Product report

Stroke rehabilitation

Aalborg university - Spring 2020
Industrial Design - MSc04 ID15
Sarah K.K. Lauritsen & Kirstine S. Appel

RE SYNC

REA

REPORT	Product
TITLE	ReSync - REA
THEME	Stroke rehabilitation
PROJECT PERIOD	3/2/2020 - 3/6/22
PROJECT TEAM	MSc04 ID15 Spring 2020 Industrial Design Aalborg University
MAIN SUPERVISOR	Louise Møller Haase
CO-SUPERVISOR	Michael Skipper Andersen
PAGES	24

Sarah Krarup Kildahl Lauritsen

Kirstine Svenningsen Appel

ABSTRACT

This master's thesis was made by ReSync (MSc04 ID15) from Industrial design, Aalborg university. The project was carried out during the spring semester, from the 3rd of February to the 3rd of June 2020.

This master's thesis covers the development of the product proposal REA, a stroke rehabilitation system, which enables and motivates stroke patients to perform self-initiated training, both at home and in early rehabilitation.

Through this project. it was explored how gamification could be implemented to motivate more frequent training, and how games could be utilized to guide patients through exercises.

Through a collaboration with a Neuro-specialized physiotherapist, the team gained insights into the rehabilitation process and -system in Denmark. This collaboration led to contact with other experts, whose insights helped to drive the design process forward along with continuous user feedback.

The resulting product, REA, enables self-initiated arm training by projecting an interactive interface onto any table by use of the integrated projector and depth sensor technology. Interaction is assisted by a handheld cursor, which enables support for the user's hand during training sessions.

By enabling self-initiated training, REA increases training frequency and maximizes training output, thereby giving the patient the best prerequisites to reach their highest possible level of function.

TABLE OF CONTENTS

Stroke rehabilitation

When rehabilitating after a stroke, repetition of exercises every few days is the key to recover lost function. Even if only a few exercise repetitions can be made a day, it will gradually help the brain reestablish signals to the arm. However, in reality few patients repeat their exercises everyday, regardless of ability level.

As stroke is not categorized as a degenerative affliction, many patients might only have access to physiotherapy once a week or not at all. With a so insignificant amount of training, patients are in risk of actually loosing regained function, or will simply not see any progress. Alternatives are paying for expensive physiotherapy themselves or self training at home.

Both with each their own barriers, as not many are able to afford specialized therapy several times a week, and do not know how to even start training themselves. On top of this piles barriers like cognitive difficulties, extreme tiredness, and physical disabilities making it hard to stay focused on boring home exercises and keep up the motivation when no progress is visible.

Limited therapy

Non progressive illness

Lack of money

Lack of initiative

No way to self-train

No affordable solutions

Lack of knowledge

Physical/cognitive barriers

Lack of motivation

Slow progress

Progress not visible

Boring exercises

Guided training

Fun and motivating

Feedback on progress

Adapted to ability level

ReSync - Rea

ReSync Rea is an arm rehabilitation system for stroke patients, which enable self-training, and motivates for everyday use. The system uses simple games as a way to guide patients through exercises, moving focus from the physical strain to the fun of the moment.

Constant feedback on performance and results visualizes progress and motivates for continual use. ReSync REA is highly adaptable to the ability level of the patient and can be used by any patient regardless of cognitive difficulty.

