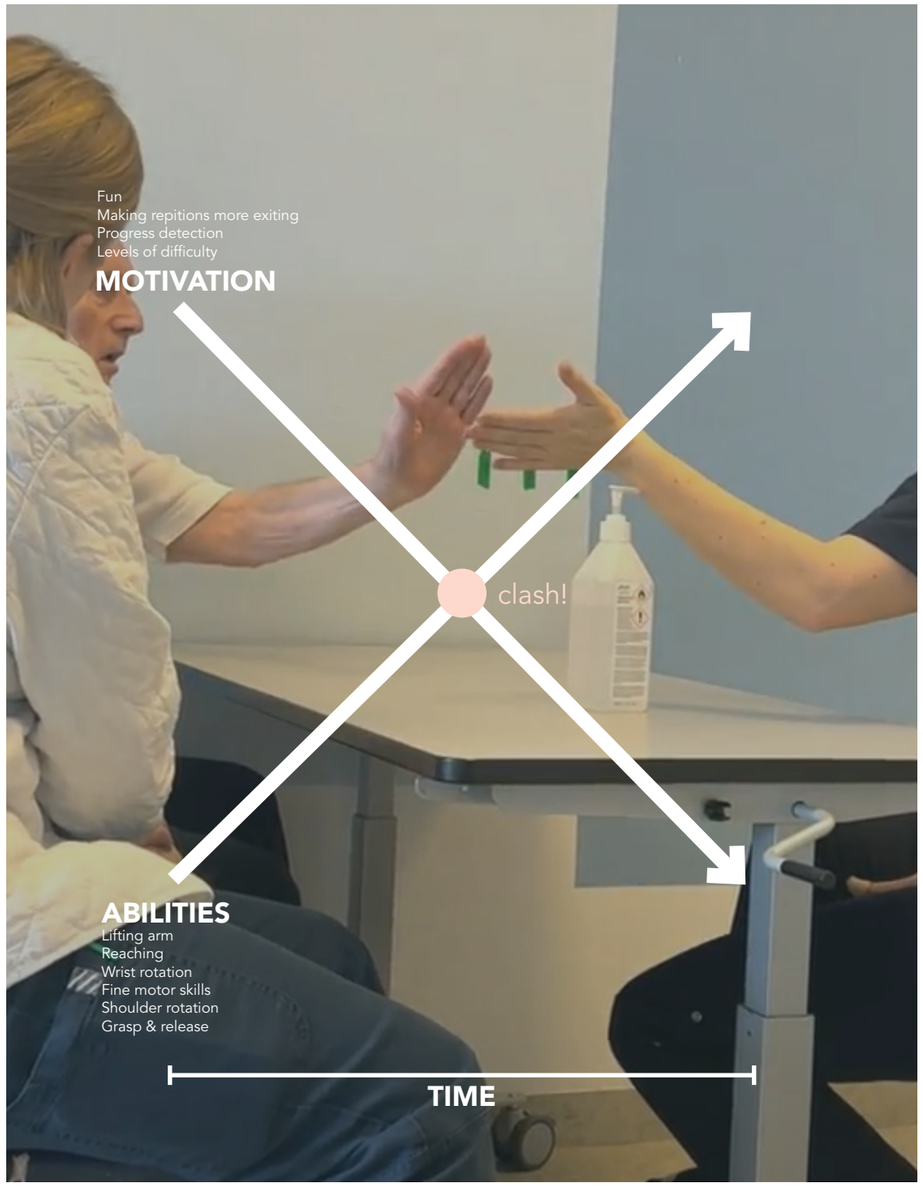
- **Can grasp an object** well but has difficulty letting go of the object again.
- Cannot drink of a half full glass of water - **do not have the last movement to get it up to the mouth**.
- Index finger and thumb are not fully working and **miss the feeling**.
- Have trouble using the arm correctly - **too big movements** than required.
- **Cannot put a watch on** his 'good' arm using the bad, that require the fine motor skills.
- Tends to use the body to move the arm in outer positions and **not using the shoulder**.

REFLECTION ON REHABILITATION-PATIENTS AS USERS

In average the patients are hospitalized for 17 days at Neuroenhed Nord, Frederikshavn. This project is extended over four months before the submission and five including the exam. This means that the team probably will meet many different patients through the development phase and not just one or two that can help through the process. Though, therapists can help to the end without any changes. The team is aware that when concepts are being developed and keeps in mind that no stroke is identical, another patient might have other wishes or values they are searching for in a product. The patients do also vary in skills due to arm rehabilitation and the team need to take into consideration that the product should work for the patient both in the early stage of their stroke and in the end of the hospitalization before discharge.

Nudge the user to do the main exercises

Increase in independence



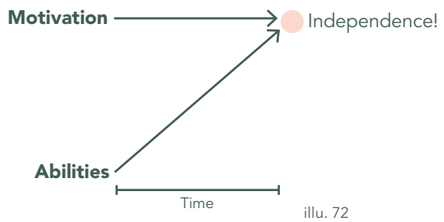
illu. 71

MAIN TAKE-AWAY

It has been seen, that the motivation is decreasing over time whereas the patient's abilities are **supposed** to increase. **There is a clash between these two parameters.**

THE AIM

The aim of the project and the following phases will be to try to stabilize the motivation through the parameters being: **fun, making repitions more exiting, progress detection and levels of difficulty**. All in all to achieve independence faster.



illu. 72

design brief 1.0

STATEMENT OF INTENT

How do we create motivation, raise the "fun-ness" and thereby contribute to step-by-step-independence and ownership of the arm patient's progress during rehabilitation?

SOLUTION SPACE

A product that can be used for arm rehabilitation that creates motivation and thereby makes sure that the patient gets the exercises done.

> GENERAL REQUIREMENTS		SOURCE	PAGE NO.
>	Product must be used for 17 days	*Timeline // facilities*	*> 21*
>	Every case is different: flexibility	*Physical disabilities*	*> 23*
>	Useability with one hand	*Apoplexiafsnit 6Ø*	*> 28*
>	Easy to clean: hygiene	*Arm-sessions*	*> 29*
>	Must provide progress detection, repititions & guidance	*Key insights*	*> 30*
>	Price less than 10.000 DKK	*Market*	*> 32*
>	Rental price less than 5000 DKK	*Market*	*> 32*
>	Fun to use	*Hocoma Casestudy*	*> 33*
>	Credible, professional aesthetics	*Hocoma Casestudy*	*> 33*
>	Must be intuitive to patients over the age of 60	*User*	*> 34*
>	Nudge the user to do the main exercises	*The main exercises*	*> 35*
>	Increase in independence	*The main exercises*	*> 35*

illu. 73

PRIMARY USER

Age: 60+
Apoplexy patients: Paresis in one arm
Regular function in the other arm
Easily distracted, lack of initiative & motivation
Function in project: Concept testing and main focal point

PRIMARY USER SITUATION

From diagnosis to rehabilitation at the hospital
Exercises daily to regain functions
Doing self-traing with extraordinary focus on the arm

illu. 74

SECONDARY USER

Occupational therapist for rehabilitation
Rehabilitation of Apoplexy patients
Function in project: Expert evaluator and information provider

SECONDARY USER SITUATION

Works at the hospital
Task is to do daily exercises with the primary user
Have an overview of the primary user's progress and forward needs for training as well as program for it

// CONCEPT
DEVELOPMENT

03

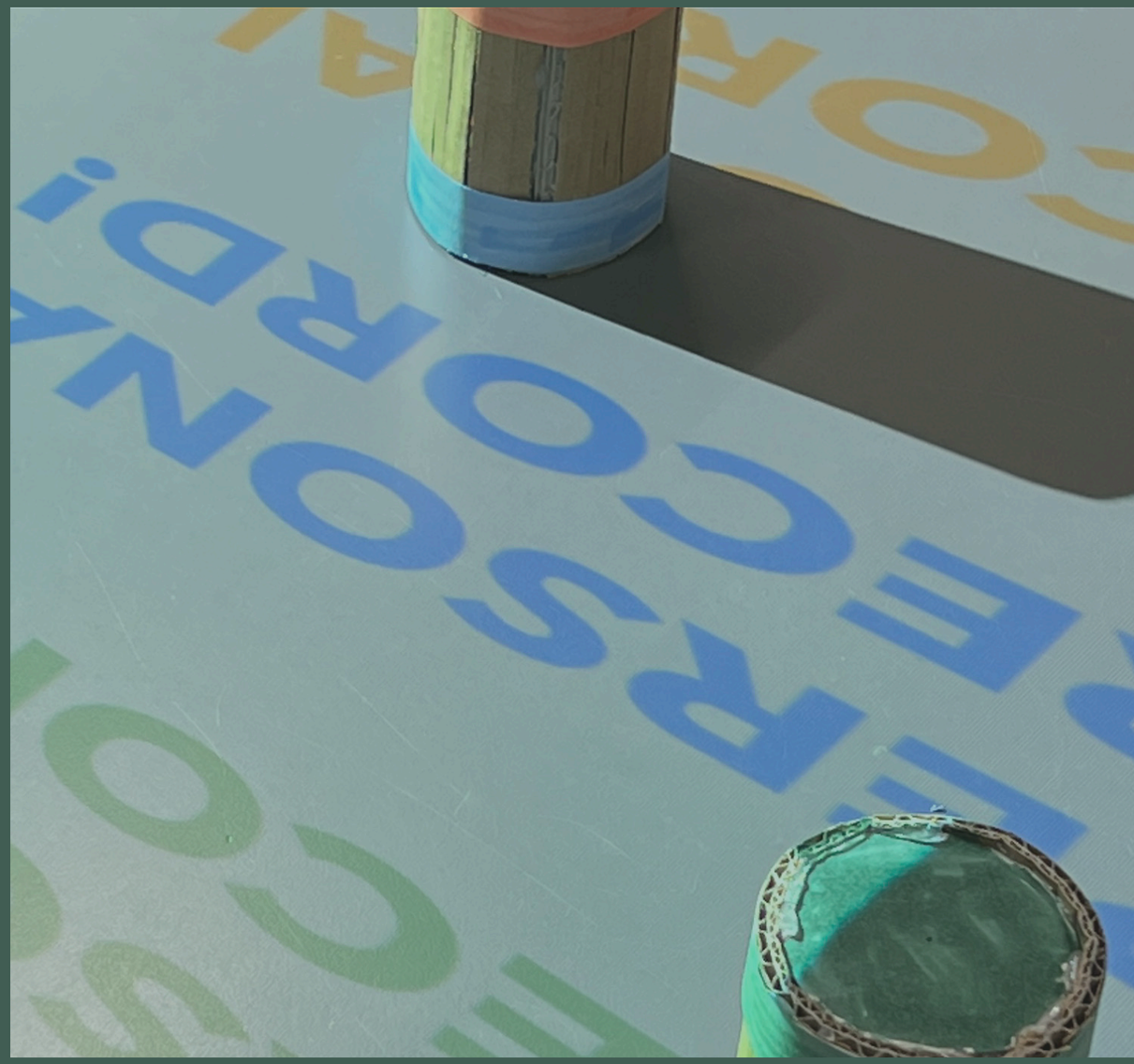
In this phase, ideas will be generated, presented and tested, in order to turn it into a concept, using the Design Brief as a guide. To be able to explore how a physical product can be incorporated in the rehabilitation setting, relevant factors will be discovered and analyzed, along with the ongoing process of covering what nuances are important when the product should motivate the arm stroke patient.

METHODS

RESEARCH
Game Theory
Game-types

DEVELOPMENT
Board
Darts
Controller
Little Friend
Afro-Ditte
Turning Game

INTERVIEW
Hjernesagen
Occupational therapist



illu. 75

INITIAL CONCEPTS

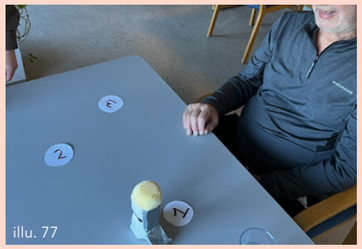
With arm rehabilitation set as the overall theme, concepts were to be made and tested on the user. This was done to pick an idea to detail further.The concepts were generated and built into physical models which were tested with Henning, the primary user. Afterwards the concepts were discussed with Pernille, the occupational therapist that knows a lot about arm rehabilitation. The concepts were evaluated based on statements the fun that the patient gets when using it [WS 15].

illu. 76

Therapist
Requirements to quality of exercises and function-improvement

Patient
The fun, gamified experience

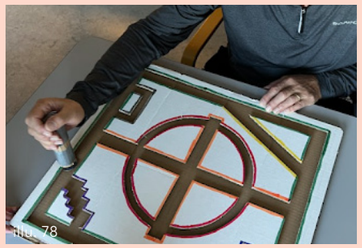
Must be balanced!
The fun experience is worth nothing if the patient does not do the correct exercises



illu. 77

'LITTLE FRIEND'
Little robot that moves around the tablesurface, and gives 'commands' to the user, telling what to do. This activity can help to gain control that can be used in the everyday tasks for the patient later.

CONCERNS
The model were moved around the table by the team, that provides some sources of error related to the user experience.
Though, the therapist sees potential if it can help to rehabilitate movements of the arm that make them able to do everyday things.



illu. 78

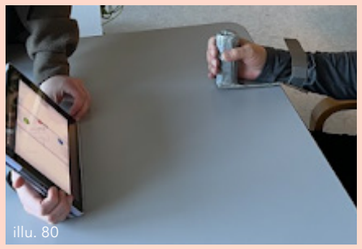
'BOARD'
A game board using a handle to complete different level of complexity. Detection and counting when the patient is hitting the sides.

CONCERNS
Henning mentioned that it reminds him of an electrical toy where you have to move a ring and not touch the wire.
Henning was able to move around all the lanes without any trouble. He was not challenged, and the movements will be identical and maybe boring after days of use.

illu. 79

'DARTS'
Adopting well known principles from a classic game, the dart game using a ball that always comes back to its starting point. The idea is to make it possible to count points that allows feedback and progress detection.

CONCERNS
May not be fun after a week of exercises. Not many opportunities to change the complexity and exercise different parts of the arm.



illu. 80

'CONTROLLER'
Controller mounted on patient, that connects to the iPad. Using gamified principles and a down-scale of the Hocoma Armeo Spring.

CONCERNS
How can we differentiate it from a Wii? If the Wii software is updated, could they just use that instead?
The test was done with a video of a game, but he played it as if it was a real game. Arm were not moved a lot.

EVALUATION
// of concepts

LEVEL-UPS
Henning has become a lot better using the arm compared to last time, and it was not expected, that he so easily could overcome the exercises. This is something the team have to keep in mind; the products should be possible to change in levels in order to push the limits of what they are capable of and make them better.

CONCEPT CHOOSING


illu. 81

The team and the therapist believe there is room for improvement with **the little friend** and **the controller** because a wide range of exercises are available to teach various arm sections. The user enjoys them a lot, and this can be used as an advantage to motivate them. This device is intended for people over 60, so it should be simple to use.
The patients that are ready to use an iPad, get one in the near future. Therefore, there is a potential to let the product "speak" together with the iPad because it is here the patients will see their daily tasks anyway.

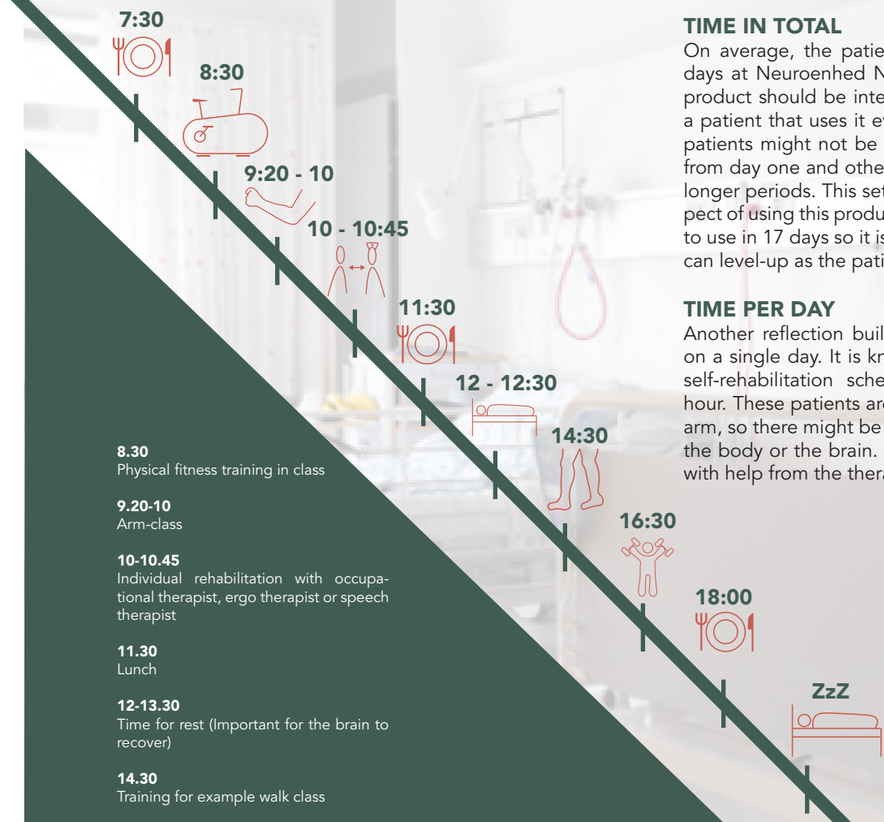
NEXT STEP
The next step is to work further with keeping the patient interested and motivated by the product over time through different levels of complexity and variety of exercises. Furthermore, it is relevant to understand the daily life and routines of a patient.

Must be compatible with an iPad

Must be possible to change in levels

A DAY AS A PATIENT

Every patient has their own daily scheme on the wards, showing their day. The patients have a lot to deal with; depression, initiative and ownership of their progress. So the rehabilitation is broken down to smaller tasks because they cannot exercise everything at same time. A typical day for the primary user is then investigated.



8.30
Physical fitness training in class

9.20-10
Arm-class

10-10.45
Individual rehabilitation with occupational therapist, ergo therapist or speech therapist

11.30
Lunch

12-13.30
Time for rest (Important for the brain to recover)

14.30
Training for example walk class

16.30
Self-rehabilitation on the wards

illu. 82

TIME IN TOTAL
On average, the patients are hospitalized for 17 days at Neuroenhed Nord, which means that the product should be interesting and motivational to a patient that uses it every day for 17 days. Some patients might not be able to use it on their own from day one and others might be hospitalized for longer periods. This sets the scope for the time aspect of using this product. It should be motivational to use in 17 days so it is important that the product can level-up as the patient's abilities arises.

TIME PER DAY
Another reflection builds up upon the time used on a single day. It is known that the patients have self-rehabilitation scheduled every day for one hour. These patients are not only rehabilitating the arm, so there might be used time for other parts of the body or the brain. This needs to be evaluated with help from the therapists.

Must be used for 1 hour a day

GAME DESIGN

// theory

It is clear that when the patients use the Hocoma Armeo Spring, they are engaged and enjoys the exercises and forget time and place. This engagement and fun are what the team also search for in the concept development, though 'fun' cannot be measured. Research into game theory was done to find the main triggers and motivational, fun parameters [WS17]. Furthermore, this is done to potentially specify the 'fun' aspect.

illu. 83

THE 6 KEY FACTORS

Gameplay can induce neuroplastic reorganization that leads to long-term retention and transfer of skill. In game design 6 key factors are identified for understanding the engaging nature of video games: reward, difficulty/challenge, feedback, choice/interactivity, clear goals and mechanics, and socialization. The key factors of game design such as choice, reward, and goals, lead to increased motivation and engagement. These factors might be helpful to the therapists as well when they evaluate the patients. (Lohse et.al. 2013)

PATIENTS IN 'FLOW'

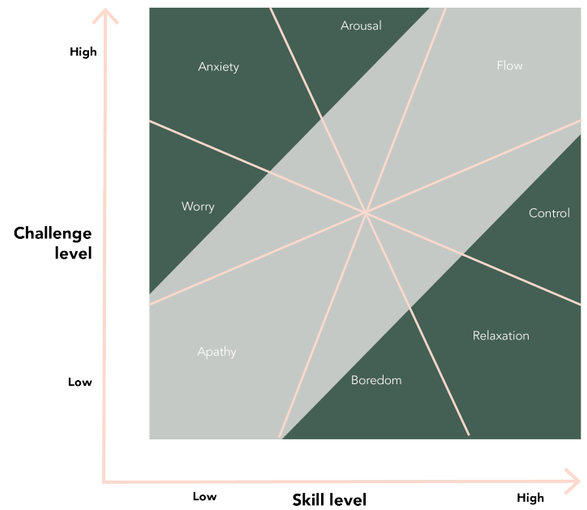
To make sure that these patients might keep the motivation they need to be in a flow. There are two basic motivation types intrinsic and extrinsic.