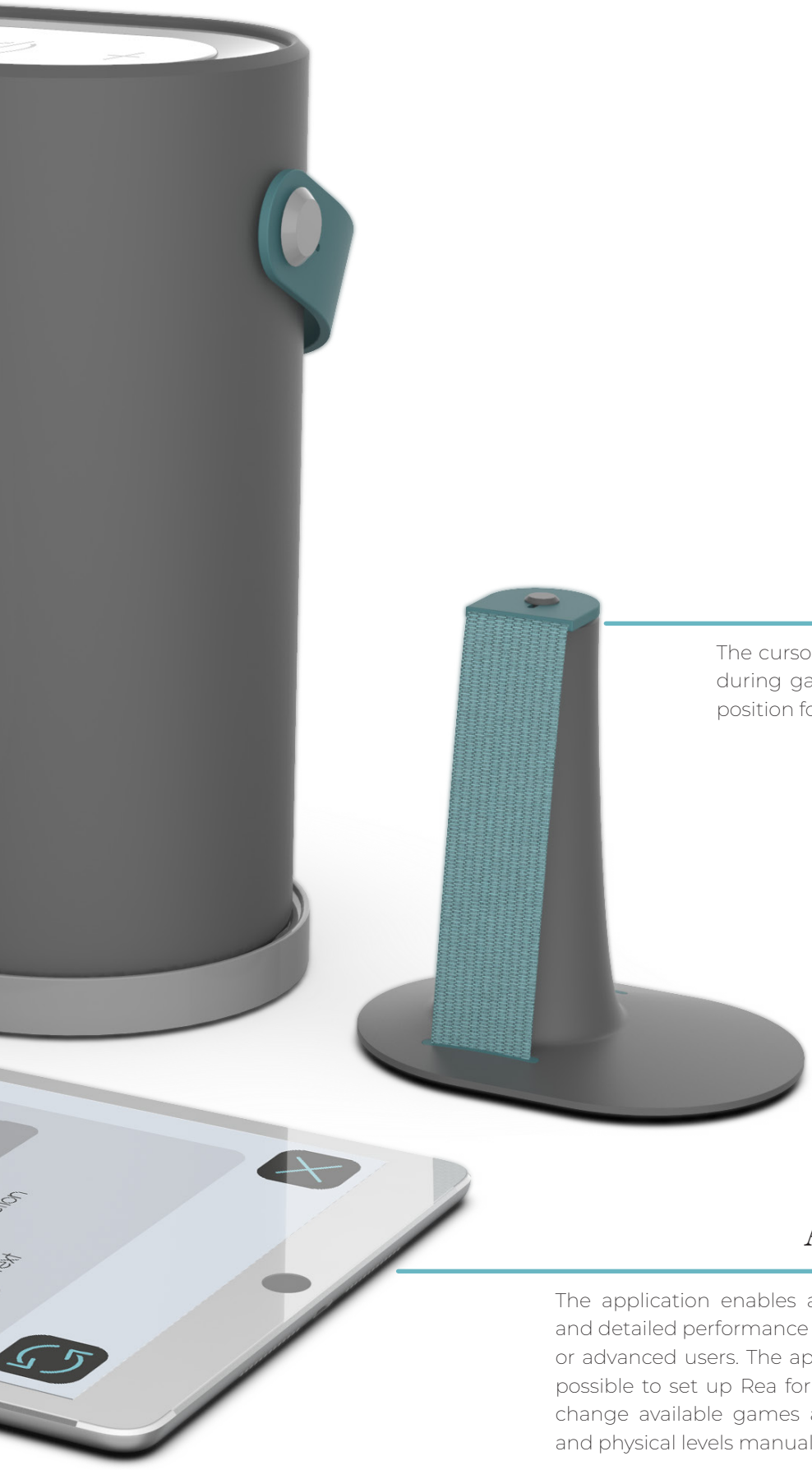
Product overview

Projector

The projector is the core of Rea as it provides the big interactive interface that guides the user through training sessions. The projection technology enables Rea to be used on any table. Rea is equipped with a battery and handle enabling quick and easy setup, as it simply has to be put in place and turned on.

Home station

The homestation is a charger for the projector, and doubles as a home for the projector and cursor between training sessions.



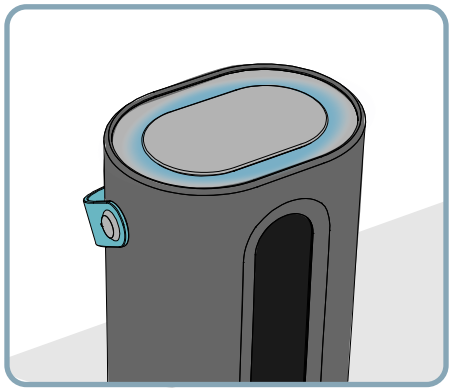
Cursor

The cursor supports the users affected hand during gameplay, providing a healthy hand position for exercises.

Application

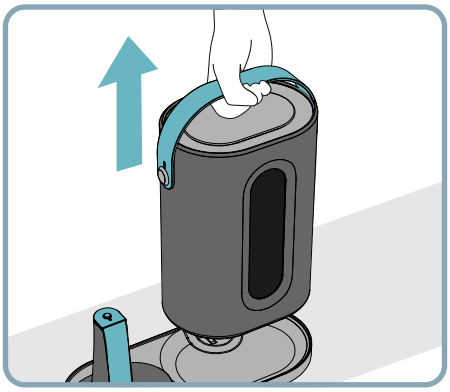
The application enables advanced settings and detailed performance data for therapists or advanced users. The applications make it possible to set up Rea for several users and change available games and the cognitive and physical levels manually.

1



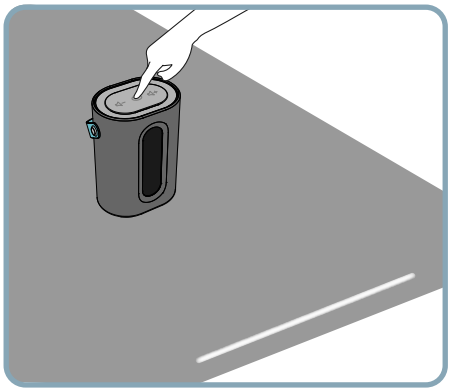
When it's time for a training session, Rea will notify the user by slowly puling blue and playing a gentle sound.

2



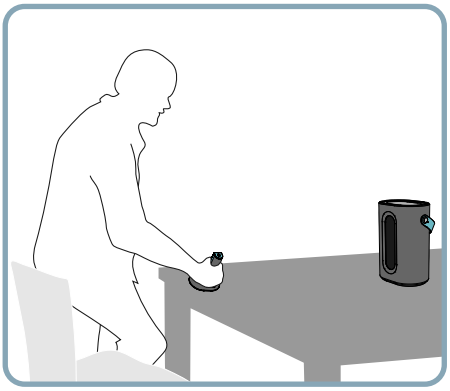
Rea can easily be carried by one hand to a table for the training session.

3



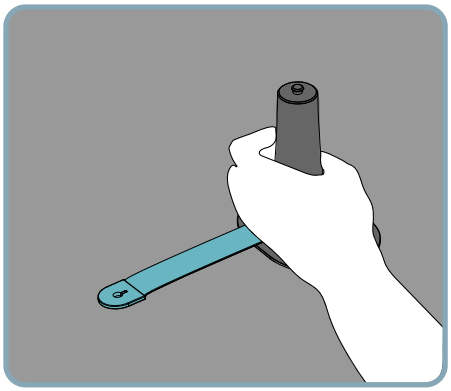
When Rea is turned on a line will appear to adjust help adjust the placement.

4



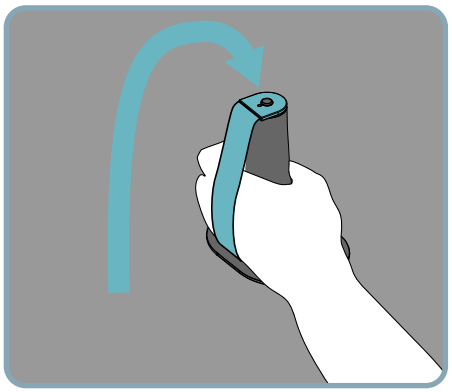
When Rea is corretly placed, the cursor will be retrieved, and the user is ready to sit down.

5



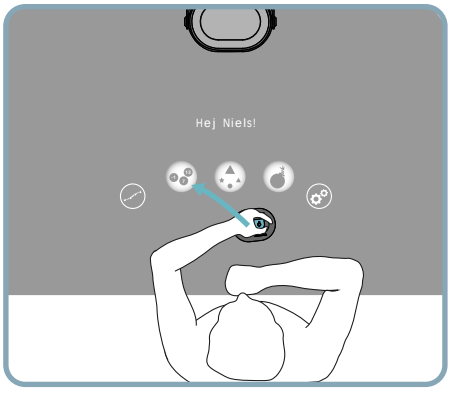
To secure the hand to the cursor, place the affected hand around the cursor.

6



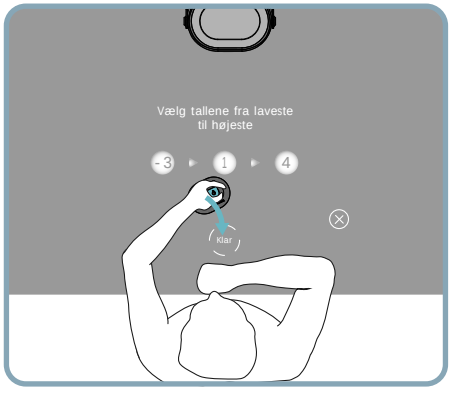
Then secure the band, by snapping the tip in place, and you are ready to play.

7

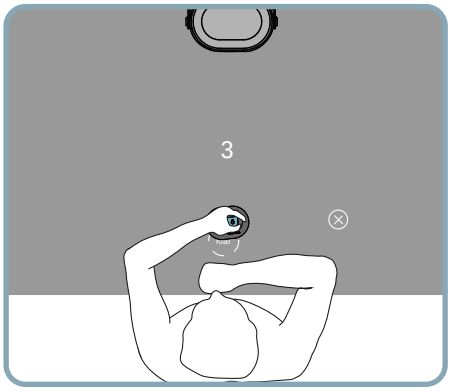


8 To start the training session, select a game from the start menu.

8

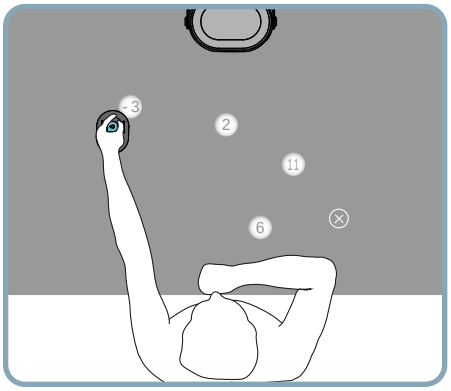


Directions for the game will be displayed.