Intrinsic motivation: A flow where you surrender completely to the moment and forget time and place, as a musician playing without thinking. (Oppland, 2016)

Extrinsic motivation: The motivation to succeed is controlled externally and is therefore short-lived. As when you are practicing to get better but still need a teacher to validate your effort. (Oppland, 2016)

OPTIMAL EXPERIENCE: THE MODEL

In order to keep in this flow, the psychologist Mihaly Csikszentmihalyi has made a flow model for optimal experience. To reach being in a flow the exercise must not be too difficult to elicit anxiety nor too easy to be boring. In the model it is seen that you will experience flow when the skill level and the difficulty of the challenge matches. Example persons with more skills will experience flow on a more difficult task that those with less skills. This match is what inspires flow where nothing else matters, intense concentration and time get distorted. This is what creates happiness in the brain. (Oppland, 2016)



Line of Flow
for optimal game-experience

illu. 84

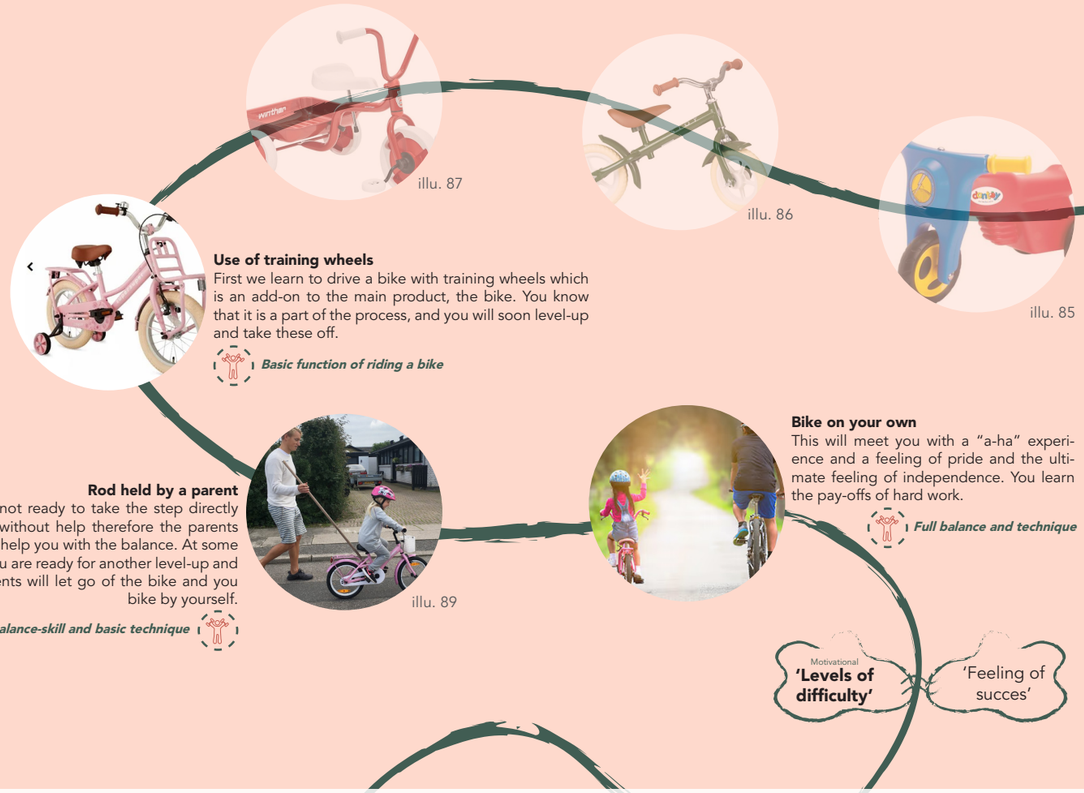
CONCLUSION

To make a concept for arm stroke patients that keeps them in a flow, the product must be able to reach different levels of skills and challenges over time. It also has to give the patient the opportunity to have intrinsic motivation when they do self-rehabilitation on the wards. An integration of choice, reward and goals will be useful to integrate to make an engaged and motivational product that can give feedback and detect the progress for both the patient and the therapist.

Balance between Challenge and Skills: Flow

THE BIKE METAPHOR

In the concept there is a need for a way to level-up to meet different arm patients at different skill levels, combined with the game theory. To make it more visual, and to understand how it could be done, the way children learn to ride a bike can be used as a design-metaphor.



illu. 87

illu. 86

illu. 85

Use of training wheels
First we learn to drive a bike with training wheels which is an add-on to the main product, the bike. You know that it is a part of the process, and you will soon level-up and take these off.

Basic function of riding a bike

Rod held by a parent
We are not ready to take the step directly to bike without help therefore the parents need to help you with the balance. At some point you are ready for another level-up and the parents will let go of the bike and you bike by yourself.

Balance-skill and basic technique

illu. 89

Bike on your own
This will meet you with a "a-ha" experience and a feeling of pride and the ultimate feeling of independence. You learn the pay-offs of hard work.

Full balance and technique

Motivational
'Levels of difficulty'
'Feeling of succes'

THE OPPORTUNITIES

When you have learned to bike the opportunities are even bigger and you can now ride a racer bike, Mountain bike and other bikes that you are not skilled in yet.
This helps us to understand another way of "level-up" than just while thinking about gamification [WS17], this could also be seen as a physical and visual add-on/off in terms of more independence and ownership.

VIEW ON HOW TO LEVEL UP

The bike adds an interesting view of how-to level-up, that includes the following parameters:

illu. 91
Gradual building up skills

illu. 92
Visual improvements

illu. 93
Changes shape after each state

illu. 94
Visual add-on

The interesting part of the bike is that it is the main product, the bike, that is used in the three levels, but skills are slowly added, and aids removed. It adds to a feeling of confidence when the main product is used from level one to three. So, in the beginning where you need to understand the basics of riding a bike, you do not need to worry about balance because you are not ready to learn that skill yet.

KEY TAKE-AWAY

This metaphor will be used in developing concepts for arm patients to make sure that they do not have to be at the top-level from day one, but that **more skills slowly will be added when the patient are ready** as when the kid have removed the training wheels and another skill is added. This will **create a feeling af succes**, which is interesting when working with motivation.

PARAMETERS TO REQUIREMENTS

Furthermore, level-up parameters have been found, that can be used to evaluate future concepts and will for now act as requirements.

illu. 95

NOSTALGIA

// games when patients were young

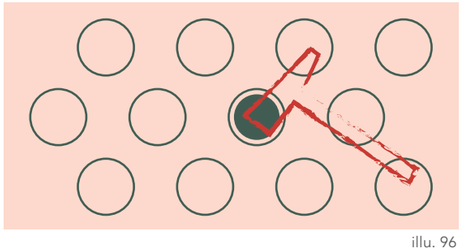
An investigation of games played over time that the patient potentially will recognize from their childhood was investigated [WS 19]. The goal is to find games that can be adapted from principles to make sure that the intended fun-aspect in the product - e.g the gamified approach - does not become too technical to understand for the elder target group and use its main characteristics to transfer it into arm therapy.

CULTRUAL DIMENSION

This cultural dimension has a significant characteristic: nostalgia. It is a human instinct to romanticize the good old days. You think back to your youth and talk about all the good stuff. It is a great opportunity and selling point if the team, as designers, can bring back the stroke patient's youth and memories. In addition, it might be advantageous if the patient says, "This reminds me of... when I was young," since this may improve engagement if the patient can quickly and easily figure out what to do or how to execute it.

WHAC-A-MOLE

It is not only important that the patient understands the principles of the game, but it also has to be beneficial for arm training, therefore, principles from the Whac-a-Mole game can be worked upon. Here the patient have to be focused on the game area and be fast when the mole appears. This game also has a dimension of time and points, and based on the nature of the Whac-a-Mole game, you want to be faster and better than the last time its has been played. This is an experience and basic game-approach that can be worked on in the future, in order to contribute to make the patient feel motivated.



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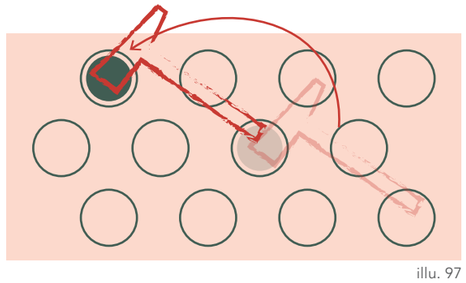


illu. 97

The game must adapt principles from the Whac-a-Mole-game

WORKSTATIONS

// on the hospital wards

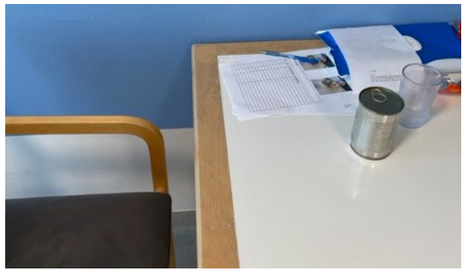
The therapists set up workstations at the patients' wards so they can do self-rehabilitation - this refers back to the 'coping strategies', introduced in the framing section. They are individually arranged for each patient. The occupational therapist told the team that the patients typically do the same self-rehabilitations exercises for a week after which the exercises are graduated or adjusted. The patients are not totally alone with the exercises, as the therapists will follow up on them once in a while.

EXERCISES FOR EVERYDAY-LIFE

The patients are not only doing arm rehabilitation they also have to do walking exercises, but an exercise could also be that they have to try to use a normal knife for dinner, speech practice and other combinations. It depends on the patient and which state they are in, but the arm patients will typically do self-arm-rehabilitation on the wards for 20 minutes a day and not more than 30 minutes.With this information, the requirement on page 41 can be revised.

PUSHING THE NUMBER OF REPITITIONS

The important thing is that they do the same exercise more days in a row because the therapists have the approach that the patients have to do the same amount of repititions or more as the day before, never less, to make sure that they become better. Illu. 98 shows a workstation where the patient has four papers with exercises, he has to do with his arm and for that he has to use a canned tomato.



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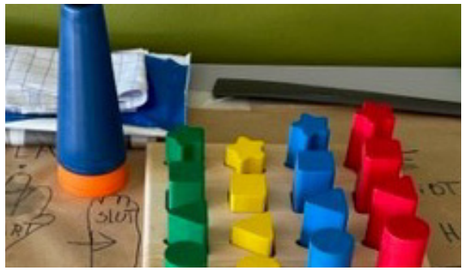

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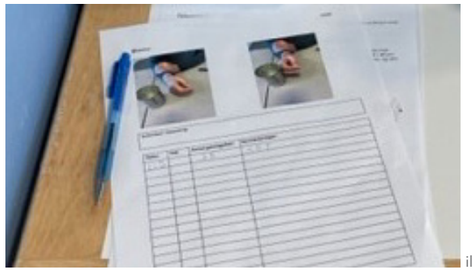


illu. 101

MAIN EXERCISES

// narrowing down

It came clear, that the team could not solve the whole spectre of exercises, which is why a main focus must be deduced.

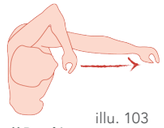
With observations from the workstations, it is known that the patients learn to do exercises that are activity based; tasks that help them to do everyday tasks. A specific example was that several patients strive to drink a cup of beer, but have trouble achieving the movement to the mouth with the elbow.

POURING & DRINKING A GLASS OF BEER

The grasp and release function is quite important in many tasks and is difficult for the patients to learn. Therefore, the team chose to make concepts that can help the patient to gain the abilities to grasp and release, rotate the elbow/wrist to fill a cup and afterwards drink it. **These 3 arm skills will be the main focus.**

illu. 102

// Grasp & release



illu. 103

// Reaching

illu. 104

// Wrist rotation

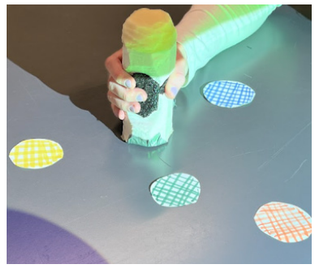
Must exercise Reaching, Grasp/Release, and Wrist Rotation

Must be used for 20 minutes a day

CONCEPT EVOLUTION

// of 'Little Friend'

In order to combine game design theory, nostalgia and the chosen 3 skills, the solution space was investigated in order to accommodate the exercises the patient must overcome in order to be able to pour and drink their own beer or milk [WS 20].



illu. 105

LITTLE FRIEND

This led the team to an evolution of the 'little friend concept' (p. 40) but instead of it moving around on the table by itself, the patient needed to move color bricks from one point to another - like the Whac-a-Mole game. The little friend should be used as the handle to move the color brick to the right color spot made by a projector. **The projector allows flexibility and adaptation to the patient's different skill level, as it creates a virtual gameboard.** When a brick is shown, the patient has to do the wrist rotation to push the top of the little friend and then grasp it again afterward to move the next brick to the right color. The level-up was tested through the complexity of the game made by the projector, here more colors will appear as the abilities get higher.

MAIN OUTPUT OF TESTING

Can the shadow be used to nudge the patient to lift the arm?

Only use 1 hand to make sure they grasp and release.

Make the bricks able to be caught and not just moved along the table.

Explore levelling-up: Faster pace, more dots, have to flip it.

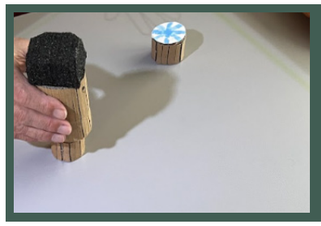
CONCEPT VALIDATION

"It looks exciting. It's a good hand/arm workout and it challenges cognition at the same time."
- Maja Klamer Løhr from Hjernesagen

AFRO-DITTE & TURNING GAME: BORN BY 'LITTLE FRIEND'

The test of 'Little friend' created the foundation for **another iteration** on the concept which led to two new concepts that also has to be tested, challenging the information in the 'main output' section.

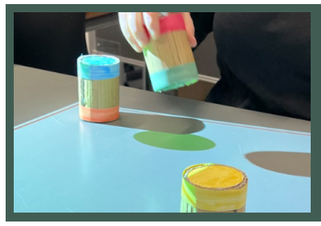
illu. 108



illu. 106

AFRO-DITTE

The idea was to develop the little friend to test a new version of the interactive game, **based on grasp and release**. It should be possible to use the handle to grasp an object and lift it to the right color spot. It requires control and force in the grasp-skill. Here the new evolution of that is called Afro-Ditte.



illu. 107

TURNING GAME

From the little friend game, it was hard to catch the bricks in grasp and release. Therefore, another iteration was initiated: what if you do the same interactions and movements but does not have to pick up a brick. And why is there only 1 cursor? If there could be more, the visual improvement might also be clearer. This resulted in the turn game allowing wirst rotation.

SUM UP

The concepts have been tested at Create on the team's colleagues, but it was hard to understand how the real patients will act and how difficult the tasks are to handle. Therefore, an urge arose to test the concepts on real patients, which can help the team further in the process of understanding how the games are played, if it is intuitive enough and if it should be possible to level more up or down.

A projector must create the game-board

CONCEPT TESTING

// on the patients at Neuroenhed Nord

To get an understanding of the concepts level of difficulty, a test with stroke patients in Frederikshavn was set up [WS 22]. This test became urgent, as it was clarified from the previous tests, that the team cannot test on colleagues who have a normal function in the arm. The test was made on two different skilled arm patients. The concepts were all using the same platform with 3 levels of difficulty: the first level has two colors to use, second level has four colors, and third level has six colors to be aware of.

TEST SET-UP

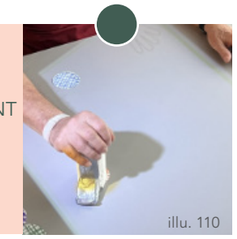
The test setup consists of a projector, a computer with PowerPoint slides in 3 levels, and 3 concepts. When the test-person has moved the right cursor to the right color dot, the next slide appears. The projector is placed on the right side of the test-person.

illu. 109

TEST RELATED TO FLOW

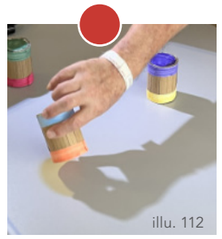
The concepts were tested on two patients. Patient 1 has a right arm parasis and Patient 2 has a left arm parasis. Both patients tested all three concepts and based on their feedback and observation, the output can be evaluated by the flow-diagram, presented on page 42.

PATIENT 1

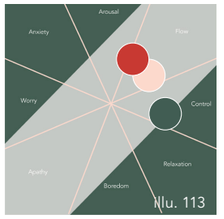


illu. 110

illu. 111



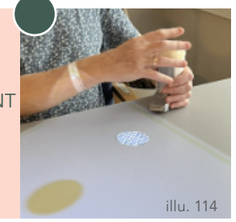
illu. 112



illu. 113

scan to see how the concepts works!

LITTLE FRIEND

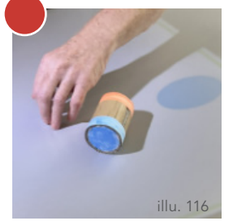


illu. 114

AFRO-DITTE

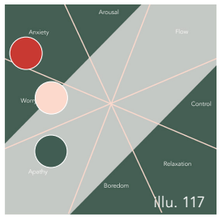
illu. 115

TURNING GAME



illu. 116

FLOW



illu. 117

PATIENT 2

TESTING CONCLUSION

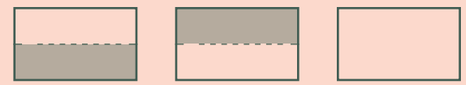
FLOW

Compared to game design theory it is important to be in a flow in order to keep the patient motivated. The grasp and release were not possible for Patient 2 yet. To Patient 1, the third level matched his skill level, so he was in a flow which also resulted in **him losing track of time**, which is what the team were searching for.
Patient 1 was challenged, but there is a potential to challenge more in order to reach the last level of hand/arm skill before he is ready for his new normal life in his home.

FEEDBACK FROM THERAPIST

The therapist believes the concepts have value because it's crucial to learn how to use the grasp function again. She stated, *"The hand leads the arm."* Furthermore, it's a good and crucial notion to turn your hand. The fact that it can be weight-modular as well is interesting.

Changing the work area is one way to accommodate patients with different skill levels. Patient 2 only needs to work on half of the "screen" at a time; once the patient is ready to continue on, it can be adjusted again.



illu. 118

The therapist told that since many Australians live on ranches, they heavily utilize web training. They focus on principles of creating exercises that are simple to set up at home, such as using canned tomatoes. This is why the therapist sees a potential of the concepts in countries such as Australia.

Game-board must be able to be adjusted

EVALUATION
// of concepts & test

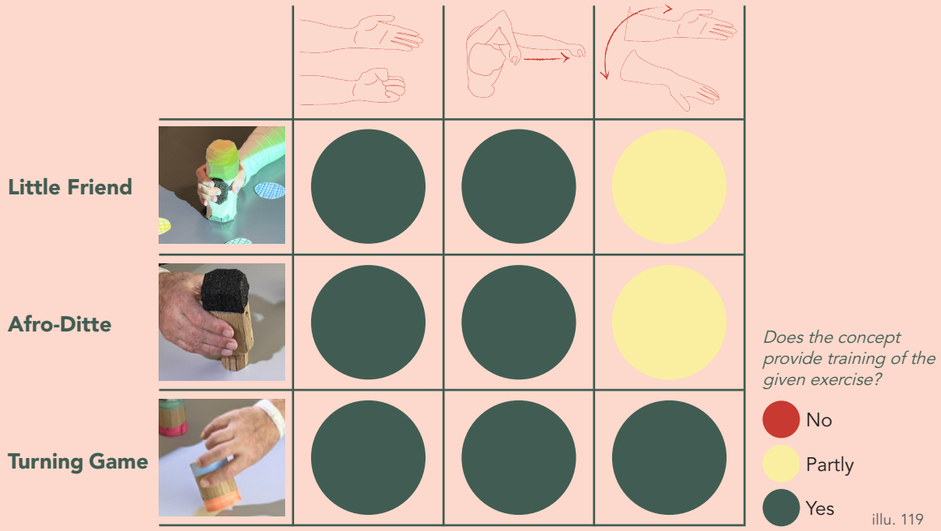
DIFFERENCE IN ABILITIES
In general, we can see that there is a need to embrace broadly, as virtually **every patient is challenged on very different levels.** Therefore, in the future, the team could think in the direction of a multi-game tool, where all 3 concepts could be included. This could also be **seen as a way to level up and accommodates the flexibility** that the occupational therapist and the patient together need, as progress with the patient can happen very quickly - such as the many improvements Henning (patient 1), the main user, has made from week to week (i.e., in the periods in which we have met him).

NUMBER OF 'PRODUCTS'
Different parts could be designed for this 'multi-tool' which can be used in different ways. Therefore, it would be interesting to look at how the number of parts can be minimized and thereby assign them different functions and let them **be included in different levels of the game.**

PROJECTOR
Challenges with the projector: A partially dark room and a visually sharp projector may be required. Perhaps the projector could be challenged or found out if other methods can provide the same result.

MATRIX OF ARMSKILLS

In order to choose between the concepts, a matrix was made [WS 24]. The concepts are evaluated on how well they manage to exercise the **3 identified arm skills.** Though, initially, other skills were included in the matrix such as push force, precision and grasp power adjustment, but in order to specify the concept-direction even further, the team decided to cut to the bone and evaluate on the most relevant exercises, that is required to pour and drink a glass of milk.



illu. 119

EVALUATION: WRIST ROTATION
Little Friend and Afro-Ditte are marked by yellow, as they partly solve the wrist rotation. Compared to the Turning Game, the 'tap on top' of it was not as intuitive as predicted and the Wrist Rotation did only reach 90 degrees, whereas the Turning Game reaches a rotation of 180 degrees.

Little Friend 90° **Afro-Ditte** 90° **Turning Game** 180°

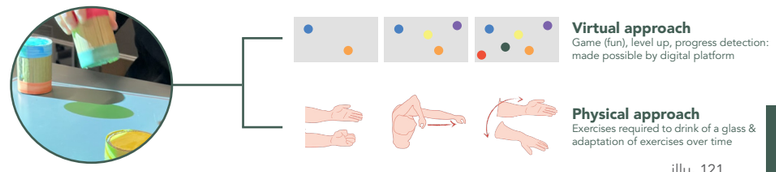
SUM UP: CHOOSING TURNING GAME
The concept with color in top and bottom, the turning game, is chosen to work further with because it is the only concept that manages to do an intuitive rotation of the wrist, which is important in order to reach the main goal being pouring a glass of milk.
With this concept it is also possible to meet the competences of the patient to make the exercise easier or more difficult. The wrist rotation was also seen as the most difficult to do - though in a good way.

CHOICE OF CONCEPT
// reflection on the process

REFLECTION ON ACTION
To narrow down the concept space and get a more specific direction, an urge was felt to be more precise. Based on the matrix [WS24], it was seen that Afro-Ditte solves and allows most exercises to be performed by the patient in every single step of the rehabilitation period. While being overly sympathetic in the desire to address every aspect of the arm patient's recovery, the team found it difficult to be specific, and have worked too much in different directions. Therefore, going back to the beginning, where the three key exercises - grasp/release, reaching, and wrist rotation - were identified, was extremely essential, as presented on the previous page. It was time to converge once more. It is a common tendency that as you get smarter, you feel like tackling more and more problems.

THE TURNING GAME
The Turning Game with the three cursors was the idea that best dealt with the three primary arm skills that the team are working with. There is a need for the Turning Game to meet the arm skills and the patient's abilities. It was found, that in order to level-up, more skills can be added to the virtual-game-task and thereby improve the skills even more.