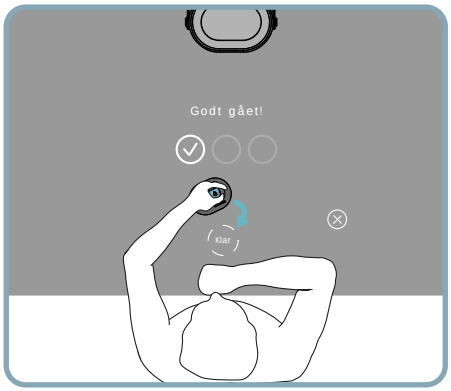
9

Once the hand is in ”ready” position a countdown will be displayed, and the game wil initiate.



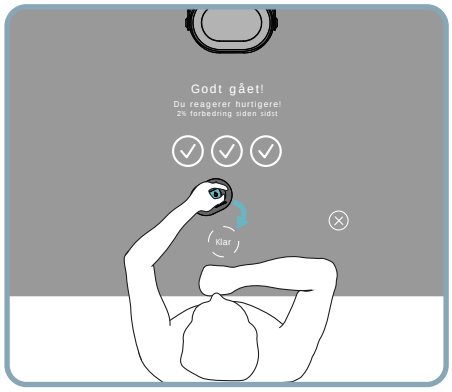
10

During gameplay possitive sound feedback will be given for corect interactions.



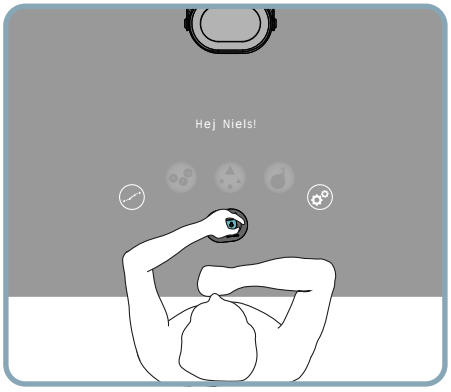
11

Between each set of exercises a possitive message will be displayed and the user can take a break.



12

After three sets a positive message will be displayed along with feedback on the users performance in the game.

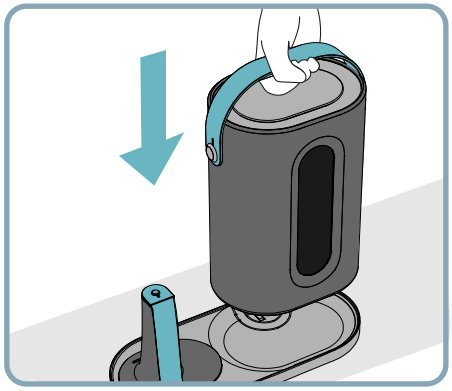


13

The number of games are customised to the users needs. When games have been played, they will appear faded.

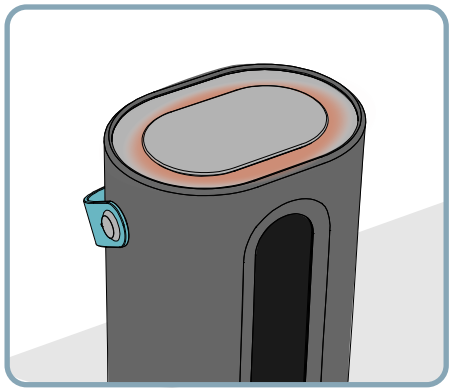
14

When the training session is over, the projector is simply turned off.



15

The projector and cursor are returned to the home station for charging.



16

The projector will emitting a faint red glow when charging.

An extension to therapy

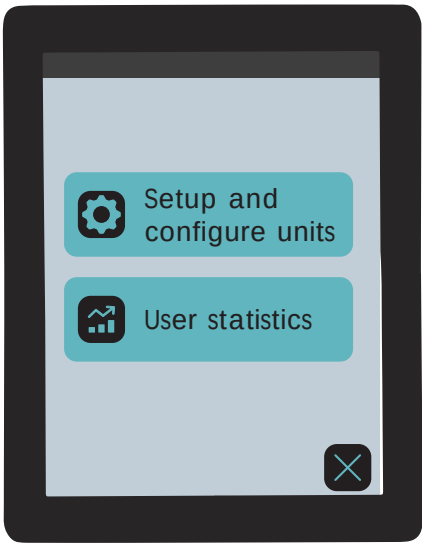
Rea is a valuable addition to physiotherapy sessions, as it extends the sessions into everyday life. By using Rea, therapists can provide home exercises for their patients, and when the patients return, their progress and detailed training data about their daily repetitions, reaching distance and reaction time can be reviewed.

As time does not have to be spent on simply activating the patient, there is more time for assessing the challenges, that slow down the patient's progress. The data Rea collects provide a bigger insight into the patient's specific problems and enable the therapist to make an even better and more focused in-person-session for the patient.

By discussing their progress with a therapist, the user will furthermore gain a greater insight into their own progress which will boost their motivation for continue development.