CONCLUSION
In conclusion, it was seen that there was a chance to **have one product that could interact and perform in various virtual level-ups rather than having multiple products that can do a variety of things.** Breaking down a single product's features in this way makes it easier to incorporate them into different game types and to concentrate on the three arm skills that were chosen. Not those exercises that the team unknowingly invented ourselves during the concept development. **The same cursor can now perform in several games, instead of several products, for several game-purposes.**



TURNING GAME

illu. 121

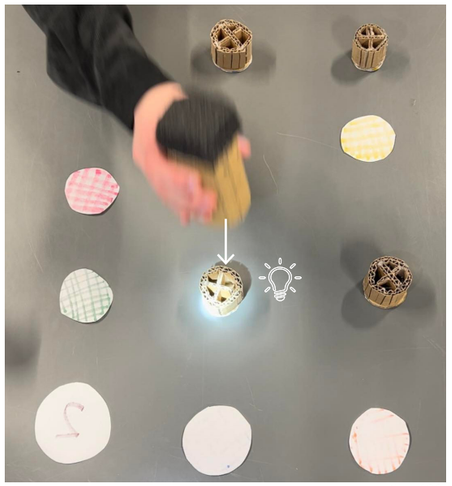
! 3 cursors must be included for level-up

CHALLENGING THE PROJECTOR

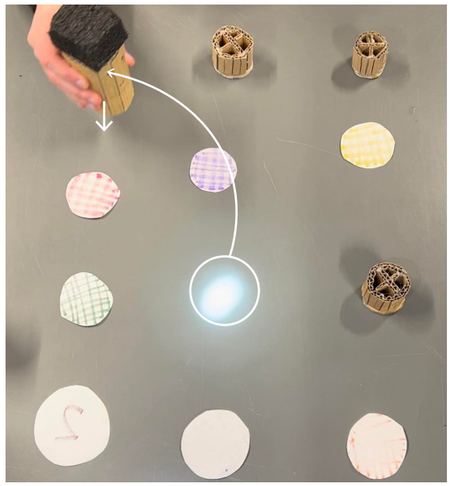
Before the test with the 2 patients, the team was told about a product called 'fit-light' that is a physical light game to train motion. It is needed to understand whether it will be a good idea to use physical elements for the game on the table in front of the patient, rather than using a projector: the team **must be aware of the possible opt-ins and opt-outs** [WS 25]. A test of a physical game has to be tested and pros and cons discussed. The concept stayed the same, but in a different 'costume'.

TEST OF PHYSICAL GAME

The idea with the physical game is to have multiple light devices placed on the table in front of the patient. One device lights up and it has to be moved to the empty spot at the table surface.



illu. 122



illu. 123

PROS & CONS

In order to be able to evaluate, pros and cons are drawn up. The listed inputs are based on the entire scenario and the challenges that may arise in the long term. Furthermore, this is done to create awareness in the design team to understand the parameters and options that may be overlooked or taken for granted.

	PROS	CONS
PROJECTOR	Wide range of exercises/games Settup by the therapists on the iPad Interactive, intelligent product Progress is easier to communicate and detect Easy setup Cheaper add-ons	The colors were not clear enough The projector needs to detect if the task is done correctly or not (concern) Use in daylight vs darkness
PHYSICAL GAME	Used in daylight Physical product Level-up is easy to see No need of colors Easy setup Can be used on the wall Bigger game board	Require light, sensor and battery in all physical elements (high price) A lot of components (e.g 20 lights) Can it be as small as intended? Progress detection: not 'user-friendly' More units to 'break'

illu. 124

SUM UP: 'BICYCLE METAPHOR'-APPROVED

Based on the above list, it can be concluded that the best solution to proceed with is the projector. The projector has the possibilities that the progress is easier to communicate to the patient and it becomes easier to make different games that suit the patients' differences in physical level. **By choosing Turning Game with 3 cursors together with a projector, there will be a visual improvement, a clear step-by-step build-up of skills, and change of appearance after each state. This refers back to the bicycle metaphor.**

illu. 125

WHY NOT MAKE A **MAT?**

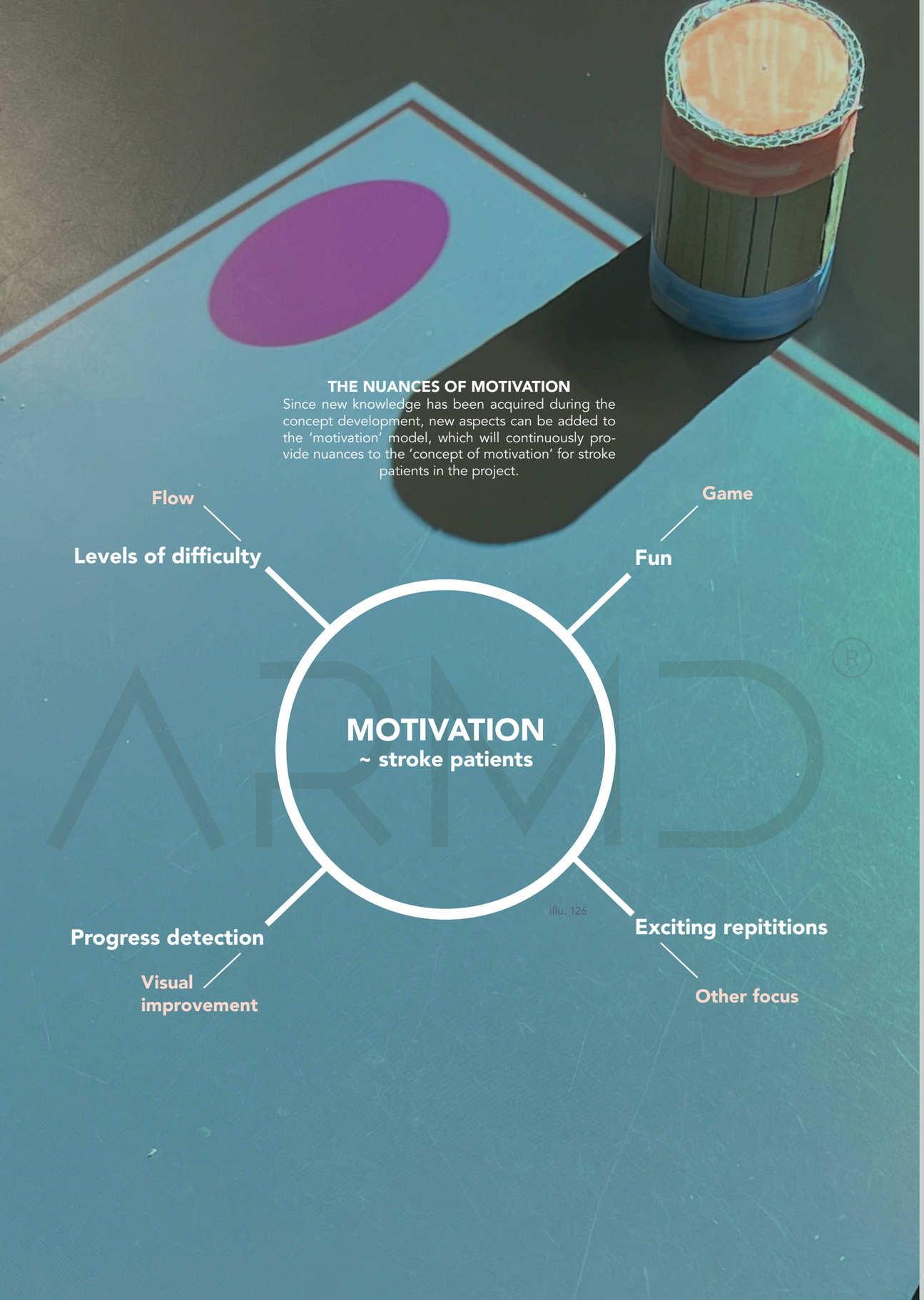
Parallel to investigating the opportunities within projector technology, an other idea emerged. Why not make a mat that can be rolled out, which contains different diodes?
The user interaction might not be intuitive for the age group to use and understand. It will have **limited game potions** and more game options will require the use of a projector which also has greater opportunity for concrete communication. Dragging an object along a mat **will give the user some problems due to friction**. There to, it is **not user-friendly for a one-handed user that has to lay this out** if they use it by themselves when they are no longer hospitalized. It will also take up a lot more **space during transportation.**

WHY NOT MAKE A **BOARD GAME?**

In this project, there is a need for an adjustable setup, as every patient never is at the same physical level. In addition to that, a physical board game will **not be able to 'evolve' or change over time** - the businesscase will not be as strong as a software that can offer several platforms or even more add-ons in the future. The use of a projector can be argued to be future-proof, whereas we nowadays would play games on our phones rather than gathering around a game of Ludo. The projector technology keeps being relevant, allows adjustments, modification and offers way more variations than a board game (update, upgrade, reload). With a board game there would be **no chance for the therapists to follow along** and figure out if the patient is not **doing the task correctly.**

CONCLUSION: **FURTHER DEVELOPMENT**

Once more, the solution area had been explored. There are currently too many concerns and unknowns regarding the variant physical game. The only critical issue with the projection during the test was the colors.
The projector idea will be developed further because it is user-friendly and fascinating. **The possibilities in technology are growing, enabling the team to offer the user more in terms of game variations and progress data accessibility, which is perceived as one way of motivating to the user when doing self-training.**



illu. 126

design brief**2.0**

STATEMENT OF INTENT

How to design a product for self-rehabilitation on the wards, that challenges the arm patients abilities during hospitalization by keeping them motivated through different level-ups and progress detection?

MISSION

Give stroke arm patients more motivational self-rehabilitation so they achieve independence faster.

VISION

To encourage the arm patient to do self-rehabilitation exercises when the therapist is elsewhere, through progress detection and gamified exercises so they forget time and place - they have to move it, to improve it.

> GENERAL REQUIREMENTS	SOURCE	PAGE NO.
> Product must be used in 20 minutes for 17 days	*Timeline // facilities* *Workstations*	*> 21* *> 45*
> Useability with one hand	*Apoplexiafsnit 6Ø*	*> 28*
> Easy to clean: hygiene	*Arm-sessions*	*> 29*
> Price less than 10.000 DKK	*Market*	*> 32*
> Rental price less than 5000 DKK	*Market*	*> 32*
> Credible, professional aesthetics	*Hocoma Casestudy*	*> 33*
> Must be intuitive to patients over the age of 60	*User*	*> 34*
> Nudge the user to do the main exercises > Grasp / Release > Reaching > Wrist Rotation	*The main exercises* *The main exercises // narrowing down*	*> 35* *> 45*
> Increase in independence	*The main exercises*	*> 35*
> Must provide progress detection, repititions & guidance	*Key insights*	*> 30*
> Must be compatible with an iPad	*Evaluation of concepts*	*> 41*
> Must be possible to change in levels	*Evaluation of concepts*	*> 41*
> Balance between Challenge & Skills: Flow	*Game Design Theory*	*> 42*
> Must be a Visual Add-on	*The Bike Metaphor*	*> 43*
> There must be Visual Improvement	*The Bike Metaphor*	*> 43*
> Change shape after each stage	*The Bike Metaphor*	*> 43*
> Must adapt principles from the Whac-a-Mole game	*Nostalgia* *Hocoma Casestudy*	*> 44* *> 33*
> A projector must create the gameboard	*Concept Evolution*	*> 46*
> Game board must be able to be adjusted	*Concept testing w. patients*	*> 47*
> 3 cursors must be included for level-up	*Choice of concept* *Physical disabilities*	*> 49* *> 23*

// PRODUCT
DEVELOPMENT

04

In this phase, the cursors and the projector is being specified through design- and user driven iterations, in order to end up having a design to mature. The design proposals will continuously be tested and evaluated according to the already identified requirements and the project’s ongoing definition of motivation among stroke patients.

METHODS

RESEARCH
Long Throw vs.
Short Throw
projector

DEVELOPMENT
Game levels
Cursor iterations
Projector iterations

TEST
Occupational therapist
Stroke patients
Electronic part
Placement of projector
Throw Distance
Buttons // interaction

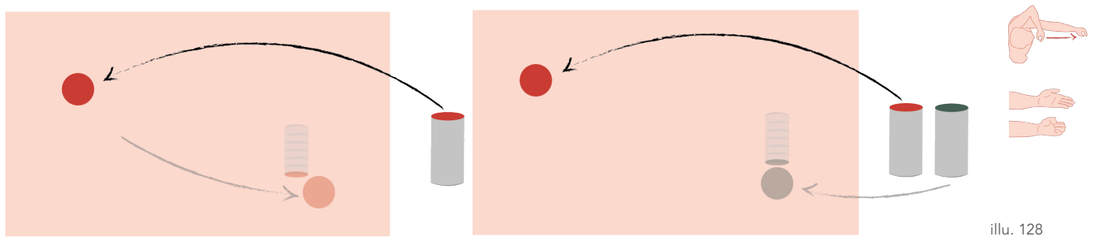
illu. 127

GAME LEVELS

From the concept-test with the two patients, who were at completety different skill-levels, it was clear that there must be focus on less arm skills in the beginning (eg. only 1 type of exercise) and later on there is a potential to add on more arm exercises. Here, there could be more games and, in each game, difficulty that meet the patient at the stage they are in. The understanding of the game needs to be **supported by sounds, to acomondate the patient.** That is why a need emerged to point out the possibilities within the Turning Game, as it earlier became clear that the cursors can 'act' and be used in the same way as Little Friend og Afro-Ditte. This section will present the gamevariations and what exercises the patient perfroms when playing the different levels.

LEVEL 1: GET THE DOT

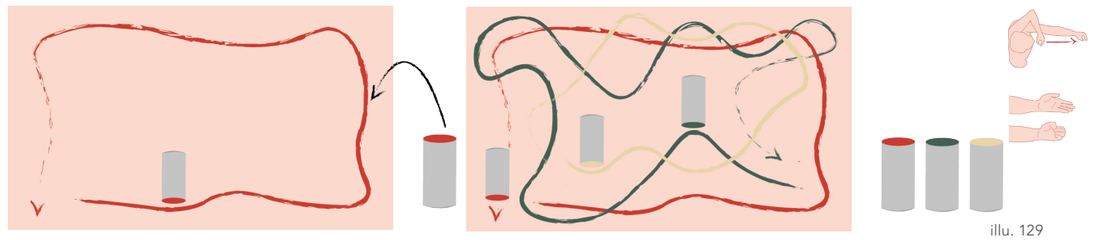
Stage 1 exercises the reach function to meet Patient 2's stage. From stage 1 to 2 an extra cursor and color can be added to be aware of. When there are two cursors to take care of an intuitive grasp and release function is added to the game. In this game it should be possible for Patient 2 to participate with a skill level that is matched with the challenge level to be in **flow.**



illu. 128

LEVEL 2: FOLLOW THE SNAKE

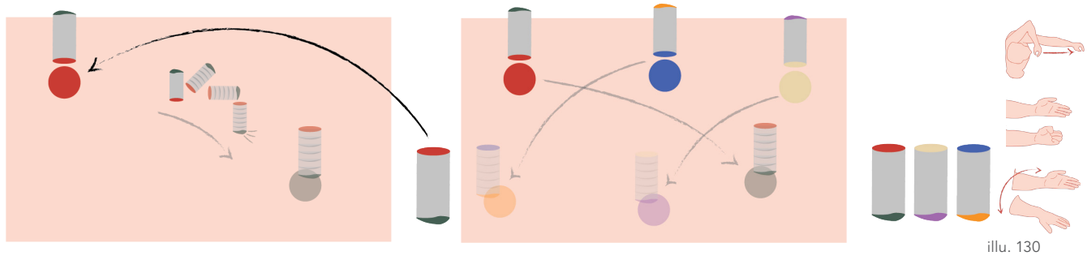
This level uses the same ideas as level 1. In this game the patient has to concentrate even more in order to make the right movement to follow the line from start to finish. It requires precision and control.



illu. 129

LEVEL 3: TURNING GAME

In this game the grasp and release, and wrist rotation function are introduced from stage 1 as from the test with the two patients. In this game, the patient is dealing with 3 arm skills at the same time, requiring a high skill set. In stage 3, the three cursors are added with six colors to be aware of to add complexity to make sure that a patient like patient 1, is in a **flow.**



illu. 130

SUM UP

More levels and games will be relevant to look further into later in the process to accommodate the fun aspect and motivation for a longer period of time. **The interface could be challenged a lot more than what is the platform right now, in order to use the full potential of a projector that can show much more than colored dots.** Next step will be to look into the 3 cursors, that is used to play the presented game, as it is a major participant in the game design and its possibilities. Furthermore, there is a need for 1:1 sound when playing the game.

! Auditory feedback: sound

CURSOR development

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PARALLEL DEVELOPMENT

In parallel with the development of the cursor, the projector is developed and the technology behind it is examined, but for the sake of clarity, the report is divided into the development of the cursor first and then the development of the projector.

PURPOSE

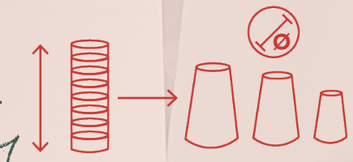
The purpose of the cursor is, that the patient must use it to do the required exercises as it will be the one that interacts with both the gameboard and the user. It does play a huge role in the intended scenario and the quality of the exercises made. The cursor must provide a good grib in terms of ergonomics and provide a whole 'level' in itself - how both of these parameters can be done, will be investigated in the following section.

OVERVIEW

IMPORTANT TO KNOW
For the sake of the reader and overview, a roadmap of the entire development of the cursor is presented here. Through the development of both form and function, the group took some detours along the way, as there was no reflection in action, but instead afterwards on action. It has been chosen to present this detour, as the team uses some of these elements for the final cursor concept, which actually turns out to be key; however, in a different way than first intended. In addition, this testifies that the easy path to the 'right solution' is not always obvious, the correct one and that there is a need to go through a lot of iterations and re-evaluation/adding requirements. The acquired knowledge and exploration of the solution space has also shown that the designer must not opt out of relevant aspects based on fear or level of complexity, that can benefit both the user and the product's core functions.

+ Changing size
+ Visual improvement
+ Change in difficulty
+ Evolve together with the patient
- Price

'EASY WAY'
WS27 - WS39



NOT height that determines the level of difficulty

NO cheating
→ **Electronic core**

!

COST AWARENESS

3→1 mold (cheaper)
DEAD (cheaper)

Stackable Individual

TECHNOLOGY:
Rogignize movements but not understand if the patient cheat.

VALUE:
No cheating offers higher quality in exercises and rehabilitation.

! !

SIZE:
Building in height adds no change in difficulty. It has a higher value to add different Ø sizes than low price.

!

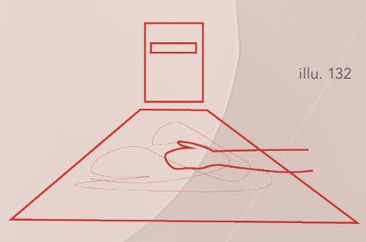
LEGO

+ Easy to understand
+ Fast to build
- Uncontrolable movements

KITCHEN AID

+ Well-known
+ More fixed
- Longer assembly time

PROJECTOR TECHNOLOGY
Laser Intelligent technology
- Infrared scanning & laser scattering to recognize **movement**



illu. 132

SKETCH ROUND
// cursor

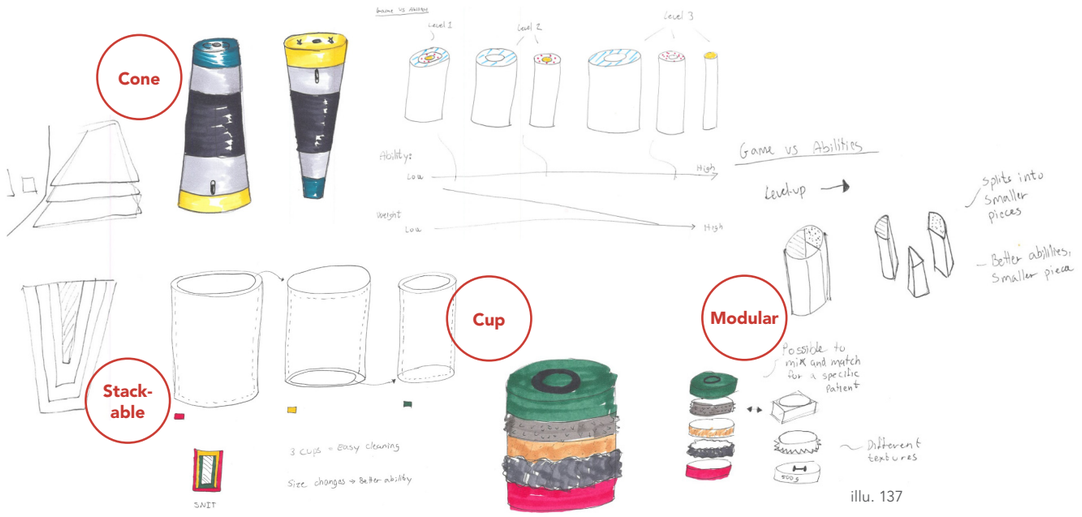
In order to detail and thus apply some form to the chosen Turning-game-concept, a sketch round was initiated focusing exclusively on the cursor itself and **challenging if the 3 parts can be compressed, re-invented or even if they are necessary for the concept**. The cursor is the one the user interacts with the most - that is why it should be intuitive in form and provide proper ergonomics to allow the intended game to be played: grasp/release, reaching and wrist rotation.
When sketching, shapes seen at the hospital and the bike methaphor was kept in mind, focussing on:

illu. 133 **Gradual building up skills**

illu. 134 **Changes shape after each state**

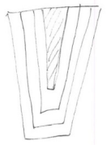
illu. 135 **Visual improvements**

illu. 136 **Visual add-on**



illu. 137

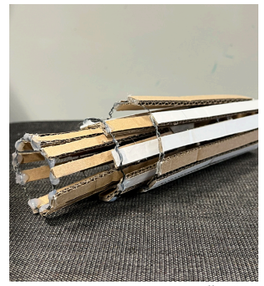
MOCK-UP: BASED ON SKETCHES
To create mockups to test the ideas, several of the concepts were combined (for additionally sketches and mock-ups, see [WS 27]). The notion of a physical development of the product, in which the product changes size as a patient levels up and gains stronger abilities, is interesting. The cursor can "evolve" over time when the patient levels up - both physically and in the game itself. The patient gains visual improvement and physically feels the level-up. The product will follow you over time and evolve together with them, which is a value that will suit the patients very well **due to the nature of their mental state of mind**. The ergonomics of the cone form were to be investigated when combined with the cup concept.



illu. 138

illu. 139

illu. 140



illu. 141

Erognomics | **Changing size** | **Bike Methaphor** | **Visual improvement** | **Change in difficulty** | **Production price**

SUM UP
A product changing shape as the capabilities improve seems to fit most of the user needs and values to fulfill, but concerns about the manufacturing cost arose. The cost of production is a **major issue since three distinct molds must be made, and three different sizes of lids** (for the bottom to hold them together during exercise at first level because they fit into each other) also need their own mold. The price is not insignificant, as the team works with hospitals and the public sector in general. **This is why other principles must be looked into, requiring a new iteration.**


illu. 142


illu. 143


illu. 144

CONCEPT IDEA: FREEDOM IN BUILD & CHEAP
The more skilled you get, the more the therapist can add on or take off (so that you have more cursors). They all come from the same injection mold, which can have a significantly positive impact on the further development process. Is it possible to adapt this marker principle and put it into the cursor design?

MARKER PRINCIPLE
// an alternative to price

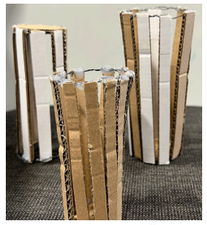
A concern about the production price based on how the three cursors can be fitted into each other, lead to a finding in the principle from a well-known marker, where the top clicks and fits in both ends. In order to lower the production price, this changes the idea of the concept. Can the principles from the markers that the team have just used for the previously presented sketches be adapted?
That is why this section will dive deeper into the principle, and how it can be manifested in the cursors.

BUILDING BRICKS

Since there is a primary worry in terms of production regarding the 3 cursors that fit into each other, many building block types are investigated [WS 28]. With this idea it would be possible to decrease the amount of mold to only one which will make the product cheaper to produce. The team have previously come to the conclusion that every stroke situation is different, therefore more flexibility is provided by opting to design further based on the building block idea. We anticipate that it also amazes and offers additional "a-ha" moments, like in the Bike Metaphor.


illu. 145

vs.


illu. 146

QUALITIES OF FITTING PARTS
With the building block principle, the product can be cheap to produce and still handle harsh treatment. It is important that the part for the cursor fits well to make sure that it will not split into several parts during exercises. We do not want the user to feel like they have to "take care" when using the design proposal. They need the feeling of "nothing is wrong by interacting in the way you do it".
Therefore, different ways to fit/fix parts were looked at [WS 33], that will be presented below; the Lego principle versus the Kitchen Aid principle.

illu. 147

illu. 148

LEGO PRINCIPLE	KITCHEN AID
Easy to understand	Well-known principle
Fast to build	More fixed than LEGO
Uncontrollable movements = the joints might not be strong enough	Longer assembly & disassembly time

SUM UP: 'KITCHEN AID' CHOSEN
The **Kitchen Aid principle is used for further development of the cursor.** It might take slightly more time to assemble and disassemble, but the value of a better fitting is more important than the assembly-time. By using this functional principle, it is also ensured that the patient does not need to take precautions during use. There are specific requirements that **the cursor can withstand being dropped or knocked over**, and when the cursor consists of several parts, these **must not be able to be separated during a game session.**

! The Kitchen Aid principle must be incorporated in the cursors

! Cursors: Must withstand being knocked over or dropped

'DEAD' OR 'ALIVE'?
// electronics in the cursor

If this is to be put in relation to the entire system consisting of 3 cursors, a projector and an interactive platform, it is important to clarify whether it is necessary to have electronics in the cursor. Therefore, the advantages and disadvantages of having a "living" or a "dead" cursor can be established. Clarifying this aspect, require seeing it all as a whole, combining the electronic implementation in the projector with the cursor. So, if the cursor turns out to be 'dead', more components must be implemented inside the projector.

'DEAD'

Must be able to take a lot of "hits" without breaking or not working. After all, we have seen through tests how much they throw around with them

Saves the elderly from a lot of irritation if the technology does not work

Must only deal with one "living product"

Cheaper to produce

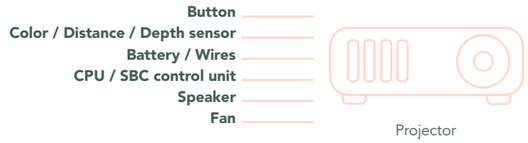
'ALIVE'

Can "go wrong" during initiated play: the technology and components can create challenges or moments of frustration for the patient

By making the solution "alive", the cursor is also made more fragile

More expensive components: the cost price is increased

It becomes more difficult for the user to understand what is happening between the cursor and the projector



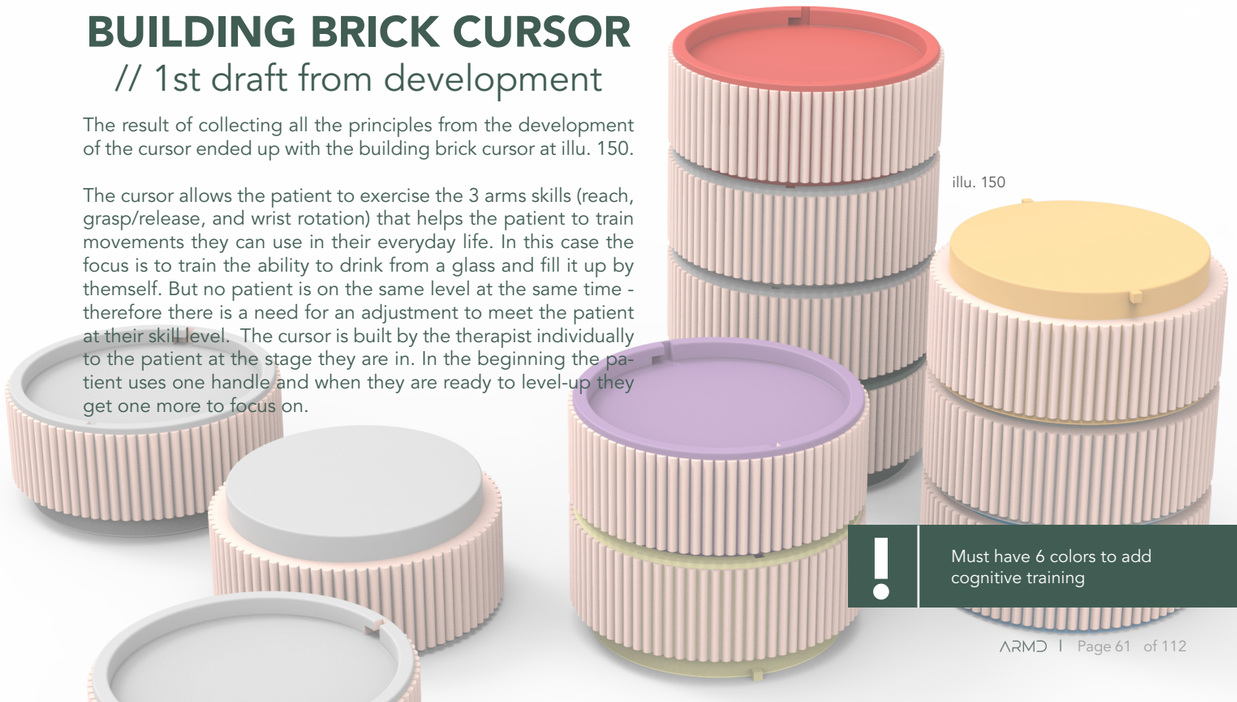
illu. 149

COMPONENT CONSIDERATIONS
Also, an initial understanding of which components must be relevant to integrate if the product is dead or alive was made [WS 31]. Based on that and the pros and cons, it was chosen to **work further with a dead cursor.**

BUILDING BRICK CURSOR
// 1st draft from development

The result of collecting all the principles from the development of the cursor ended up with the building brick cursor at illu. 150.

The cursor allows the patient to exercise the 3 arms skills (reach, grasp/release, and wrist rotation) that helps the patient to train movements they can use in their everyday life. In this case the focus is to train the ability to drink from a glass and fill it up by themself. But no patient is on the same level at the same time - therefore there is a need for an adjustment to meet the patient at their skill level. The cursor is built by the therapist individually to the patient at the stage they are in. In the beginning the patient uses one handle and when they are ready to level-up they get one more to focus on.


illu. 150

! Must have 6 colors to add cognitive training

ONE STEP BACK

// reflecting **ON** action

The projector technology was also researched while the cursor was being developed, and making use of already existing technology was a top priority. Therefore, the idea was to apply laser intelligent technology, which identifies motions using infrared scanning and laser scattering [WS 34].
Though, this section challenges all the discoveries that has previously been made, reflecting **on** action.

CRITICAL, UNCOVERED USER INSIGHT: HANDLING FAILURE OR CHEATING

However, there is a concern that has not been addressed: the patient's ability to intentionally or unintentionally cheat or be exposed to failure.
The laser intelligent technology can detect movement and touch on the surface. However, in theory, you can use any object to reach the target, so you can not be sure that the patient is not cheating to make it easier to reach, and it doesn't know whether the cursor is pointed in the right direction. The idea behind it was that any movement was positive, but the cheating element can not be ignored. These patients does not necessarily cheat on purpose, they do what they think are right, but they might forget how to do it and make their own rules.

RE-VISITING 'DEAD' OR 'ALIVE'

Looking back at the advantages and disadvantages of using electronics inside the handle versus not, it is obvious that the team were quite biased due to the fear of doing so. **For the concept, doing the task right offers much more value to the product and the patient than the awareness of unit price.**

EPIPHANY IN SIZE OF CURSOR

Another main thing that the team overlooked when using the building block system was, that it is not the change in height that is important, **it is the change in size of diameter that makes the difference in difficulty when having a game-session**. This realization came clear when the 'Building Brick' was 3D printed for testing purposes. To balance and place a thin obejct is much more difficult than handling a think obejct with a big surface.
On the basis of it, it was necessary to step back and reconsider the cursor concept in terms of sizing.

! Cursors must differentiate in diameter of top/bottom

! The cursor must include electronic components

CURSOR SIZE

Although it was previously chosen not to have electronics inside the cursors, it was clear that this would become a necessity in order to make the product and its vision work as intended. In addition, the team has become aware of a decisive factor, namely that **it is not actually the height of the cursor that determines the degree of difficulty - it is the diameter of the 3 cursors.** This means that the 'easiest' requires a larger diameter than the 'hardest'. For this reason, different diameters are set up and the size is estimated [WS 39].

RE-INTRODUCING AN 'OLD' SHAPE

All the items were felt and reviewed. Here, 3 different items were found, each of which would be ideal according to the 3 different levelups. It was chosen that they should all have the same height, as the diameter is now the decisive factor. A new concept for the cursor has been chosen. A shape from former investigation have been brought back to life, that is slightly more ergonomic than the straight cylindrical cursors. For each cursor, the diameter will vary in both top and bottom, adding even more 'visual level up' and the ability/possibility to level up physically.

S: Ø3 - Ø4
M: Ø5 - Ø6
L: Ø7 - Ø8
All has H: 10 cm illu. 151

illu. 152

ELECTRONIC PART

// incorporation

When having electronics inside the cursor, it still needs to fulfil the requirement of hygiene. Therefore, the courses consist of two parts: the electronic part that should be identical for the three different-sized cursor shells. The size of the electronic part is restricted by the size of the smallest cursor. In this section, new knowledge about the cursor sizes will determine the size of the electronic part while keeping identified requirements in mind [WS 47].


illu. 153


illu. 154


illu. 155


illu. 156

BENEFITS

When the electronic part is identical it allows more freedom for further development of the cursor shell, that can be made in a lot of shapes. To that it will help to lower the production price and the complexity while making identical electronic cores when the cursors need to be of different diameters. It creates more opportunities to expand the business and sell more, together with the modularity and flexibility. Different ways of connecting the two parts were sketched upon.

CONCLUSION

The conclusion of that is to use the **kitchen Aid principle** where there is a pin at the electronic part and a track inside the shell that the pin fits into. In the electronic part there is space for the fingers to do the rotation. To do the rotation you need to hold the shell with one hand and use the fingers to rotate the inner part with the other hand. The idea was 3D printed and it worked as intended (illu. 154-156). Furthermore, **the 'shell' can be put in the dishwasher.**

! Must be able to be cleaned: Alcohol, soap, chlorine & water

Gradual building up skills

Changes shape after each level

Visual improvements

Visual add-on

SIZE: **large**
For patients at level 1

Ø top: 7 cm
Ø bottom: 8 cm
H: 10 cm

SIZE: **small**
For patients at level 3

Ø top: 3 cm
Ø bottom: 4 cm
H: 10 cm

SIZE: **medium**
For patients at level 2

Ø top: 5 cm
Ø bottom: 6 cm
H: 10 cm

‘TURNAROUND’

// 2nd iteration outcome

illu. 157

Size L

Size M

Size S

COLORS OF CURSORS

The tests indicated that it was challenging to distinguish between the colors, particularly red, orange and yellow but also blue and purple. It was debated if using patterns or numbers would help to differentiate. Here, the electronic part is really helpful. With this integrated, there is a ring at the bottom and a full colordot at the top. As a result, it was feasible to choose colors for the top and bottom to make them simpler to identify from one another. The combinations are shown for all sizes to the left.

PROJECTOR development

illu. 158

PARALLEL DEVELOPMENT

As previously mentioned, the projector and the cursor are developed in a parallel track. Variants of the projector that belong to previous iterations of the cursor will therefore be presented and reflected upon. This is done as these iterations have important and directional insights for the final design proposal.

PURPOSE

The purpose of the projector is to enable the virtual gameboard; it opens up the interactive platform that makes it **possible to explore and include motivational factors such as progress detection, levels and game theory.**

SHORT THROW VS LONG THROW
// projector

During the tests the team were using a long throw projector which means that the projector has to be in a high position in a long distance for the table. In this section, the abilities within projectors are investigated, in order to clarify and specify what type the projector must be to meet the concept. Tests have been performed with a long throw projector.

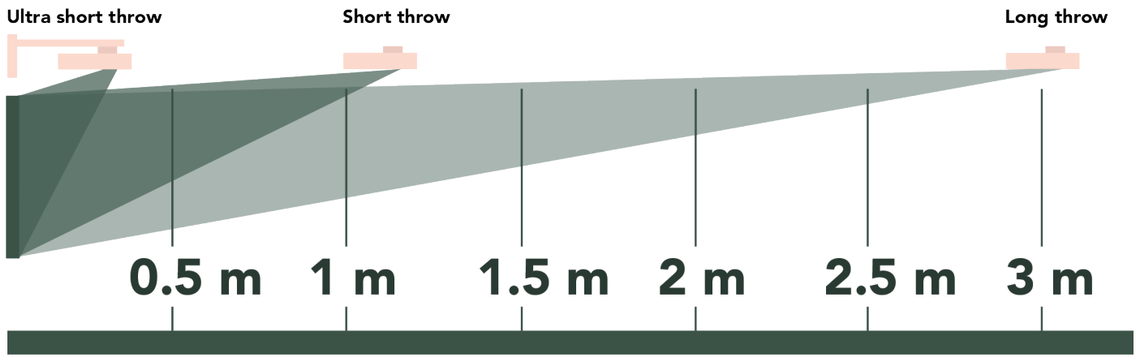
3 VARIANTS
The team have been looking at different possibilities for the projector. Three different types of projectors appear, each having its individual way of projecting an image:

1. Ultra-short-throw projector
2. Short-throw projector
3. Long-throw projector

DIFFERENT SET-UP SCENARIOS
Long Throw:
A possibility would be to use a long-throw projector placed in the loft above the patient and throw it down to the table. Though, this will make the solution very stationary and not give the patient the option to bring it along to therapy sessions at the hospital or to bring it home in a period. Therefore, other solutions were looked into.

Ultra Short Throw:
An ultra short throw projector can be placed at the table in front of you and still project to the table. Applying this type of projector, makes the concept transportable.
(Formovie, 2022)

CHOSEN VARIANT
An ultra short throw projector is chosen to use for the concept. When using an ultra short throw projector, the patient does not have to adjust on lens to fit the size of the screen or table surface. Furthermore, the projector can be placed in front of the patient or on the side. If the projector is moved on the table, the projected screen will still be the same size no matter what. This makes it easier for the patient to interact with it, and it can easily be decoded whether the projector is placed correctly or not.



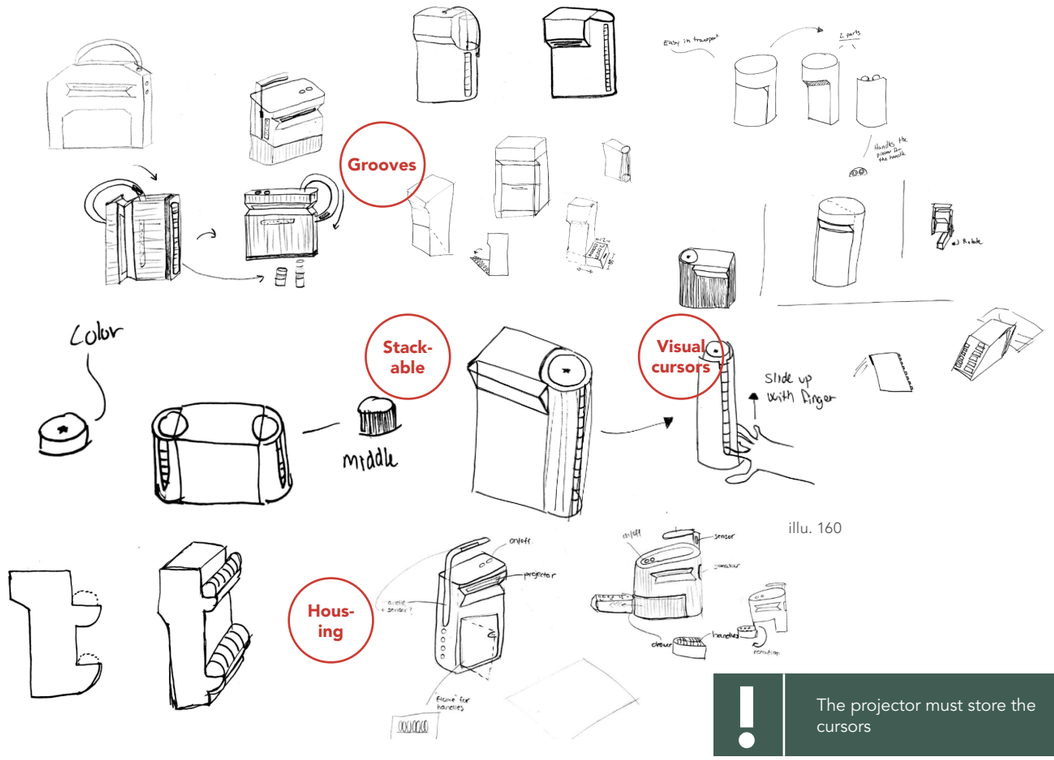
illu. 159

The projector must be Ultra Short Throw

PROJECTOR SKETCHES
// to fit the 'building brick' cursor

With an initiating product proposal for the cursor (p. 61), the focus can now be directed to the corresponding part: the projector and the "intelligence" itself. In order to understand what is possible within this area, research is first carried out in the area for links to different projectors using this technology [WS 34]. With knowledge about the abilities within interactive projectors that project to the table, it is now known that there is no need to get the projector up high, or tilt at a large angle. It is also possible to create a projected image on a table surface that is not distorted as in our previous tests.

SKETCHES
A sketch round is then initiated, brainstorming dimensions, functions and aesthetic expression of this part of the design. The main focus for designing the projector is the integration of the parts for the cursor concept.



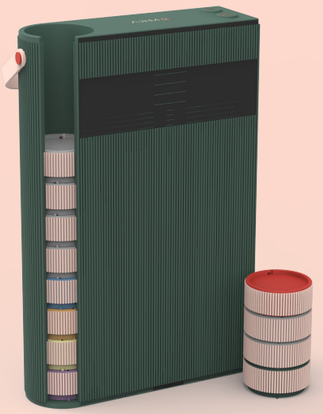
illu. 160

The projector must store the cursors

CONCLUSION
The drawings highlighted the importance of making the cursors visible and **incorporating them into the projector's design. The bike metaphor, which claims that a "visual level-up" and "visual improvement" are required, supports this.** The patient can track their level by keeping an eye on the cursors on the sides. As a result, the idea for Milestone 3 was proposed.

CONCEPT IDEA
// presented at Milestone

The size of the designed projector is based on the size of current technologies, but further research is necessary to make sure that the components fits inside the shell. Although the colors may **appear childish**, the patients are still maintaining their dignity based on the products that are currently in use and exist. **Colors are a good way for the patient to understand the product** because it is something they have used their entire lives, and there is a need for simplicity to understand the product. Though, the choice of color have to be reassessed.
Additionally, the team are dealing with the issue of: We are teaching them how to move their hand and use arm-functions again, which they gained as children. To accomondate this, another iteration is needed.



illu. 161

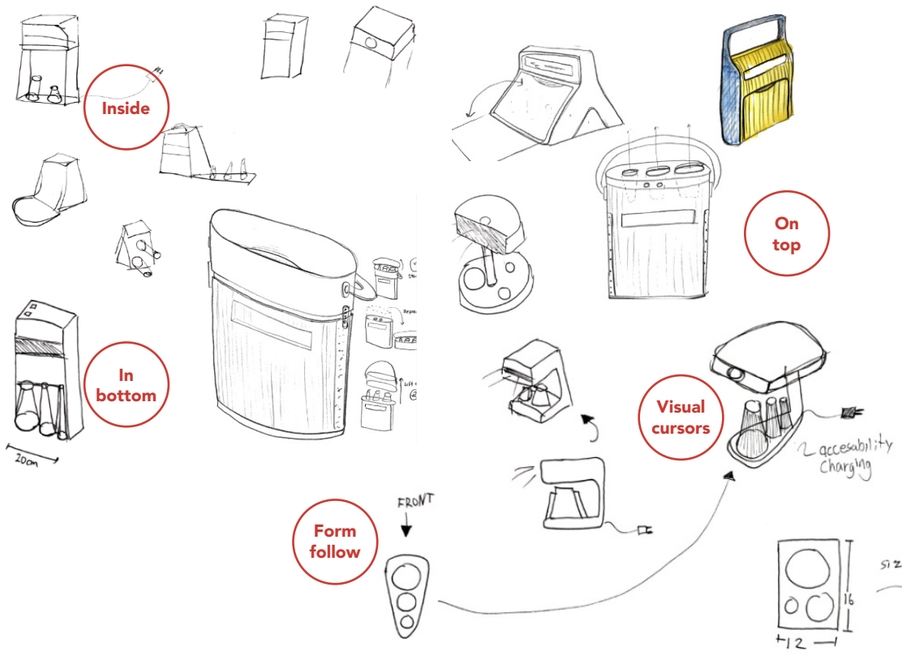
illu. 162

PROJECTOR SKETCHES
// to fit the 'Turnaround' cursor

Since the cursor has changed since the previous projector concept, an additional iteration of the projector concept is required [WS 48].
Because the projector is a system and none of the components should be utilized independently, the cursors must be an integrated element of the device. This is why it is crucial to create a projector with integrated cursors that are simple for users to understand. In order to ensure that users cannot cheat, it has been discovered that cursors must have electronics within. This means that when the cursors are in the "waiting" position, they must be charged. This section investigates the design of the projector, based on the new findings.

SYSTEM DESIGN: WHERE TO STORE THE CURSORS?

Inspiration from Tjalves system design was used to look at where the cursors could be placed/ stored: At the side, under, inside, behind, under a lid, and on the top in combination with different arrangements of the cursor placement.



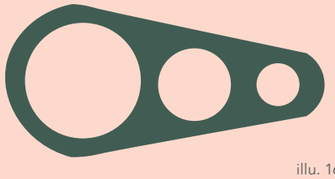
illu. 163

illu. 164

illu. 165

MOCK UP MODEL: STORAGE ON TOP

It was discovered that the optimum approach to integrate the cursors is to arrange them at the top with the bottom up. They are simple to lift up and then place back in their proper positions. The form is based on the cursor sizes shown in the figure.



illu. 166

CONCLUSION

This resulted in a projector with the cursors integrated. When the cursors are in the projector, they should be charged. The cursors' top view is used to create the shape of the projector. The projectors currently on the market served as the basis for the size and height.