On top of providing progress data about patients, the application also enables therapists to adjust and customize Rea's interface and the cognitive and physical levels of the games to the current needs of the patient. Examples being turning on voice directions for users troubled with text or adjusting the available games to create a focused training program customized to the patient. The progress data and settings are communicated between the application and projector via Bluetooth.

Configure several units and collect patient data.



Customization and planning for individual users.

Detailed progress data and registration of compensatory movements.

Features

Handle

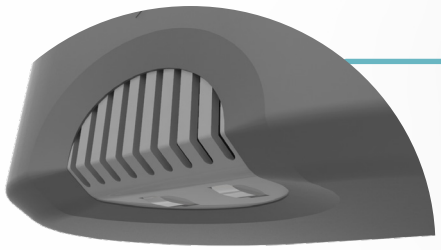
Rubber handle enables easy transport during setup, and gives the product a playful look.

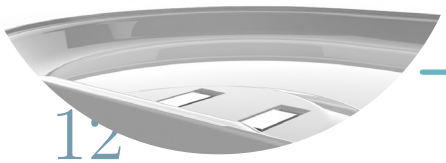
Rubber cover

Gives the projector a sturdy yet soft appearance, and protects it against shock.

Bluetooth button

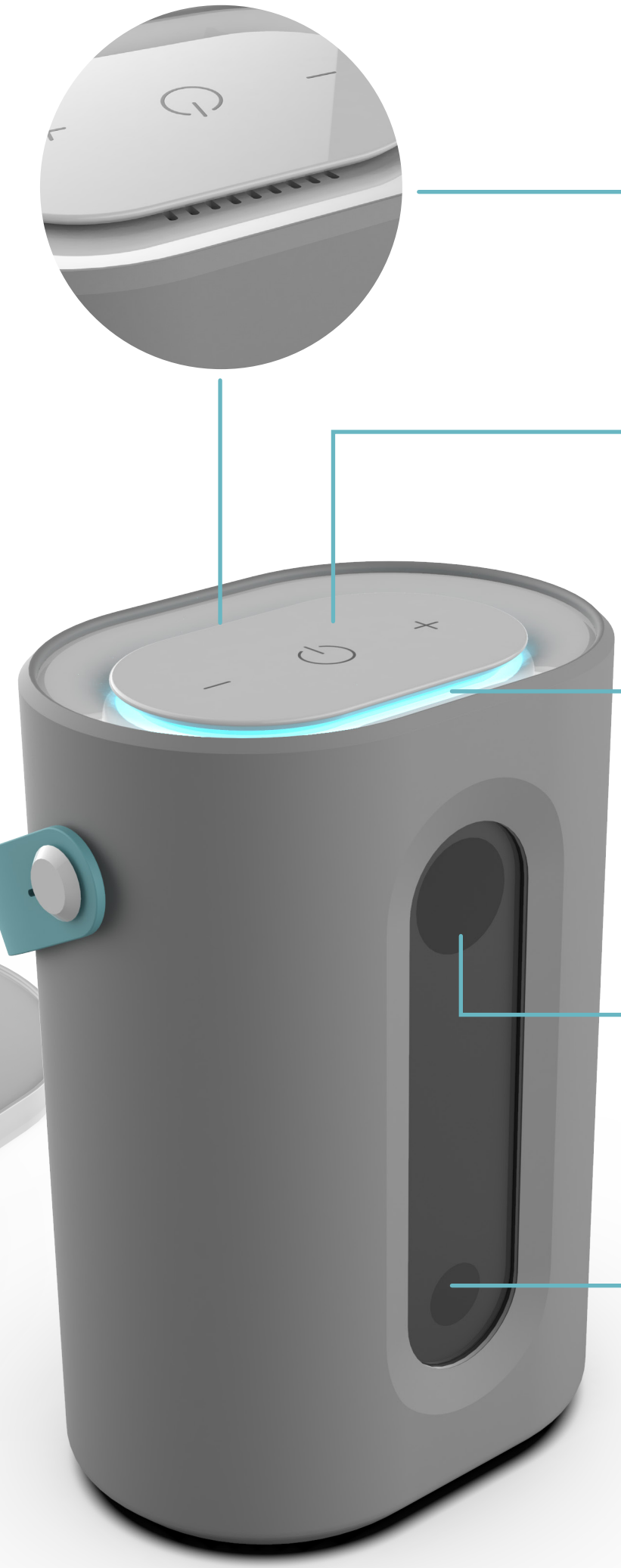
A touch button underneath the cover activates bluetooth, to connect to the application.





Charging

The projector is charged via charging contacts. The battery lasts for an hours use.



Speaker

Speakers and LED light enable audio- and visual notifications.

Touch buttons

Big buttons for the most important interactions; turning the projector on and off, and adjusting the sound.