> The projector must charge the cursors

PLACEMENT
// of the projector

With a final projector-concept, more detailed aspects can be looked into. This section will investigate the shadow that occurs during use and the placement of the projector on the table [WS 44].

OVERALL PLACEMENT: LEFT, RIGHT OR IN FRONT?

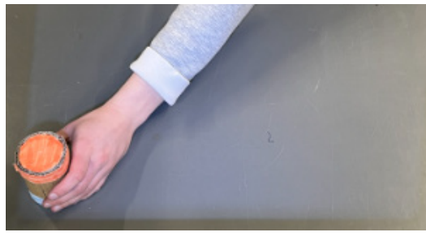
A test was set up, investigating shadows and the ability to reach the projector, in order to determine where the projector must be placed on the table. It is concluded that the **projector should stand in front of the patient** when working with arm patients since it doesn't matter if the patient has paresis in their left (illu. 169) or right arm (illu. 167-168). Additionally, it is the most intuitive location for the projector, as the patient easily can access it to turn it on. In this location, **shadows have less of an impact on the game**.

SHADOWS

The patient may be prompted to pull back their arm or release around the cursor by the projector's continued creation of shadows, which adds a value and may cause them to take more action than they are aware of, meaning that the shadow has a quality. The test may contain a few slight mistakes due to the projector's long throw, rather than ultra-short throw, but it depicts how shadows appear.

illu. 167

illu. 168



illu. 169

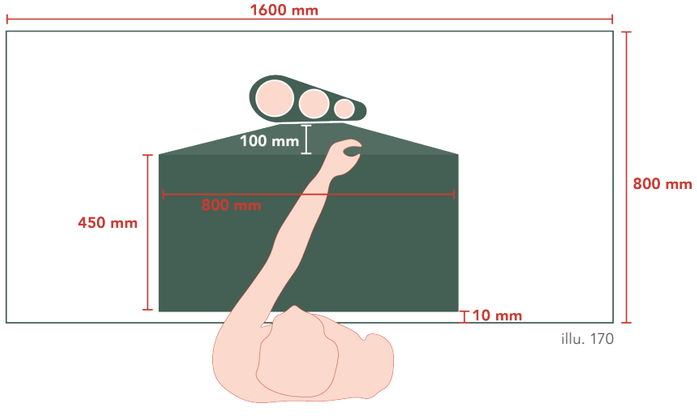
> The projector must stand in front of the user

THROW DISTANCE
// from projetor to the user

Since it has been decided that the projector must be placed in front of the user, the Throw Distance gets connected to the user's ability to reach out and turn it on/off. Therefore, the Throw Distance and gameboard size must be investigated and specified. In this test, requirements for the projector's Throw Distance and screen size can be deduced related to the user's abilities [WS 44].

TEST OUTCOME

The cardboard model has been used to test the distance at various distances. Measuring from the top of the gameboard, 100 mm proved to be the most comfortable distance. In this configuration, the gameboard is 10 mm from the bottom edge of the table. The projector will be positioned 560 mm away from the patient as a result. When setting up the projector, the table must have a minimum depth of 650 mm. This is relevant since the majority of desks and worktables have a depth of 800 mm.



illu. 170

> Screen must be 36"

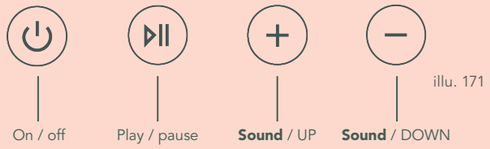
> The projector must stand 560 mm from the user

> The Throw Distance must be 100 mm

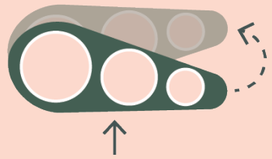
BUTTONS

OPPORTUNITIES
The location of the buttons was also looked into in addition to the projector's arrangement [WS 45]. The play/pause button and the on/off button are the two main interfaces, however if a patient is playing in their ward when others are there or if their hearing is poor, they can also adjust the volume. The test revealed, that if the buttons were on the front, pressing them might cause the projector to move.

NON-SLIP
It was discovered that the projectors in use already had non-slip bottoms, and that will be used for this concept as well as a way to prevent this interaction response from happening. Due to the patient's awareness, it was chosen that the buttons should be close to one another, incorporating a 'interaction-bar'. It will be simpler for them to interact with when they can just focus on one part of the projector at a time, as they can struggle with concentrating and maintaining focus.



illu. 171



illu. 172

Enable start / pause

Non-slip material must be incorporated on the bottom

FEEDBACK
// progress detection

The very focal point and frame of this project is that the patient requires feedback and tracking of progression to stay motivated during rehabilitation. First, feedback on progress detection was investigated related to time versus repetitions [WS 43], and then Pernille, an occupational therapist, evaluated it in order to specify the needs.

PATIENT FEEDBACK
The patients need feedback during the game as well, but this is focusing on the feedback that will be shown on the gameboard after finishing a game, what can be called progress detection.

For the patient, repetition is the key to tracking improvement. Time was discovered to be irrelevant to these users. The patient's perception of success is dictated by the therapist if the therapist decides in advance the number of repetitions (this might be, for example, 1 repetition more, or 20 repetitions more than last training session). In this approach, the therapist may regulate the success and progress rates, and the patient only makes progress that isn't necessarily "felt".

The therapist can ensure that the **patient only receives motivating feedback** and, as a result, **nudge discreetly**. Giving them a carrot makes it a successful experience. According to the Therapist, the patient needs feedback on how many dots they hit and how well they hit them, which will be compared to previous workouts and ranked from 1st to 3rd depending on the patient's own competition.

illu. 173

THERAPIST FEEDBACK
The therapist creates the patient's workouts via an app and then receives more thorough feedback on the patient's development. Different factors might be important for them to track, according to Pernille, the occupational therapist.

Steering, reach area, and placement precision are important factors. **The hand shaking, the patient's ability to regulate how much power they use** when hitting the dot, whether the cursor is **precisely put or tilted at the edge before being positioned correctly,** and if the **steering is controlled or really harsh and uncontrollable** are additional elements that affect steering.

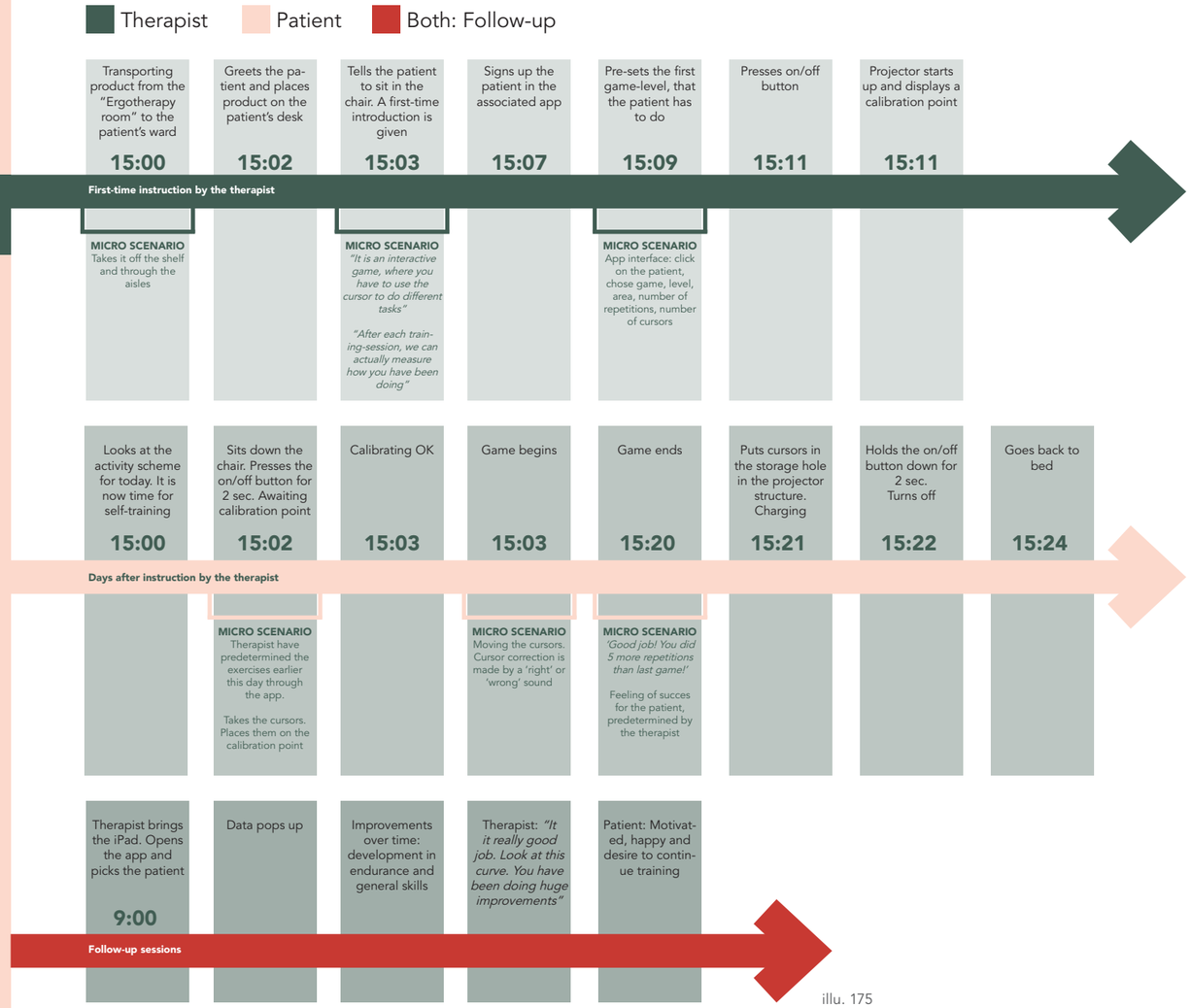
By incorporating an app into the virtual aspect of the concept, utilizes the possibilities within the technology and provides concrete data of the progress. This accommodates the therapist and the user, as the progress will be presented in a more tangible way, which previously have been identified as being a huge need.

illu. 174

WRITTEN SCENARIO
// patient & therapist

In order to clarify, map and understand how the product proposal is intended to be used, a written scenario is made. This includes usage patterns from previous tests. This is necessary in order to break down the entire usage situation and become sharp on the shortcomings that may exist within interaction, user experience and construction. In addition to that, the scenario is made to bring the design proposal and the users to life in this specific context [Van Boeijen, 2013]. The scenario will be temporary.

The scenario when using the product proposal can be divided into 2 actors; the patient, who has to do self-traning and the therapist, who handles the data and helps the patient set up.



illu. 175

CONCLUSION: FURTHER WORK BASED ON SCENARIO
It was a good tool to communicate with each other in the team and to understand the missing links.
Though, it shows, that the team **must unfold and make the interactive platform** more specified and nuanced in 'what can go wrong' when playing the game. Clarifying this aspect, will contribute to the user experience as the physical parts of the design proposal are coming along. Furthermore, aspects of **transport must be investigated.**

// 2nd projector-iteration outcome

Preseted, tested and validated by patients and therapists at Neuroenhed Nord

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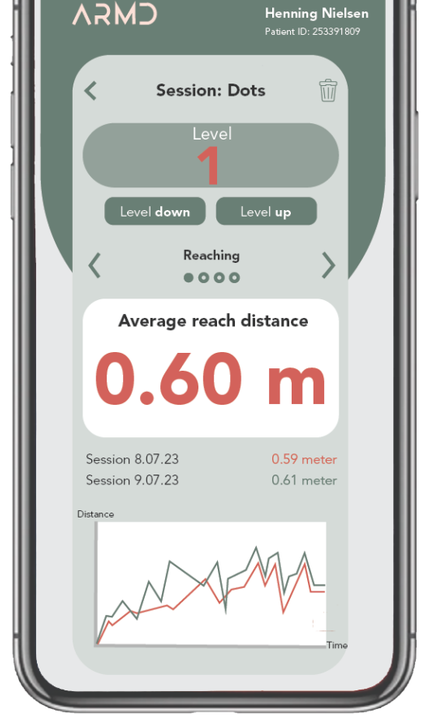

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ARMD

Regain

The conclusion of the product development is ARMD, consisting of an ultra-short throw projector device and 3 different sized cursors. With ARMD the motivational and funny aspect known from the Armeo Spring (p. 33) is downscaled to make the patient able to gain the same experience

– ***alone!***

The size of this design is
L x D x H: *23 x 11 x 32 cm*

VISION

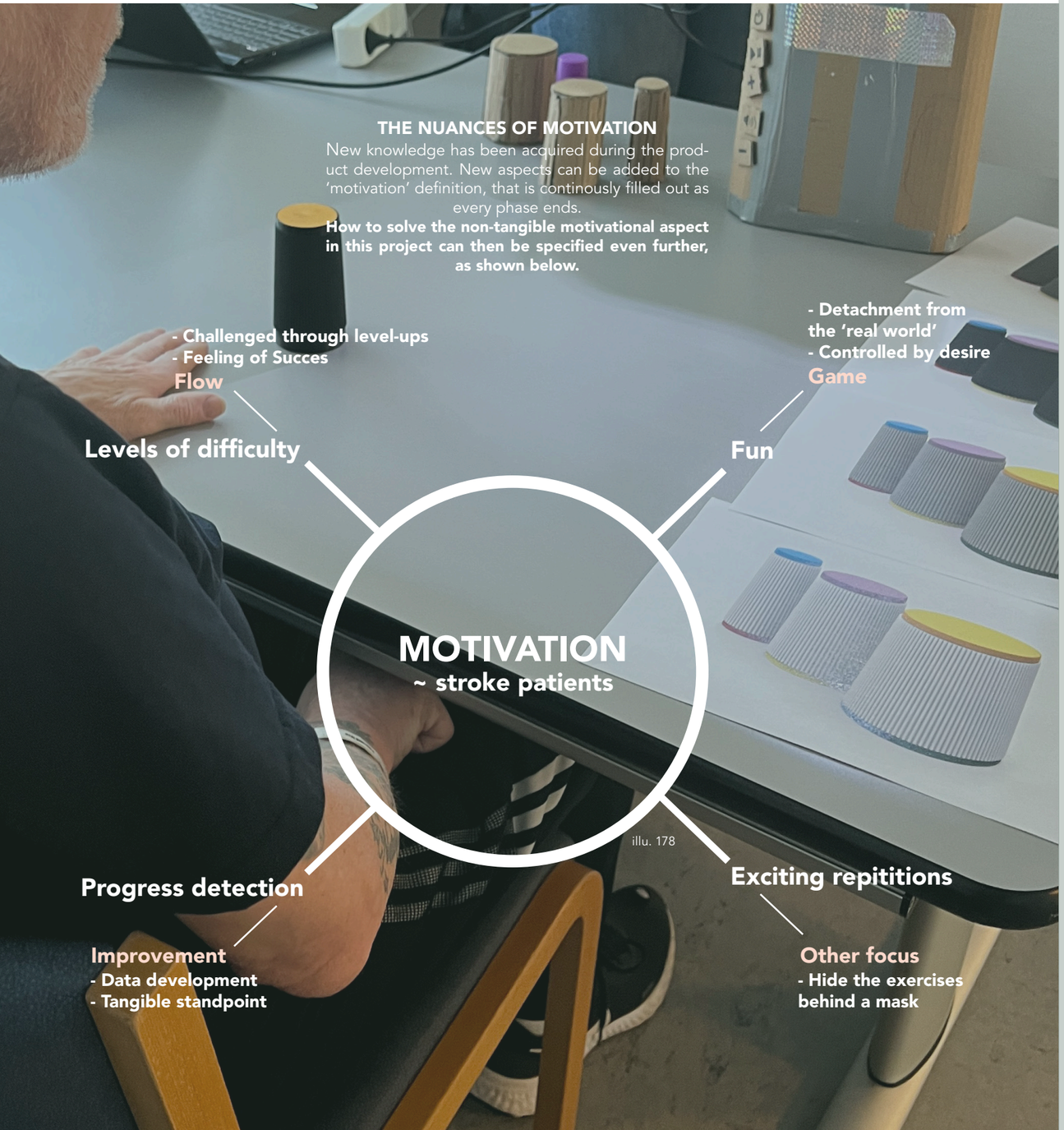
To encourage the arm patient to do self-rehabilitation exercises when the therapist is elsewhere, through progress detection and gamified exercises so they forget time and place - they have to move it, to improve it.

MISSION

Give stroke arm patients more motivational self-rehabilitation so they achieve independence faster.

STATEMENT OF INTENT

How to design a product for self-rehabilitation on the wards, that challenges the arm patients abilities during hospitalization by keeping them motivated through different level-ups and progress detection?



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design brief 3.0

> GENERAL REQUIREMENTS	SOURCE	PAGE NO.
> Price less than 10.000 DKK	*Market*	*> 32*
> Rental price less than 5000 DKK	*Market*	*> 32*
> Product must be used in 20 minutes for 17 days	*Timeline // facilities* *Workstations*	*> 21* *> 45*
> Must be intuitive to patients over the age of 60	*User*	*> 34*
> Nudge the user to do the main exercises > Grasp / Release > Reaching > Wrist Rotation	*The main exercises* *The main exercises // narrowing down*	*> 35* *> 45*
> Increase in independence	*The main exercises*	*> 35*
> Balance between Challenge & Skills: Flow	*Game Design Theory*	*> 42*
> Must provide Progress Detection	*Key insights*	*> 30*
> Professional aesthetics	*Hocoma Casestudy*	*> 33*

> CURSORS	SOURCE	PAGE NO.
> 3 cursors must be included for level-up	*Choice of concept* *Physical disabilities*	*> 49* *> 23*
> Useability with one hand	*Apoplexiafsnit 6Ø*	*> 28*
> Kitchen Aid principle must be incorporated	*Building Bricks*	*> 60*
> Must withstand being knocked over or dropped	*Building Bricks*	*> 60*
> Must have 6 colors to add cognitive training	*Building Brick Cursor*	*> 61*
> Must differentiate in Ø top / bottom > **S:** Ø top = 3 cm Ø bottom: 4 cm > **M:** Ø top = 5 cm Ø bottom: 6 cm > **L:** Ø top = 7 cm Ø bottom: 8 cm > All H: 10 cm	*One step back* *The Bike Metaphor*	*> 62* *> 43*
> Must include electronic components	*One step back*	*> 62*
> Must be able to be cleaned: Alcohol, soap, chlorine & water	*Electronic part* *Arm session*	*> 63* *> 29*

> PROJECTOR	SOURCE	PAGE NO.
> A projector must create the gameboard	*Concept Evolution*	*> 46*
> Auditoory feedback: sound	*Game levels* *Key insights*	*> 56* *> 30*
> Must be an Ultra Short Throw projector	*Short throw vs. long throw*	*> 66*
> Must store the cursors	*Projector sketches 1.0*	*> 67*
> Must charge the cursors	*Projector sketches 2.0*	*> 68*
> Must stand in front of the user > 560 mm from the user	*Placement* *Throw Distance*	*> 69* *> 69*
> Throw distance must be 100 mm	*Throw Distance*	*> 69*
> Non-slip material on the bottom	*Buttons*	*> 70*
> Enable start / pause	*Buttons*	*> 70*

> GAME PLATFORM	SOURCE	PAGE NO.
> Must adapt principles from the Whac-a-Mole game	*Nostalgia* *Hocoma Casestudy*	*> 44* *> 33*
> Game board must be able to be adjusted: 36"	*Concept testing w. patients*	*> 47*
> Must be compatible with an iPad	*Evaluation of concepts*	*> 41*
> Must be possible to change in levels	*Evaluation of concepts*	*> 41*

// MATURATION

05

The maturation phase will be divided into different parts: Business, Materials, production & construction and finally the detailing of ARMD. The phase will be based on tightening up all the loose ends, which is done through tests, more development and finally through product specifications. Furthermore, the interface will be unfolded and worked with to develop a use case.

METHODS

RESEARCH
Materials
Accelerometer
Game possibilities
Wireless charging

DEVELOPMENT
Interface
Transport bag
Construction
Business model
Budgetting

TEST
Shimmer
Final game interface

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MARKET SIZE & TIMELINE

It is essential to understand how many products that potentially will be sold first in Denmark and later in other countries to understand the size of the market.

YEAR 1:
PRODUCT MATURATION

The first year will be focused on product maturation (e.g design project with Epson, certificates and prototypes), the creation of sales channels (talk to government and hospitals) and a market strategy (marketing, creating awareness). Furthermore, control groups would be established in order to prove the relevance and functionality of the product.

YEAR 2:
DENMARK

The first sales year will be focused on Danish hospitals that have an occupational unit or apoplexy unit; these facilities are listed in WS 29. Based on the size of Neuroenhed Nord in Frederikshavn, it is predicted that **100 units** might be sold for the 31 hospitals in Denmark that have these units. They would purchase 5-7 in Frederikshavn, according to Rikke Brorholt, the head nurse at Neuroenhed Nord in Frederikshavn.

The focus is on hospitals and rehabilitation facilities since this is where patients frequently spend their initial few months and because this is when the brain is most flexible. However, ARMD will be useful after the patient is discharged, so it could be sold to private and public residences and rehabilitation facilities. This implies that ARMD can be sold to occupational and physical therapists as well as other departments that specialize in brain injuries. Within the first sales year, **200 units** could potentially be sold in these regions.