LED lights

Allows for visual training notifications and indication of charging status.

Short throw projector

Projects the interface onto plane surface.

Depth sensor

Enables interaction with the interface by registering movements. It also registers the body's distance from the projector, enabling data on compensatory movements like forward leaning.

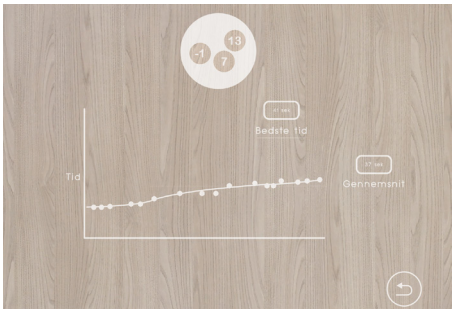
Interface

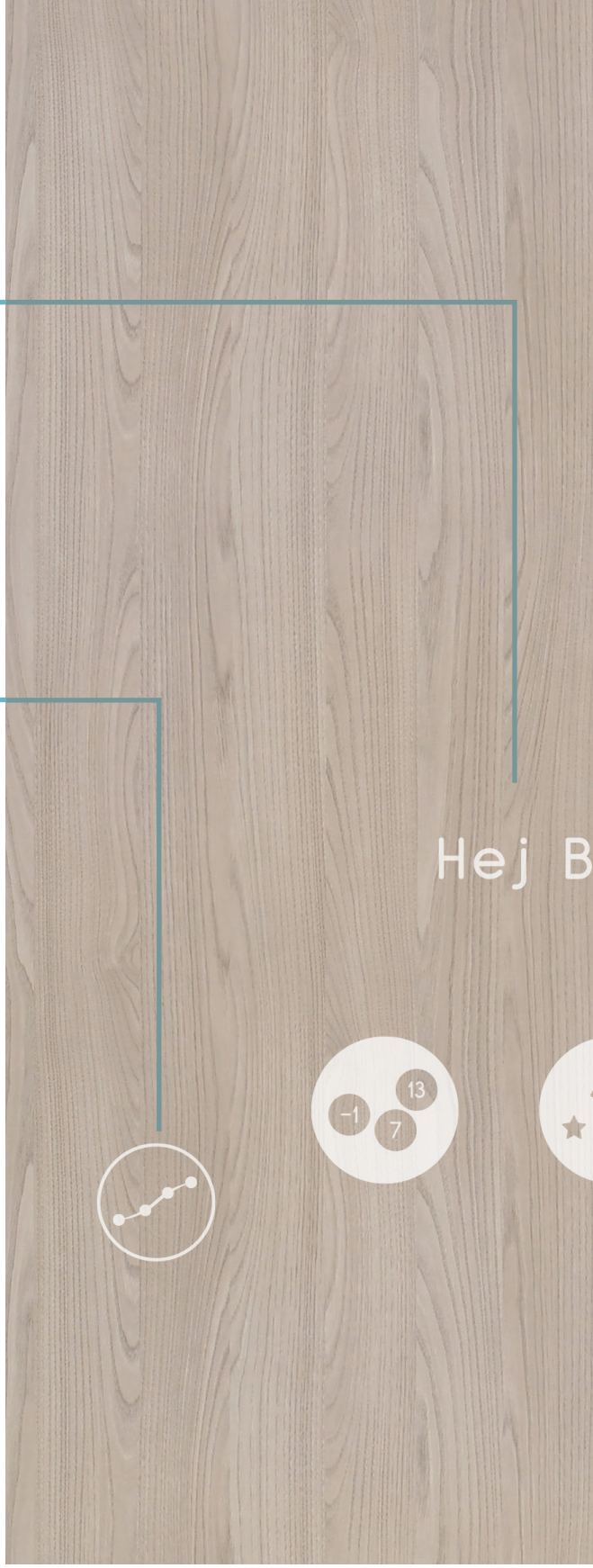
First time setup

When Rea is set up for the first time, the user will be guided through a test of reaching distance, reaction time and a couple of games to gauge the cognitive level of the user. Available games and levels will then automatically be set accordingly. This can also manually be changed in the application.

Progress

In the progress menu the user can see their physical and game related progress. The vissible and detailed progress data adds to a feeling of acomplishments and hope for recovery.





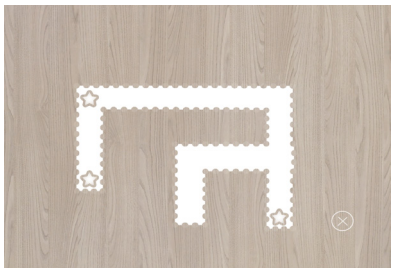
Design

Rea's interface is designed to be age neutral and to stand the test of time. The minimalistic design makes it easy to understand and clearly visible on any surface.

ente!