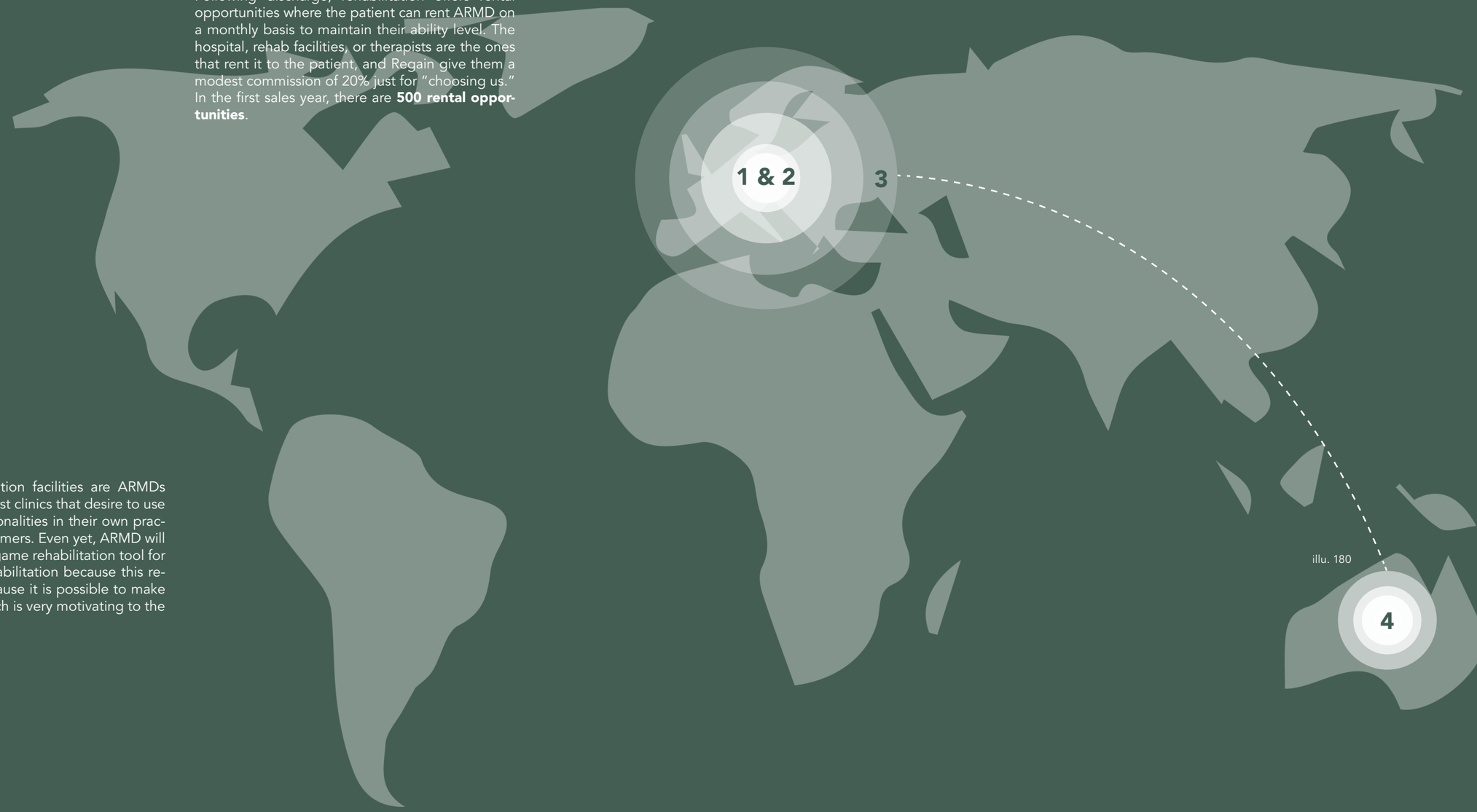
Following discharge, rehabilitation offers rental opportunities where the patient can rent ARMD on a monthly basis to maintain their ability level. The hospital, rehab facilities, or therapists are the ones that rent it to the patient, and Regain give them a modest commission of 20% just for "choosing us." In the first sales year, there are **500 rental opportunities**.

YEAR 3:
FURTHER MARKET EXPANSION - EUROPE

The number of stroke incidents across Europe each year is 1.1 million, compared to 12.000 in Denmark. To further develop the business, sales channels might be established for hospitals and private clinics throughout Europe.

YEAR 4:
FURTHER MARKET EXPANSION - AUSTRALIA

Furthermore, it is known that Australia may have an important market, where there is much dialogue about "evidence-based learning" in the occupational therapy profession and where it is challenging for therapists to physically visit patients who live on ranches and in remote areas. As a result, there are a lot of consultations taking place on platforms like MS Teams and Zoom. Specifically with this configuration, ARMD might be readily added. Australia has a 40.000 yearly incidence rate and an even bigger potential for house rehabilitation compared to Denmark.



illu. 180

CUSTOMERS

Hospitals and rehabilitation facilities are ARMDs main customers. Therapist clinics that desire to use the exercises and functionalities in their own practices could be new customers. Even yet, ARMD will be promoted as a gym-game rehabilitation tool for the initial phases of rehabilitation because this remains the goal and because it is possible to make significant changes, which is very motivating to the patient.

MARKET ENTRANCE

// in the danish healthcare system

Firstly, when entering the Danish healthcare system it is important to have an idea of how that could be done. The business plan was reflected on and developed in sparring with 'Idé-klinikken' at Aalborg Universitetshospital. A department that deals with the development and implementation of innovative products for the healthcare system on a daily basis. Therefore, they were able to provide relevant knowledge about buyers, the government's procurement structure and ideas for the specific plan [WS 35].
The healthcare sector is a bit complex to enter because there is a difference in entering the reginal department and municipal departments. That is why these departments will be looked into.

Sparring with Idéklinikken
Aalborg Universitetsshospital

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THE REGIONAL DEPARMENT

Are the hospitals and the rehabilitation facilities in the special sector. The special sector includes rehabilitation facilities such as Frederikshavn, Brønderslev, Thisted and Hammel. These are departments that would be able to purchase ARMD themselves if they have the money to do so. Places like these often get money from foundations for new equipment. In general, the regional coffers are larger than the municipal ones.

illu. 182

THE MUNICIPAL DEPARMENT

Municipally owned nursing homes and institutions that specialize in brain injury. Taking a view back, this department includes stage 3 and 4 presented on the timeline on page 20-21.

THE CONFLICT & HOW TO SOLVE IT

The **conflict happens when the patient goes from the regional department to the municipal department**. This will be where the renting is taking place and will be done through municipal funds or insurance for a period.
When the patient is discharged from the regional services (hospitals), they must not take the hospital's belongings with them. In this phase, the patient transfers from the regional management to the municipal management, and if they wish to use the ARMD after discharge, this must be borrowed through the municipality.
As a company, Regain will therefore have to sell to both the regional authorities and to municipal authorities. Another aspect is the private sector which is an additional sales channel.

CONCLUSION

Awareness of the price when entering the regional department was **discussed with Idé-klinikken and with sparring it was possible to came up with a strategy to enter with a low price and continue earning money** later on.

BUSINESS PLAN

// ARMD by Regain

VALUE PROPOSITION

Motivates stroke patients to do more self-training, so they get faster through the system and out contributing to society again.

REFLECTION
In order to prove the value proposition, so called "control groups" must be created once the first prototypes of ARMD are ready. This will help justify why the regional hospitals are to spend their money on ARMD.

KEY RESOURCES

FINANCIAL
In order to start Regain as a company, funding is required.

CONSULTANCY IN SOFTWARE AND GAME DEVELOPMENT
Are needed to fully develop the interface and the corresponding app.

ONGOING SPARRING WITH THERAPISTS
To ensure ongoing value proposition-validation and quality check, close connections must be established between therapists and the stroke patients in control groups. Only by this connection can the product continue developing, business can grow, and more features can be added.

KEY ACTIVITIES

PRODUCT MATURATION AND MANUFACTORING
Firstly, prototypes must be constructed. Tests on patients run simultaneously.

SALES AND MARKETING
Sales Channels must be created, requiring a sales team to convince the regions and the clinics to purchase the product. A business identity and ads must be made.

COLLABORATION
For the projector, it could be considered to collaborate with leading projector companies in the development of the projector; for instance Epson. This could potentially add more credibility to a smaller start-up business.

FUTURE SET-UP

In order to secure cash flow in the future setup, additional strategies were looked into.

CURSORS
In the future, it would be possible to expand the possibilities within the design of the cursors. By incorporating the inner electronic part that can be unmounted, possibilities within different shapes, sizes and even purposes can be purchased as extra features to the existing ARMD solution.

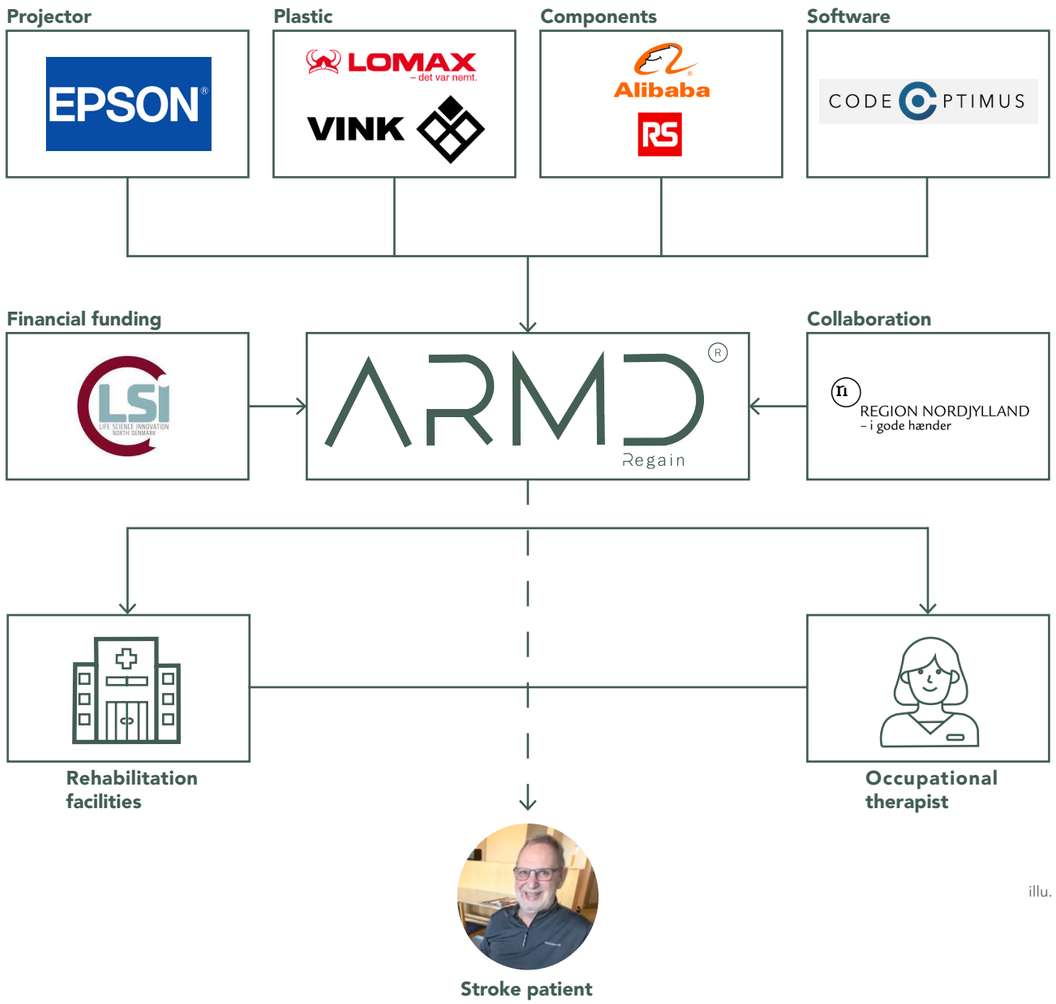
GAME/SOFTWARE
By having the software and interactive gameboard, development within the area is possible in the future. It is possible to create different, more graphic games.

EXPANDING TARGET GROUPS
Hand in hand with the development of the different games, ARMD could be used in nursing homes, kindergartens and Schools. The variants of playable games could vary from teaching games to social games, where you can compete against each other, still using the cursors and the projector.

PRODUCTION
When being a startup business, you deal with a lot of risks. That is why the production method started out to be 3D printing. This is a way less expensive production method, compared to injection molding, that requires design and manufacturing of several tools. If the business fails, huge investments in production do not get lost. Furthermore, when 3D printing a lot more flexibility in terms of different cursor designs is possible. This is a cheaper method to do the market entrance.

BUSINESS MODEL

The model shows suppliers, manufactures and collaborators that help Regain's ARMD reach stroke patients and the regional hospitals.



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SALE TO REHABILITATION FACILITIES

ARMD must be sold directly to the regional rehabilitation facilities as well as municipal rehabilitation facilities for a price of **6.500 DKK** per single unit. Private clinics are incorporated. Over time, European and Australian rehabilitation facilities and private clinics will be a part of the market share.

6500 DKK

total unit price

PRODUCT RENTAL

When entering the market for private clinic owners and even the municipal rehabilitation facilities, a single unit could be rented for **750 DKK** per month for a period of time.
It would work in such a way, where the therapist in the clinics suggests the patient to use ARMD. To make this deal of interest for the clinics, a 20% contribution of the price will go to the clinic. In this way, interest is maintained both ways.

750 DKK

per month

GAME INTERFACE

// future possibilities

It is taken into account which possibilities are available within the creation of the software that is an aspect of the product proposal, in order to support the business case. ARMD may grow further and potentially be a part of various usage scenarios or professions by having this linked software.
The 'dot game' is currently the answer, according to the current situation. This is where the game-related aspect of the design currently stands. In order to prepare for the future, this section is looking into how the same concepts might be applied to more graphic games.

BUG SMASHING

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Using the same principles as in the dot game, it could be bugs that has to be smashed, instead of getting the dots correct.

JUMPING GAME

illu. 185

The cursors could act the jumping, moving man. The different plateaus would require that the patient reaces back and forth.

BLOWING UP BALLOONS

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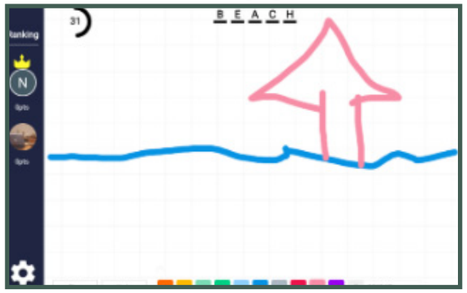
Same principle as the bug game. Though, here the turning aspect could be incorporated, so in order to blow up the yellow balloon, you would have to pop it by turning it over and match it with the yellow color.

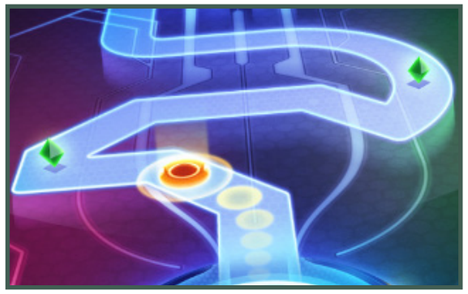
DRAWING GAME



illu. 187

Play against eachother or just drawing by yourself. Potential is seen in: Nursing homes, Kindergartens, and Schools.

FOLLOW LINE



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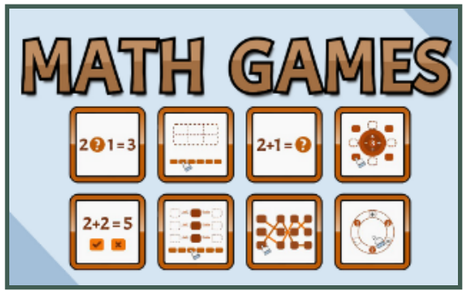
This game requires coordination and precision in the movements from side to side. The better you get, the faster til screenplay runs.

MATH GAMES



illu. 189

For cognitive training, combined with physical training, a math game could be an opportunity. Games could be designed so all the main exercises would be done.

CONCLUSION

In general, it can be seen that there are many opportunities within the desired game setup. In relation to the future, a software/interaction design department must be established, to help the founders behind ARMD bring the intentions to life.

COST

It is needed to look into the cost related to the construction of ARMD to support the business case. For a more detailed overview see **[WS 30]**.

INVESTMENT
There is a need for investment in developing ARMD further to be ready for sale. The investment will be approximately 1.016.000 DKK covering development cost, prototypes, traveling, office renting, tooling, registrations and carious consultant work.

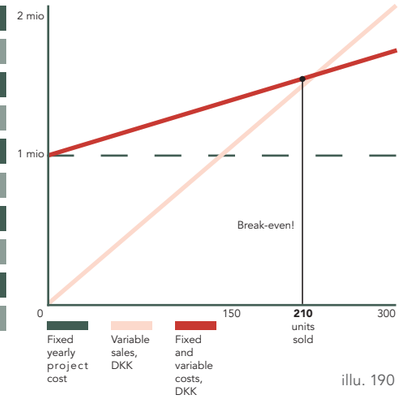
PROJCTOR UNIT
The projector unit consists of many different components which includes materials for the shells, SBC control unit with Bluetooth, coil and basic components used in an LCD projector. It is estimated to have a cost of 1.136 DKK.

CURSORS
The cursor cost is estimated based on material used for the shell, SBC control unit with Bluetooth, IMU, Battery and a coil. These components are integrated in all three cursors. One cursor will cost 182 DKK which means that the three will cost 546 DKK.

COST OF ARMD
This means that all in all the one projector unit and three cursors will have a total cost of **1.682 DKK.**

BUDGET: PRODUCT SALE
With these costs related to sales it is possible to earn money from the first sales year (year 2). With a sales price at 6.500 DKK and a cost of 1.682 DKK it means that Regain will have a variable profit ratio at 74,1 % which is seen as a good business case. With this strategy it is possible to reach breakeven after 210 units are sold.

	Year 1	Year 2	Year 3	Year 4	Year 5
Units sold	0	300	3000	6000	8000
Sales price, DKK	6500	6500	6500	6500	6500
Product cost, DKK	1682	1682	1682	1682	1682
Profit per unit, DKK	-	4818	4818	4818	4818
Variable sales, DKK	-	1.950.000	19.500.000	39.000.000	52.000.000
Variable cost, DKK	0	504.729	5.047.200	10.094.400	13.459.200
Yearly project cost, DKK	1.016.000	1.016.000	1.016.000	1.016.000	1.016.000
Variable profit, DKK	0	1.445.280	14.452.800	28.905.600	38.540.800
Balance, DKK	-1.016.000	429.280	13.436.800	27.889.600	37.524.800



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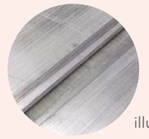
BUDGET: PRODUCT RENTAL
Regain can increase the income by incorporating the renting method. The sales strategy is what covers the fixed costs, therefore if all projectors are rented continuously from the first rental year (year 2) onward, there will be a profit. The rental price will be 750 DKK per month and the one that recommended ARMD will have 20% in compensation. If this plan were to be successful, year two should have seen the production of 125 units. The balance will vary if they are not completely rented out each month. Here, it is a risk to produce them all if they are not rented, but it is one step that Regain should take to increase income.

	Year 1	Year 2	Year 3	Year 4	Year 5
Units rental	0	500	4500	7200	13.000
Unit rental price, (pr month) DKK	750	750	750	750	750
Rental time (months)	0	3	3	3	3
Rentals per year	0	4	4	4	4
Sold for rental	0	125	1125	1800	3250
Product cost, DKK	1682	1682	1682	1682	1682
Variable sales, DKK	-	375.000	3.375.000	5.400.000	9.750.000
Compensation 20%, DKK	-	56.250	506.250	810.000	1.462.500
Variable cost, DKK	-	210.300	1.892.700	3.028.320	5.467.800
Variable profit, DKK	-	108.450	976.050	1.561.680	2.819.700
Balance, DKK	-	**108.450**	**976.050**	**1.561.680**	**2.819.700**

illu. 191

MATERIALS
It is important that the materials chosen is resistant to water, alcohol, soap and chlorine while it is important that the product can be sterilized at the hospital. ARMD is used by arm stroke patients that in the beginning can have big uncontrollable movements which means that the material should be able to resist because it will be handled roughly. The materials must be simple to process, as the entire business case is based on having as cheap and easy a production as possible to start with.
To fullfill the requirements, these materials have been chosen:



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Aluminum 6061

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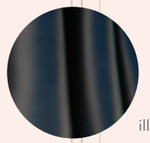
ASA



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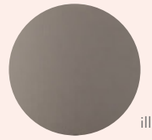
EPDM



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Silicone

MATERIALS, PRODUCTION & CONSTRUCTION

THE PROJECTOR CASE

MATERIAL

The projector case will be produced in ASA, as many of the properties fulfill the desires. The choice of material requires an antibacterial coating in the post processing phase, which ASA allows. ASA provides a smooth surface, is easy to work with and can be exposed to sun and heat which is important when designing a projector (3D Eksperten, n.d).

PRODUCTION

The projector case is 3D printed. The case is printed in 2 parts, as the front part has co-printed support in its structure to retain the internal components. The 3D printing technology allows colorchange when printing, so the intended colordetails can be co-printed as well. It is known, that it is a complex structure to 3D print.

TOP, MIDDLE & BOTTOM PARTS

MATERIAL

For the top, middle and bottom part of the projector, the aluminium alloy 6061 will be used with a 3mm thickness. Aluminum is light-weight and cheap, compared to other metals, and can add a different expression to the large plastic surface of the projector. This alloy has a high strength, great welding and laser cutting properties, which is utilized during the production of these parts. (Xometry, n.d).

PRODUCTION

The EN AW 6061 alloy has good properties in laser cutting and welding, which is used during the production of these parts. All Aluminum parts will be cut on the same 3mm sheet.

Top:
A 3mm sheet is laser cut in the shape of the projector structure. In the same operation, the 3 holes that hold the cursors are cut out.

Middle part:
On the same sheet, the middle part is laser cut - but without any holes. This is where the cursors rest and recharge.

Bottom:
For the bottom part, the top part and the bottom part are laser cut. The top part is slightly smaller than the bottom part. In the same cutout, a strip is cut, which is then bent and welded together with the top and bottom part.

NON-SLIP BOTTOM

MATERIAL

To ensure that ARMD does not move when being used, a rubber material is added to the bottom of the projector to avoid unintentional movement. It has good anti-slip properties and can withstand washing for hygienic reasons. Ethylene-propylene-rubber, or EPDM, is utilized specifically because it is resistant to acid, base, alcohols, and water (Hounisen, n.d.).

PRODUCTION

The EPDM comes in sheets, where the shape of the bottom plate will be cut out.

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THE CURSOR CASE

MATERIAL

The cursor case will be produced in ASA, as a plastic-material meets the production method the best, and meets the requirement to be able to withstand being knocked over.

PRODUCTION

It will be 3D Printed as the production method for the cursor case because it allows the cursors to be produced in different sizes which will benefit the user's rehabilitation process and ability to level up visually.

THE SILICONE DETAIL

MATERIAL

To conceal the screws holding the two pieces together, silicone strips are placed along the sides of the projector. Silicone is useful in the medical field due to its potential for hygiene (Rubber Proff, n.d.). It aids in sealing connections to prevent liquid from entering the electronics when it is cleaned.

PRODUCTION

The nature of silicone requires molding. Therefore, the detail will be produced in a small mold. If it becomes necessary to disassemble the projector, this detail can be torn off and glued back on.

THE ELECTRONIC PART

MATERIAL

The electronic part will also be produced in the 3D printable plastic, ASA.

PRODUCTION

The electronic part with all the components will also be 3D printed and glued together, when the components are successfully incorporated. The user cannot access the components, once the production is completed.