Lots of motivating games

Rea contains a wide array of games fitted to any level of both physical and cognitive ability. In gameplay the user vil recieve both visual and auditive feedback to communicate correct interactions.



Settings

The most important settings are available on the product interface, to enable use without the application.

Planning

In planning, training sessions can be sceduled, to help remember to train every day at a chosen time. The planning is highly customizable to the users everyday life and can be adjusted in both duration, specific weekdays, time and instances per day.

Anytime anywhere

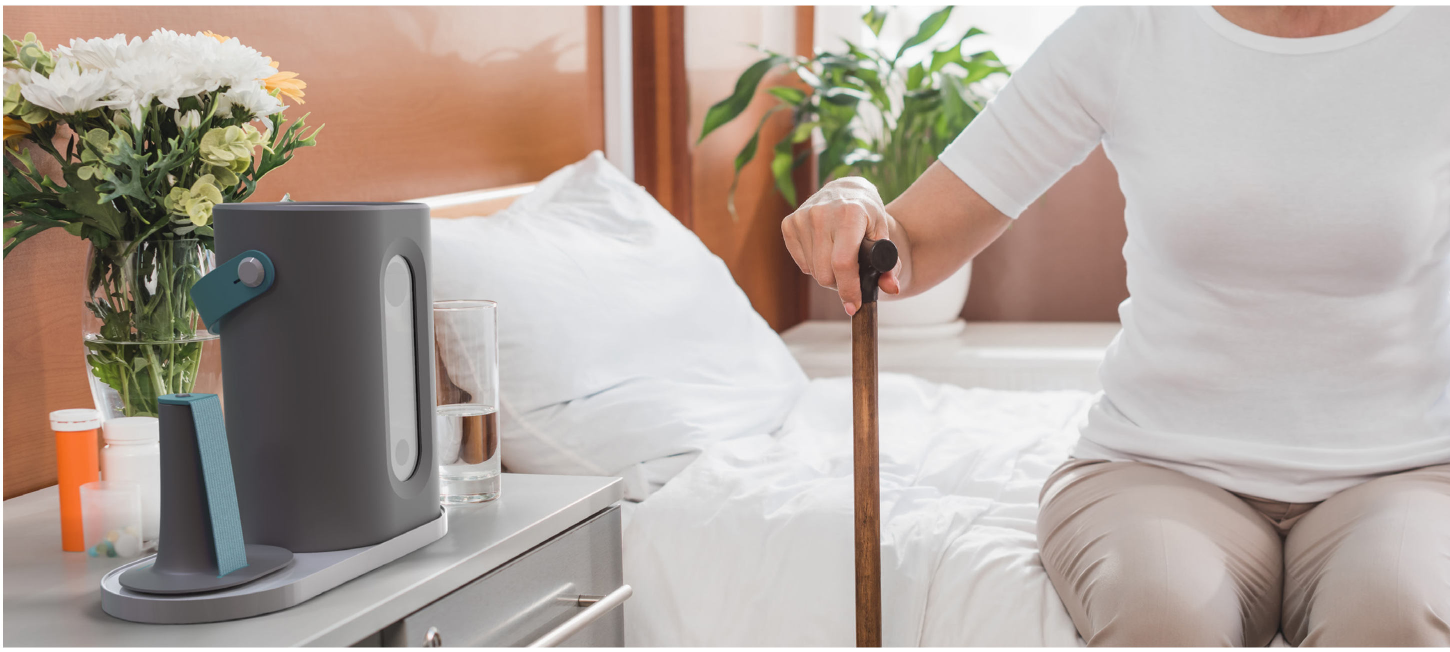
REA enable self-initiated training, by use of gamified training. The product can be used anytime anywhere, from early rehabilitation in rehabilitation centers, at home or in group therapy sessions. Rea supports the greater part of gross motor arm rehabilitation and can therefore follow the user through their progress.

ReSync Rea is provided in a hardcase to provide an easy and safe way to transport and store the product. The products sturdy design enables it to last for years between different users in many contexts.

AT HOME

THERAPY

REHABILITATION



Cursor

Cursor

The cursor is designed for patients with a weak grip and/or no fine motoric skills. It has a soft touch rubber coating to avoid the hand sliding off.

Weight

Inside the handle is a weight to ensure that the cursor is not easily knocked over.