Cursor & projector: Must be 3D printed in ASA

Top, middle & bottom must be produced in Aluminum 6061: EN AW 6061

PRODUCTION REFLECTION: 3D PRINTING

It was chosen to work with 3D Printing based on the parameters below, as the production method for the cursor case and the projector case. It will be held up against the businesscase, reflecting on the initial set-up. (TWI, n.d.)

Low entry cost:
Not many ARMD's will be sold in the first years. Injection molding will be too high in price. As a start, 3D printing is a good entry point for the business case, and if the product becomes a success, Regain can start discussion using injection molding instead.

Changing design:
3D printing allows Regain to create more shapes and add more cursorcases to the product over time without having a high risk. This allows the concept to vary a lot more which will add value to the user and benefit the business case.

Small and complex items:
3D printing is beneficial to use for small objects such as the cursor case. If wanted more complex shapes can be made for the cursor without problems.

Time consuming:
3D printing is a lot more time consuming than injection molding.This is not necessary to be fast because of the quantity of cursors that is going to be produced in the beginning.

WIRELESS CHARGING

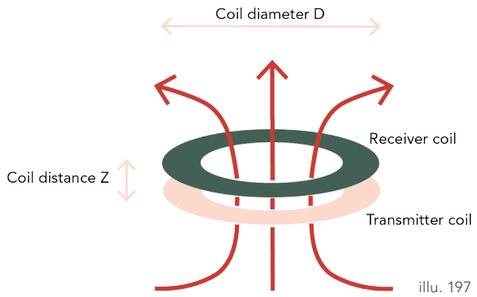
// in the cursors

Regarding the fact that the cursors have an electronic component, charging them should be possible, which is what this section investigates. Wireless charging is being looked into to reduce interactions caused by having to remember to charge the cursors. Since the design calls for the cursors to be put back in the projector, wireless charging is enabled which ensures that the user does not have to charge the cursors individually.

TWO TYPES

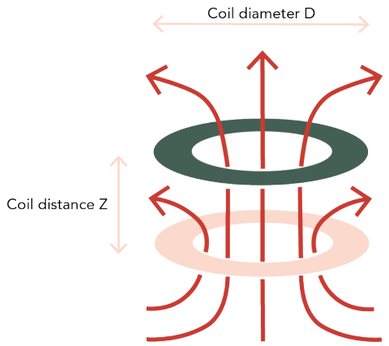
Two types of wireless charging were found; **Resonance charging and Inductive changing.**
Resonant wireless power transfer allows power transfer within a flexible distance from the transmitter rather than requiring the transmitter and receiver to be physically touching, as in inductive charging. Additionally, a resonant charge enables the simultaneous charging of numerous devices with various sizes and power requirements. (Infineon, n.d)
Induction has the highest amount of power with best efficiency compared to resonance where the distance between the coils will decrease the magnetic field (Wireless power consortium, n.d).

Inductive



illu. 197

Resonance



illu. 198

CONCLUSION

It can be concluded that it is possible to charge the cursors in both ways but to have the biggest possibilities **the resonance charging can be used** so the cursors do not have to touch the charging plate and all 3 cursors (receiver) can be charged based on the same coil (Transmitter) in the projector.

- The electronic part must have a reciever coil
- Must be a minimum of one transmitter coil in the projector
- Charging: Resonance wireless charging

COMPONENTS

// cursors

All the cursors have identically electronic parts. The cursor needs to communicate with the projector through the Bluetooth via the SBC control unit to communicate the data collected by the IMU. The cursor is charged by wireless charging and needs therefore a coil to charge and a battery to make sure that it works doing the exercise**. The small cursor has a weight of 100 grams, medium is 180 grams and large is 290 grams. This is for a 50% infill when 3D printing.**

ELECTRONIC PART

SBC control unit
58 x 28 mm
illu. 199

IMU
27 x 20 mm
illu. 200

Battery
Ø 24 x 5 mm
illu. 201

Coil
Ø 17 mm
illu. 202

Ø: 30 mm
H: 60 mm
illu. 203

ACCELEROMETER

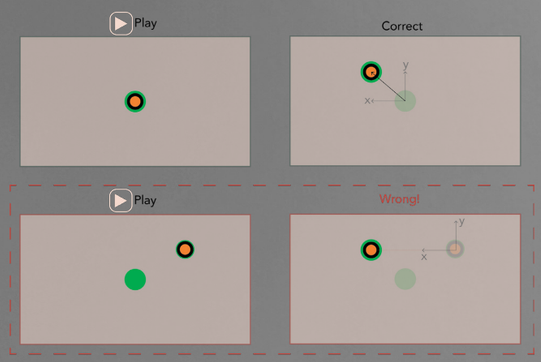
An **IMU consists of an accelerometer, gyroscope and a magnetometer**. The accelerometer is used to measure movement and to determine whether the cursor is placed in the right direction, at the right spot. To get a better understanding and evaluate if the implementation is correct, accelerometers are researched upon.

WHAT IS IT?

An accelerometer is a device that measures acceleration based on an object's velocity change. Commonly we know the sensor from our smartphone devices. The accelerometer is used in maps to understand our position, and through tilt sensing to measure if the phone is landscape or portrait. Accelerometers are mostly used to detect position, velocity, vibration, and to determine orientation. (Shawn, 2020)

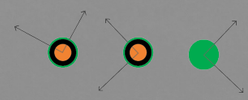
HOW TO USE ACCELEROMETER IN THE CURSOR: STARTING POINT

The accelerometer does not know where it is located, it only knows that it is been moved and its orientation. Therefore, there is a need for calibrating the location on the game board from the start of every exercise. That could be done by having a dot that the cursor has to be placed at before the game starts. When it is placed at the dot you press start and the program will measure the distance from the starting point. Thereby the software should be able to calculate if the cursor is placed right or not. ***There is a big issue then, if the calibration is not done correctly the whole game will be wrongly measured and will not work as intended.***



illu. 204

The software also has to handle that the cursor will change orientation during a game, not just in the z direction but also in x-y when the handle is moved. The software needs to handle advanced planar displacement in terms of rotation (x,y), parallel, and orientation (z).



illu. 205

PRECISION

It is needed to know how precise the patient has to be. The accelerometer is not mm precise so there needs to be a degree of freedom in the precision.

illu. 206

It is okay if the cursor is not placed precisely in the middle but most of the cursor needs to touch the dot. It will be tolerated if there is a **deviation of 15-20 mm** for the biggest cursor and **10 mm for the smallest cursor**.

PROGRESS DETECTION

The accelerometer is used for measuring the orientation on the gameboard in relation to x, y and z. The new spot is measured based on the acceleration of the cursor in relation to the lastly measured coordinates; happening in the software. The IMU also detects the progress, using the gyroscope. The gyroscope can measure the movement of the hand in general, which can help the therapist to figure out where the patient needs to practice more. These two elements are the key in understanding the placement on the gameboard and to detect the progress of the patient's movements and abilities.

ALTERNATIVE SOLUTION

There are shortcomings to the accelerometer that requires correct calibration. If that becomes a problem in the real scenario it is possible to integrate a camera into the solution, which might help to understand the right placement of the cursor in relation to the dots. Then there is still a need for the IMU for progress detection.

illu. 207

Watch how it works here

‘SHIMMER’ TEST

// IMU

In order to understand how the technology is used for the measurements that is needed in order to provide the progress detection, a device called Shimmer have been found, that meets all the requirements needed to proper control and detect the training session. It consists of a **3-axis accelerometer, 3-axis gyroscope, 3-axis magnetometer and integrated altimeter.** With this device, all signals can be measured simultaneously and in real-time.

illu. 208

TEST ON PATIENT

The team did a test at Neuroenhed Nord with the Shimmer integrated in a prototype of the cursor. The patient should then play the dot game and from that, information of the patient’s movements were gained through a representation in graphs.

For the test the acceleration was measured (plot 1) and the gyroscope (plot 2).

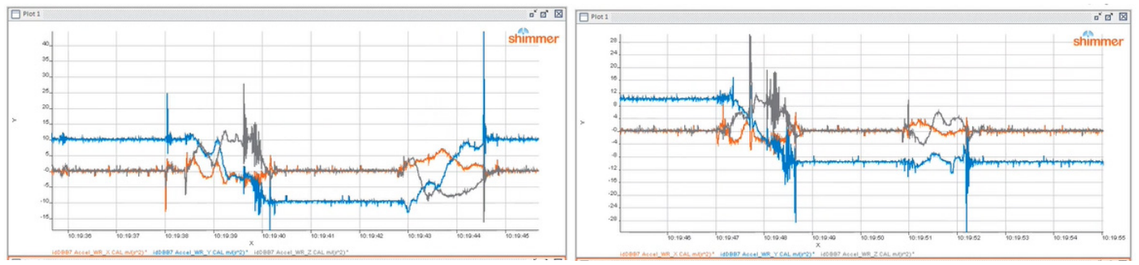
RESULTS

The results of this experiment demonstrate that the accelerometer performs best at indicating when there is a change in acceleration; in this case, the peaks indicate that the cursor has been relocated at the table. The cursor’s orientation is shown by the various peak colors. For the purposes of the concept, this is where the software will determine whether the cursor is on the dot or not. The peak decides whether or not the cursor is positioned correctly.

CONCLUSION

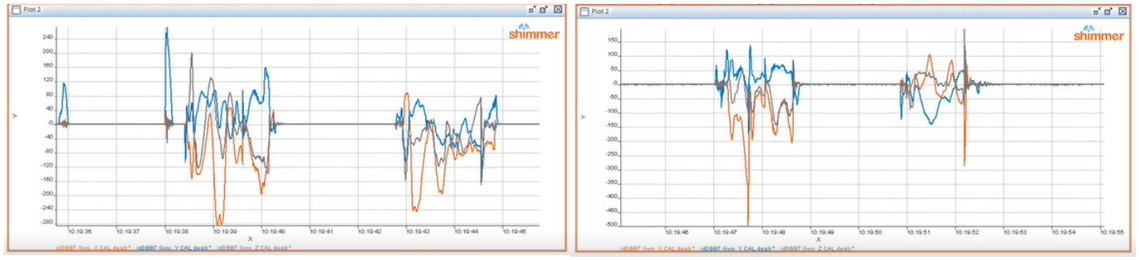
It is obvious that in order for the cursor to perform more useful measurements for the therapists to analyze, **a gyroscope must also be added.** Because of this, the Shimmer’s technology, an inertial measurement unit **(IMU) with an accelerometer, gyroscope, and magnetometer,** is used as a sensor inside the cursor. After an exercise, the therapists would want to study the hand movement, such as steering and hand shaking, in order to help the patient, strengthen the weak functions. The gyroscope makes it possible to see these movements.

PLOT 1: Acceleration



illu. 209

PLOT 2: Gyroscope



illu. 210

An IMU must be incorporated in the cursor to provide progress detection

COMPONENTS

// projector

The projector is an ultra-short throw projector that is able to communicate with the cursor. Therefore, there is a need for an SBC control unit with Bluetooth. It also needs a coil to charge the cursors through wireless charging. These components are the ones that are different from a normal long-throw **LCD projector (Cosmo Channel, 2019).** Though, the team are making an ultra-short throw projector and that it might look different inside but the overall components are the same. From the research of ultra-short throw projects, it is seen that it is possible to make them vertical standing, reverse to the long-throw projectors that are normally horizontal.

SPECIFICATIONS BASED ON EXISTING PRODUCTS

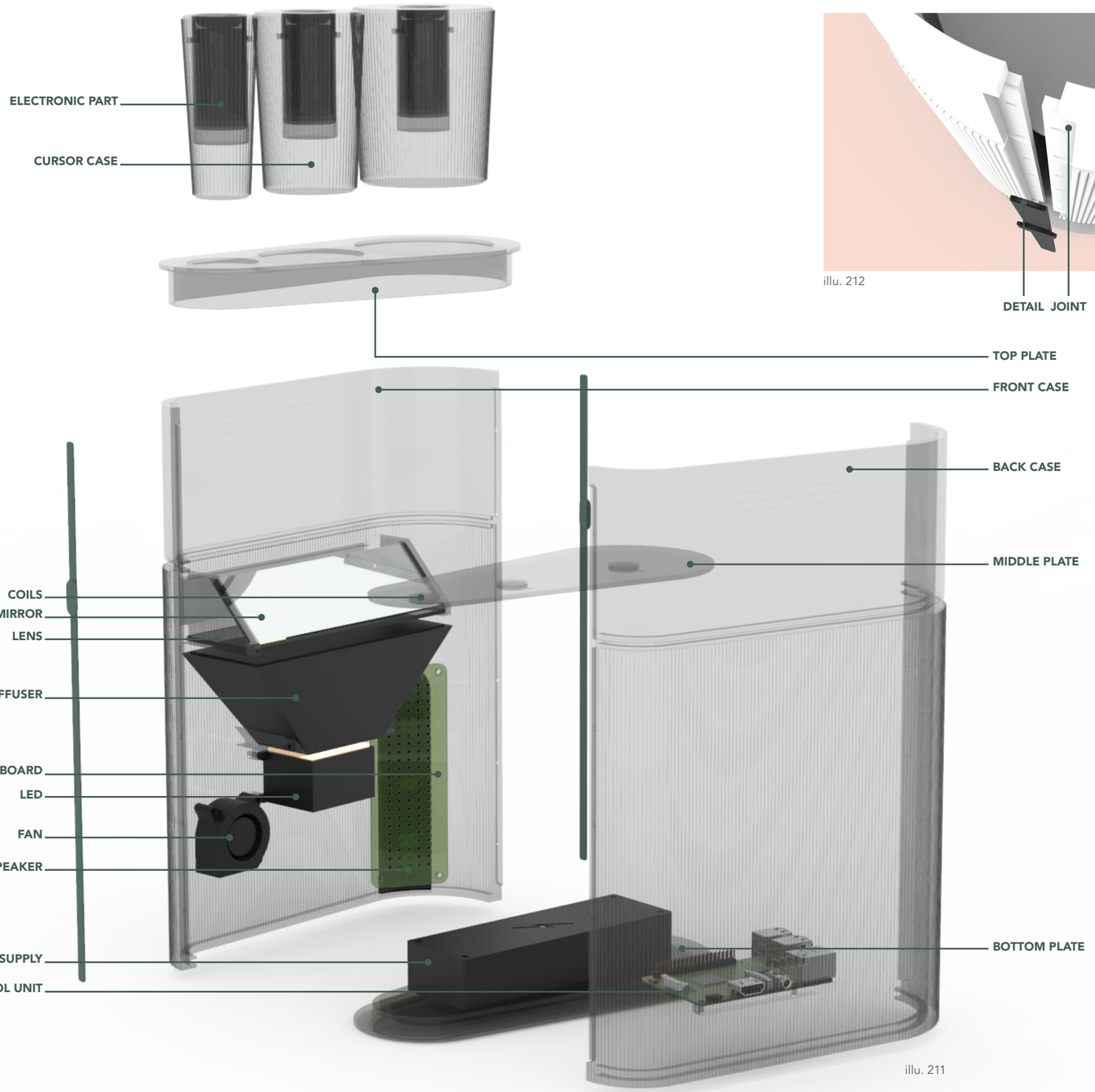
In order to determine which specifications the projector must have, the specifications of three different existing projectors, including the two projectors utilized for testing and one projector from a lecture room, have been examined. Additionally, the kind of projector that will be used for ARMD has been chosen. **In WS 53 it is possible to see the fundament of the decisions.**

A projector with **2000 ANSI lumens will be used** for ARMD, based on the projectors the team currently have in use, **requireing a power supply of 200 W.** An **LCD projector is the technology of choice** since it is less expensive than a laser projector, allows for high lumen output, and is useful in brighter rooms.

REFLECTION ON SPECIFICATION PROCESS

It has been difficult to find the right specifications for the projector. That is why the specifications have been held up against the cheap projector that the team have been using during the tests, that does not accommodate the requirements regarding resolution, throw distance and lumens. The poor projector used during tests was compared to much better projectors. The better projectors had specs that were far too oversized compared to the functionality ARMD needs to have. It was therefore decided to place the ARMD in the middle of this scale, which is reflected in the specifications.

- 2000 ANSI Lumens
- 13W LED light
- LCD projector
- Resolution: 1920 x 1080 pixels
- 16:9 aspect ratio
- Power Supply of 200 W



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CONSTRUCTION

// projector

The construction of the projector was investigated [WS 52].
The geometry of the projector will in this section be unfolded, with a specific focus on the construction. ARMD have been constructed to both retain the components and alow technicians to open the product and repair if a defect should occur. By constructing in this way, ARMD can enter into the circular economy; regardless of whether it is a component failure or damage to one of the external parts. It can easily be replaced.

illu. 212

ASSEMBLY & MOUNTING

The body of the projector have been divided into 2 parts: the front and the back case. In the future, these parts accommodates being injection molded if the businesscase were to be succeeded. When assembling the projector, components, bottom- and middle plates must be attached to the front case. When this is successfully done, the back case can be attached and the topplate with holes for the cursors will be attached as well. The whole structure will be held together by the use of smaller screws along the case-joint.
The cursor is a 'dead' plastic shell until the electronic part is inserted. The electronic part is inserted using the 'Kitchen Aid' principle.

DETAILS

By being able to collect and access the screws from the outside of the structure, there will be a need to hide them away for aesthetic reasons. To hide the screws, a silicone strap is inserted along the side, which also acts as an aesthetic detail to the product.

RETAINING COMPONENTS

The components inside the projector are retained and mounted as mentioned above on the projector's front case. On the front case, mounting areas are printed (in the initial years) or molded (in the future) to enable the internal components to be retained. Furthermore, these will be attached to the front case with smaller screws.

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TRANSPORT BAG

When entering the detailing phase of the projector, transport and handling comes relevant. ARMD must be transported from the occupational clinic at the hospital to the patient's ward. In the future, the team want to make sure that ARMD can be transported to the home of the patient, when discharged from the hospital, allowing private use.

HANDLE ON THE PROJECTOR

More handles attached to the projector were tested [WS 54] because challenges are seen in the way the product is transported. During this test, awareness arose of the specific things the design requires if it is to be stored, maintained and transported, which is the intention of the product's use.

ARMD requires the following parameters if it is to be transported using a handle:

1. Protection of the lens
2. Retention of cursors
3. Recessed buttons
4. High demands on material: special shock-absorbing material
5. Cleaning etc. dust collections

All parameters can be solved by storing ARMD in a transport bag that comes with the product when purchased. In this way, **the design proposal can also accommodate any future scenarios where it could possibly be taken home in private homes.** There would be **no risk of it breaking if it bumps into objects, no dust will get in, the cursors can be loose, the lens is not exposed, and the material does not have as high requirements.**

TEST OF IDEA

This product was tested in the unpacking scenario with the weight of aprrox. 2 kilos. What was relevant to observe was how intuitive it was to do the unpacking and how the person grabs the product. **The test person grabs the product from the top, just above the middle cursor.** The solution takes care of that interaction with **a surface that provides a better grip in the area.**

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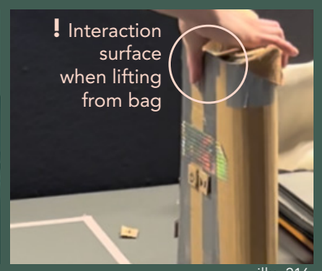

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PRODUCT *identity*

It was necessary to specify the product identity because ARMD as a product and concept is not seen on the market. Is it a piece of gaming equipment or fitness equipment? This section will therefore define and outline the identity of the product, by specifying the product identity according to the aesthetics and positioning of ARMD in the market.

ARMD deals with different aspects of identity; it is a technological projector device for elderly at the hospital. It was vital to get right to the core of what ARMD is, because it is difficult to picture how that might appear. It should not just blend in with other hospital devices but be more friendly to meet the patients. ARMD is not a senior play station; rather, it is a fitness tool. You visit the gym voluntarily if you want to strengthen yourself, lose weight, or do anything else. Playstation games are played willingly for entertainment and to help you relax. That is not what the concept of ARMD stands for.

Regain has developed a fitness tool since the user exercises the arm and hand with the intention of improving control. Regain utilize games to keep users engaged and make training enjoyable so that time and location are forgotten - like a rowing machine in a gym, where you may compete against yourself in sports like darts, fishing, and distance games.

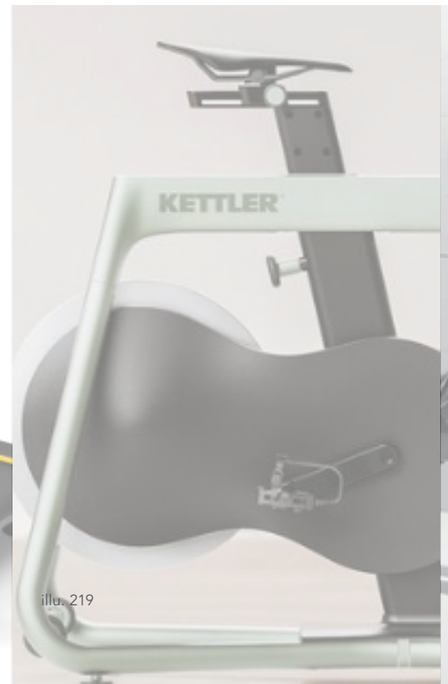
Together with the therapists and patients at Neuroenhed Nord the identity with light colors and clear details is the one they prefer the most for this fitness tool. It is discussed to make sure that ARMD has the expression as a fitness tool. For both of them it was easier to understand the use and it will be more visible at the wards. It is important that it has highly visible buttons which is the interaction areas, that the colors at the top and bottom of the cursors are easy to distinguish between to do the task right, and a clear orientation with a marked bottom for the projector.

illu. 217

gaming

fitness/gym

illu. 218



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THE INTERFACE

// how to play

To **dive deeper into the "not physical", and very important part** of the product, it is necessary to specify and test the interface with focus on the feedback the patient gets when starting the game, playing the game, and when finishing a game session.

Based on the situation-overview, it is phase 3 and 4 that will be looked deeply into and tested in terms of exactly what feedback the patient needs **[WS 58, 59]**. The other phases will also be described in relation to the thoughts behind the interface.

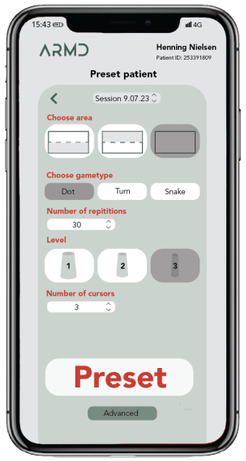
0 Preset	1 Menu	2 Play	3 Feedback	4 Data
THERAPIST Pre-setting game to the individual patient	**PATIENT** Choosing if they want to play for fun, or the pre-setted game	**PATIENT** Playing the game	**PATIENT** Tangible, easy understandable feedback on the session	**THERAPIST & PATIENT** Talk about the data and analyze it

illu. 221

0 Preset

APP PRESETTING

The therapist pre-set the exercises in the app before the exercise could begin. Here, the therapist has the opportunity to customize the exercise for the patient. The size of the gameboard, the game the patient must play to gain new abilities, the amount and size of cursor, and the number of repetitions the patient can perform to ensure they experience progress are all options.



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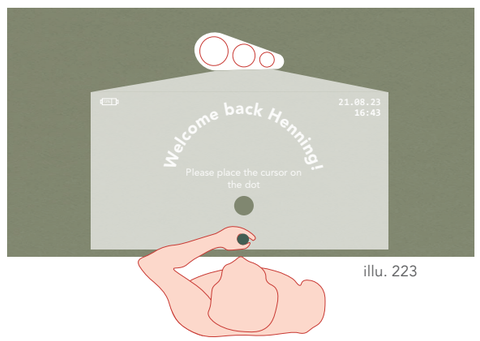
1 Menu

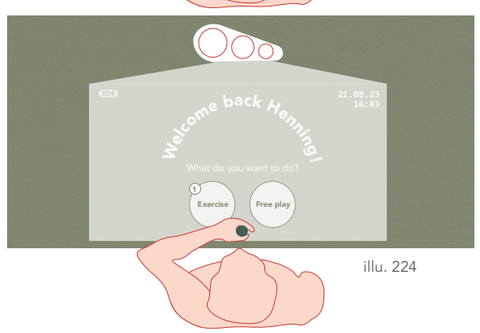
CALLIBRATING AND MENU

The calibration point, which is very crucial to have in order to have the system recognize where the cursor is on the gameboard, is the initial interaction the patient has with the gameboard. In the first exercises the patient gets familiar with ARMD together with the therapist, where the therapist has to help and state that this point is important to do correct. When the cursor is placed correctly, the patient presses the start button on the projector and the menu pops up.

If the patient wants to practice more than what the therapist has planned for them, they have the option of using the menu. After completing the predetermined exercises, the patients are given the chance to play freely here. But first they have to do the preset gaming exercise which will start when the patient sets the newly calibrated pointer on the exercise icon.



illu. 223



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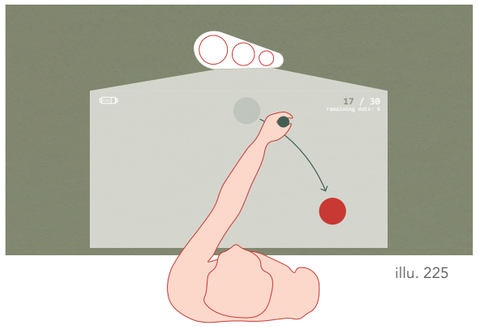


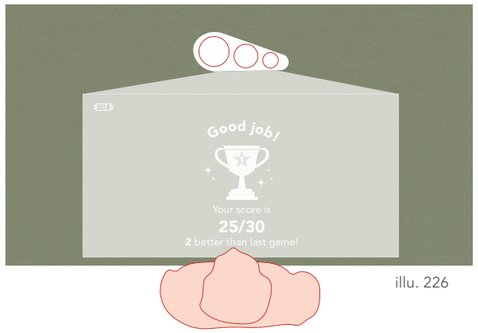
illu. 225

2 Play

START EXERCISE

There is a need for feedback when the patient is playing. This aspect of providing motivational feedback through the game is to ensure that they keep moving and have fun with it. But there is a need for feedback if there is a failure and when the user do it right. To understand which kind of feedback existing games provide, Subway Surfers and Guitar Hero were looked into [WS 59]. The outcome was, that the feedback throughout the game should give an understanding of whether you are hitting right or wrong [WS 59].

During the game there are different scenarios. The patient may play the game correctly, but they might also place the cursor on the incorrect colored dot, not hit the dot exactly enough, or lose track of the fact that a new dot has emerged. These issues must be addressed and are further discussed in the use case.

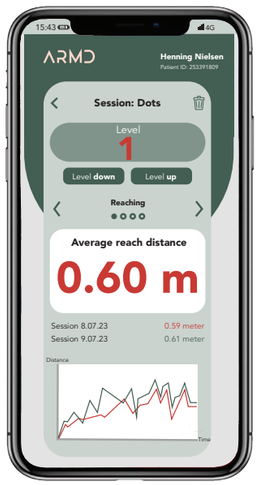


illu. 226

3 Feedback

UP-FRONT FEEDBACK

When finishing the game, the feedback has to reflect something easily understandable, evaluating the game just played. Most stroke patients are easily distracted and have problems with their observation. Various feedback scenarios have been set up [WS 58].
In order to achieve the best possible training, it is chosen that the therapist predetermines the number of dots that must appear on the gameboard. In this way, it is ensured that the patient performs the desired repetitions. They can easily see if they were better than last time.



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4 Data

ANALYSIS & PROGRESS

All the data analysis takes place in collaboration with the therapist, where the therapist can guide, cheer and 'plan the next step' in the rehabilitation based on the advanced data output. When the patient has finished the game, the data will be stored in the app that is possible to access from an iPad. This data will be analyzed by the therapist and evaluated together with the patient.

The progress detection can be divided into 5 parameters:

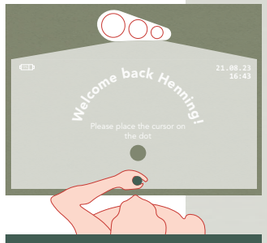
1. **Reaching**
2. **Reaction time**
3. **Shaking**
4. **Precision**
5. **Force**

Provide visual feedback based on dots hit

USE CASE

// patient vs. system response

When working with a system that does something hidden based on the interaction of the patient it is complex to understand. Therefore, throughout the process, the team have made use cases to understand the system behind the patient interaction [WS 50]. These cases were not directly compared to the patient interaction but just a description of the system behind and the patient interaction separated. To make it easier to understand the system and interactions, they are described in relation to a specific part of the user interface.



CALIBRATING

PATIENT

1. Turn on projector

2. Moves the cursor

3. Place it on the calibrating dot in the right color

4. Press start on the projector

SYSTEM RESPONSE

1. Button push (ON)

2. Measure acceleration until stop

3. Measure x, y, z and save for the game start

4. Button push (START)

MENU

PATIENT

1. Move cursor to make a choice

2. Place on exercise

3. Wait for exercise to start

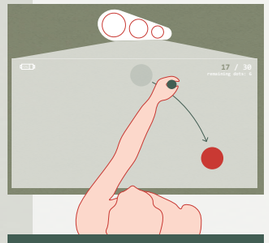
SYSTEM RESPONSE

1. Measure acceleration until stop

2. Measure new x, y, z to get the distance

Is it placed on: Exercise (distance x, y, z) or free play (distance x, y, z)

3. Start the exercise



PLAY

PATIENT

1. Move cursor to the dot in the same color

2. Wait for response: sound *"new dot"*

3. Move cursor again

SYSTEM RESPONSE

1. Measure acceleration until stop

2. Measure new x, y, z to get the distance

If the cursor is placed at the right distance (x, y) at the right orientation (z): sound *"correct"*

Create new dot

3. Sound "new dot"

POTENTIAL FAILURES WHEN PLAYING

FEEDBACK

PATIENT

1. Look at the progress

2. Decide:
More games: move cursor to menu or finish: turn off the projector

SYSTEM RESPONSE

1. Print output score: "Dots hit correct" of "total dots"

1., 2., 3. ranking related to last game?

Dots hit compared to last game

2. Measure new x, y, z: is it on menu? Go to menu

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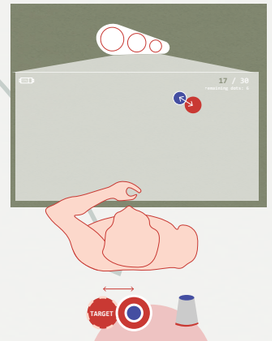


Target practice

PATIENT

1. Move cursor to the dot in the same color: did not hit the dot precise

2. Wait for response: sound "*Wrong*"

3. Wait for response: sound "*New dot*"

4. Move cursor again

SYSTEM RESPONSE

1. Measure acceleration until stop

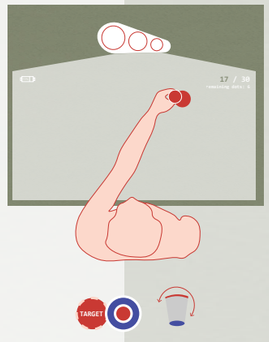
Measure new x, y, z to get the distance

Z is right but x, y distance is wrong

2. Sound "*Wrong*"

3. Create a new dot

4. Sound "*New dot*"



Cursor orientation

PATIENT

1. Move blue cursor to red dot

2. Wait for response: sound "*Wrong*"

3. Wait for response: sound "*New dot*"

4. Move cursor again

SYSTEM RESPONSE

1. Measure acceleration until stop

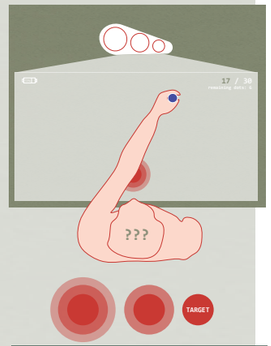
Measure new x, y, z to get the distance

X,y distance is right, z distance is wrong

2. Sound "*Wrong*"

3. Create a new dot

4. Sound "*New dot*"



Awareness

PATIENT

1. Waiting for new dot

2. Hear a sound "*new dot*"

3. Removes arm/hand

4. Sees the dot

5. Move cursor to the dot in the same color

6. Wait for response: sound "*new dot*"

7. Move cursor again

SYSTEM RESPONSE

1. No movement detected (IMU)

2. Sound "*new dot*"

3. Pulse the dot

Delay 5 sec: sound "*new dot*"

Is cursor moved?

No: repeat 3 times

- Create new dot
- Sound "*new dot*"

5. Yes: Normal 3 play

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SPECIFICATIONS

> PRODUCT SPECIFICATION	MIN	MAX	TARGET	UNIT	PAGE
PROJECTOR					
> LxDxH	-	23 x 11 x 32	23 x 11 x 32	cm	*> 73*
> Brightness	1700	2000	2000	ANSI lumen	*> 92*
> Resolution	-	1920 x 1080	1920 x 1080	pixels	*> 92*
> Light source	13	20	13	Watt	*> 92*
> Aspect ratio	-	16:9	16:9	ratio	*> 92*
> Type			LCD	Binary	*> 92*
			Ultra Short throw	Binary	*> 66*
> Throw distance	-	100	100	mm	*> 69*
> Weight	2,0	2,4	2,4	Kilo	*> 94*
CURSORS					
> Height	-	10	10	cm	*> 64*
> Size: S	-	Ø top: 3 Ø bottom: 4	Ø top: 3 Ø bottom: 4	cm	*> 64*
> Size: M	-	Ø top: 5 Ø bottom: 6	Ø top: 5 Ø bottom: 6	cm	*> 64*
> Size: L	-	Ø top: 7 Ø bottom: 8	Ø top: 7 Ø bottom: 8	cm	*> 64*
> 6 colors, top/bottom			Yes	Binary	*> 61*
> Material & surface must handle being knocked over			Yes	Binary	*> 60* *> 87*
> Must be resistant to heat, soap, alcohol & chlorine			Yes	Binary	*> 63*
> Electronic part must fit inside cursor-case	H:6,1 Ø:2,8	H:6,2 Ø:2,9	H:6,2 Ø:2,9	cm	*> 64*
> Must be charged in the projector			Yes	Binary	*> 68*
> Weight: S	100	150	100	Grams	*> 89*
> Weight: M	200	250	200	Grams	*> 89*
> Weight: L	300	350	300	Grams	*> 89*
> Measure if the exercises are done correct > Movement X, Y, Z			Yes IMU	Binary	*> 62* *> 91*

> PRODUCT SPECIFICATION	MIN	MAX	TARGET	UNIT	PAGE
COMPONENTS					
> Coils: resonance wireless charging			Yes	Binary	*> 88*
> IMU	-	27x20	27x20	mm	*> 89*
> SBC control unit w. bluetooth, 2 pcs			Cursor Yes	Binary	*> 89*
			Projector Yes	Binary	*> 92*
> Power supply	100	300	200	Watt	*> 92*
GAME SOFTWARE					
> Screen size	-	-	36	Inches	*> 64*
> Must be compatible with an iPad			Yes	Binary	*> 41*
> Different levels of difficulty			Yes	Binary	*> 41*
> Game must nudge the user to do: > Grasp / Release > Reach > Wrist Rotation			Yes	Binary	*> 45*
> Data collection for Progress Detection			Yes	Binary	*> 97*
> Provide Visual Feedback based on number of dots hit			Yes	Binary	*> 97*
> Auditory Feedbacck, sound > New dot > Right > Wrong			Yes	Binary	*> 56*
> Enable Start / Pause			Yes	Binary	*> 70*
PRICE					
> Sale	6000	7000	6500	DKK	*> 82*
> Rental, per month	700	800	750	DKK	*> 82*
MATERIALS					
> Cursor & projector case			ASA	Binary	*> 86*
> Top, middle & bottum plate			EN AW6061	Binary	*> 86*
> Non-slip			EPDM	Binary	*> 86*
> Side detail			Silicone	Binary	*> 86*

// EPILOGUE

06

This phase will round off and finish the project through a conclusion and reflections based on both the product and the process that the team went through, in order to present the final proposal: ARMD by Regain.

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CONCLUSION

This Thesis has been centered around the topic "Stroke rehabilitation" - more concrete about the patients that experience paresis in their arm and has to regain their functions in their arm and hand again. The aim with this Master Thesis was to create a motivational product for self rehabilitations on the wards when hospitalized.

Many interviews and visits were conducted with the people caring for the patients as well as the patients themselves, in order to obtain insight into this world. The team had good opportunities to speak with therapists and patients during the entire process at Neuroenhed Nord in Frederikshavn, where the team had the freedom to come and go almost as wanted. This has been essential to reach the product proposal: ARMD.

The motivational aspect in arm rehabilitation is key for ARMD, to make sure that the patients keep progressing and enjoys it at the same time. To deal with a non-tangible parameter as motivation, it has been divided into smaller frames that has been the directional factors for the final proposal of ARMD: levels of difficulty, fun, progress detection and exciting repetitions. Especially the ability to see the progress is extremely motivating to the strokepatients.

Practise the armskills

It has been a clear factor to create a product that practice the armskills to make sure that the product has evidence from a therapeutic view. With ARMD the patients can practice their armskills, but we cannot control if they use their shoulder to move the arm or if they do an inner or outer rotation with the wrist. Though, we can track it with the data collected by the IMU. This is something that has to be tested further to make sure that the patient learns the right movements and the app has to be programmed to track all this data.

Game in relation to motivation

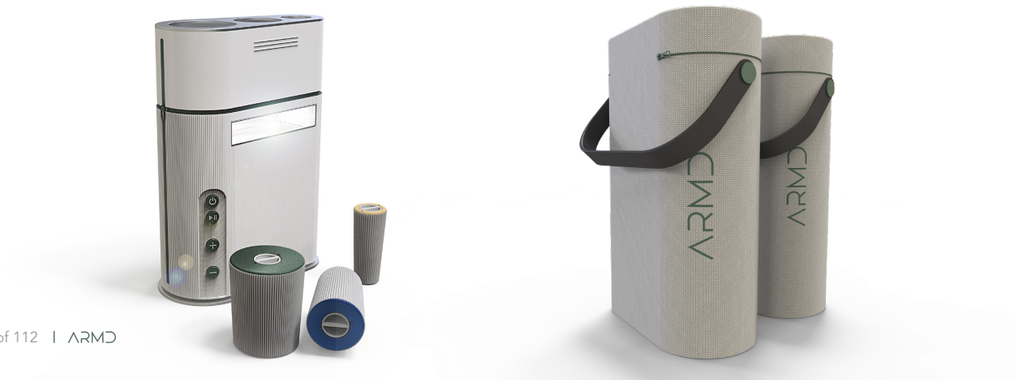
The game is always changing. It is not just a predictable activity that is right in front of you like the current solutions, so you have to be concentrated and aware of the next dot appearing and which cursor needs to be moved.
Though, motivation regarding the game itself, has not been solved in the desired degree, due to the lack of competences in game design and programing. Possibilities within the interactive area has been suggested in the report, but it has not been brought to life or tested on patients, lacking in the identified motivational aspect of 'fun'.

Based on multiple games and different cursor usage, the principles behind the game are useful for a variety of skilled patients. But the therapists are the ones who follow the patients and create their personalized program through the app. The software should manage the settings that can be modified so that a variety of patients can use ARMD successfully and with motivation - motivation is not achieved, if the game is not pre-set 'correctly' by the therapist. So, the solution sets high demands to the therapist's analytical mindset, which potentially can be more of a burden rather than an advantage, as this have not yet been tested.

Self training: software and feedback

The brain responds well to feedback. Therefore, sound and visual feedback is used through the game and up front feedback on the gameboard when the game has finished. This should help the patient through the exercises in a way that keeps them motivated and prevent them from cheating. Though, it has not been tested how the patients acts, without observation in the room, which could cause problems. To ensure that the patient cannot cheat, the IMU should aid in communication with the software. The test needs to be set up without us present, in order to demonstrate this in practice.

In general, this project lacks understanding and testing of the software. It is not known if the feedback, that gets presented to the patient right after a game is the 'correct' feedback, as only the appearance itself has been tested in different variants. The bottom line here is that there is a lack of skills in programming and game development, which in the future would require collaboration with experts in these areas.



PRACTICE ARMSKILLS

solved	missing to fullfill the goal
Grasp & Release Wrist rotation Reach	How much data can the IMU track? Require that the therapist: Tells the patient that they have to move the arm, not using the shoulder and to rotate the wrist a specific way

GAME IN RELATION TO MOTIVATION

solved	missing to fullfill the goal
Active gameboard: require focus 3 cursors - 6 colors to build up skills	Develop game interface Testing game over time Preset and app testing with therapist

SELF-TRAINING: SOFTWARE & FEEDBACK

solved	missing to fullfill the goal
Visual and sound feedback while playing Up front feedback Progress detection IMU as the brain	Lack in programing Test if the feedback is understandable

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REFLECTION

MOTIVATION

The team have chosen a focal point in the process, which is motivation and which is a flighty term to deal with. The problem is that it cannot be measured, tested or seen. Motivation among patients cannot be seen with the naked eye and thus not validate the product proposal with a view to the very frame of the Thesis. However, the group has instead defined other factors that are tangible, which are parts of the term 'motivation' in stroke rehabilitation and which have been able to help specify the approach. In order to definitively conclude whether the desired degree of motivation is achieved through the proposal, working prototypes would have to be produced and tested on patients over a longer period to see the effect, the patients behaviour and definitively confirm the value proportion.

USERS

Through the process the team have talked with different stroke patients and tested the concept with them. In general, the team has had exceptionally good chemistry and communication with both occupational therapists, nurses and physiotherapists. In addition, the group has also had good communication with the available patients at Neuroenhed Nord. However, these patients come and go, as they are continuously discharged and recovered. For this reason, main user Henning was discharged in the middle of the project, which is why tests took place on other patients who were approximately at the same skill level as him. However, the team has been so privileged to get the contact information on the main user, which is why he was subsequently contacted to keep the relationship going during the development.

When talking about the patients, it must also be said that they have a difficulty expressing what they think about the product due to their brain damage. The patients have therefore mainly been used to investigate whether the desired exercises were actually carried out, of which it is the therapists' feedback that has shaped the project and its direction.

TESTING METHODS

The product proposal ARMD has been complex to test.

It was challenging to test the interaction, how intuitive it is to set up etc., due to the testsetup. The team still tested whether it was understood, but there is a lack of nuances of credibility. It has been tested in chunks but troubles in testing the whole situation emerged, due to the split projector setup and model - in reality it is one part. The ARMD projector is an Ultra-Short-Throw projector, that is rarely available in shops, at uni or in private ownerships, compared to Long-Throw projectors, which is the projector type that has been used in the testing. Testing close to a reality scenario needs to be understood:

- The placement of the projector: is it intuitive to understand where on the table it should stand when it is turned on?

- Is it intuitive to calibrate? It requires that the patient is aware of the gameboard and the information given here, and later on press the start button on the projector.

It has been difficult to communicate and describe an interactive platform, both on paper and to each other during the development. This is probably also why the game setup is a simple dot setup with inspiration from Whac-a-Mole, as it was easy to communicate, intuitive and fast to test. Therefore, this game has been the center of test and it was a good way to validate that it was the correct armskills that was practiced, even though the 'fun' gaming experience initially was set to balance with the exercises.

In general through the tests, the team were the ones making 'damage control' when playing, but the team have not covered what would happen, if we were not present during testing and watching. Perhaps some communication/interaction issues have been overlooked, which definitely is something ARMD must test, if the Regain-busines were to be brought to life.

CURSOR DEVELOPMENT

As mentioned in the report, the cursor development has been a messy part of the design process. That was due to the team getting afraid of the price because it was wanted to do it all as cheap as possible as the thought was that it would be easier for the product to enter the market. In addition to that, it was a process in such a hurry that the team forgot to reflect IN action, and instead had to pay for it and reflect ON action.

However, the team were able to incorporate some of the parameters that has been found into the final design, so the detour has paid off in some degree. The team should have stopped in the process and looked at the most important parameters. Here, it would have been beneficial to use the boards even more in the grouproom to keep track of the most important values, requirements and inputs from Frederikshavn. In this way, the team could have had a validated reason for choosing a concept or not - not just because of irrationally fear. The team simply lost the overview of the most important factors, "the value for the patient", but found after this detour back to the most important points.

The cursor have had the highest prioritization during the development as this is the product that the patient interacts with the most. This means, that parameters of the projector such as materials and its properties (ex. shock absorbency or resistance) would have been relevant to look into.

PRIORITIZING OF FRAMING AND CURSOR DEVELOPMENT

The team have put more effort and time into the framing and concept development, as it has been more important to have a solid, strong foundation and really understand these complex users. The team have had a therapeutic view on the way to exercise. For the same reason, there is a lack of specification during product development, which is why the product is far from finished.

It has been a priority to validate the concept itself and the game, to ensure that it is a valid training and has great potential for the arm patients. This means that the interaction with buttons and their placement was prioritized lower. The goal has been to reach an understanding of the complex user, creating a game interface where they practice the main armskills (reach, grasp and release, and wrist rotation), creating level ups that ensures that different skilled patients can use the product, understand what will motivate and which feedback is needed for both patient and therapist.

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LIST OF ILLUSTRATIONS

* Note that illustrations, that have not been refered to on this list, is of own production. *

The design team during a test
Neuroenhed Nord
Frederikshavn
2023

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2023

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