Strap

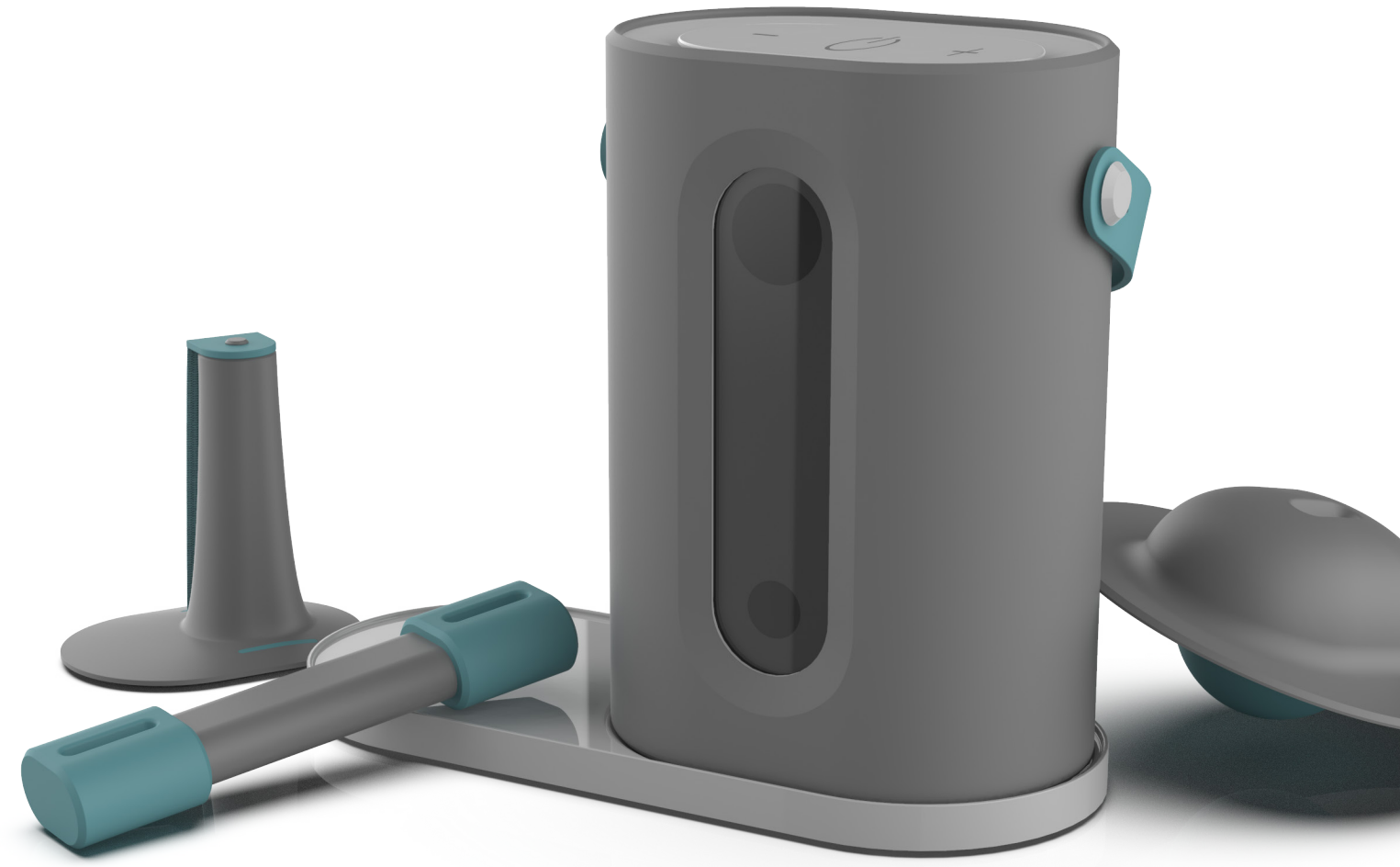
The cursor is outfitted with a strap to keep the hand in place. The strap can be placed through the holes in either side of the handle to accomodate use by both hands. The strap can also easily be removed if it isn't needed.

Felt

The underside of the cursor has a felt sheet, to make it easily slide over any surface.

Further development

Rea is a versatile system. The wireless design and simple setup mean that it can be used pretty much anywhere, that has a surface big enough. In future development it will be easy to build on top of the Rea system by adding software updates and new interaction elements instead of the cursor to broaden the product portfolio and encompass other valuable exercises for arm rehabilitation. Examples being fine motoric, precision control, or pronation/supination.



“Training with the arm gets boring quickly, if it is just repetitions with weights. Combining training of the arm with cognitive workout, mindfulness or games, is much more rewarding

Lisbeth, 60 years, Ischemic Stroke

“Training the arm by performing small fun tasks seems quite brilliant

Leif, 51 years, Ischemic Stroke

550.000 NEW USERS EACH YEAR

Rea caters to a big market, as every year 550.000 new european users experience the need for arm rehabilitation. This number is only counting cases within stroke, but the product could easily be applied in rehabilitation for other neurological diseases like cerebral palsy as well creating an even bigger market. Even very weak shoulder patients could benefit from REA as well, for example right after an operation.

Value creation

What can Rea do for you?

Therapists

- Data on patients' progress equals focused training sessions.
- By being a partner, they will gain a new revenue steam.
- Faster development equals happy and loyal patiens equals more patients.

Rehabilitation centres

- Faster and more effective rehabilitation equals cheaper rehabilitation

Patients

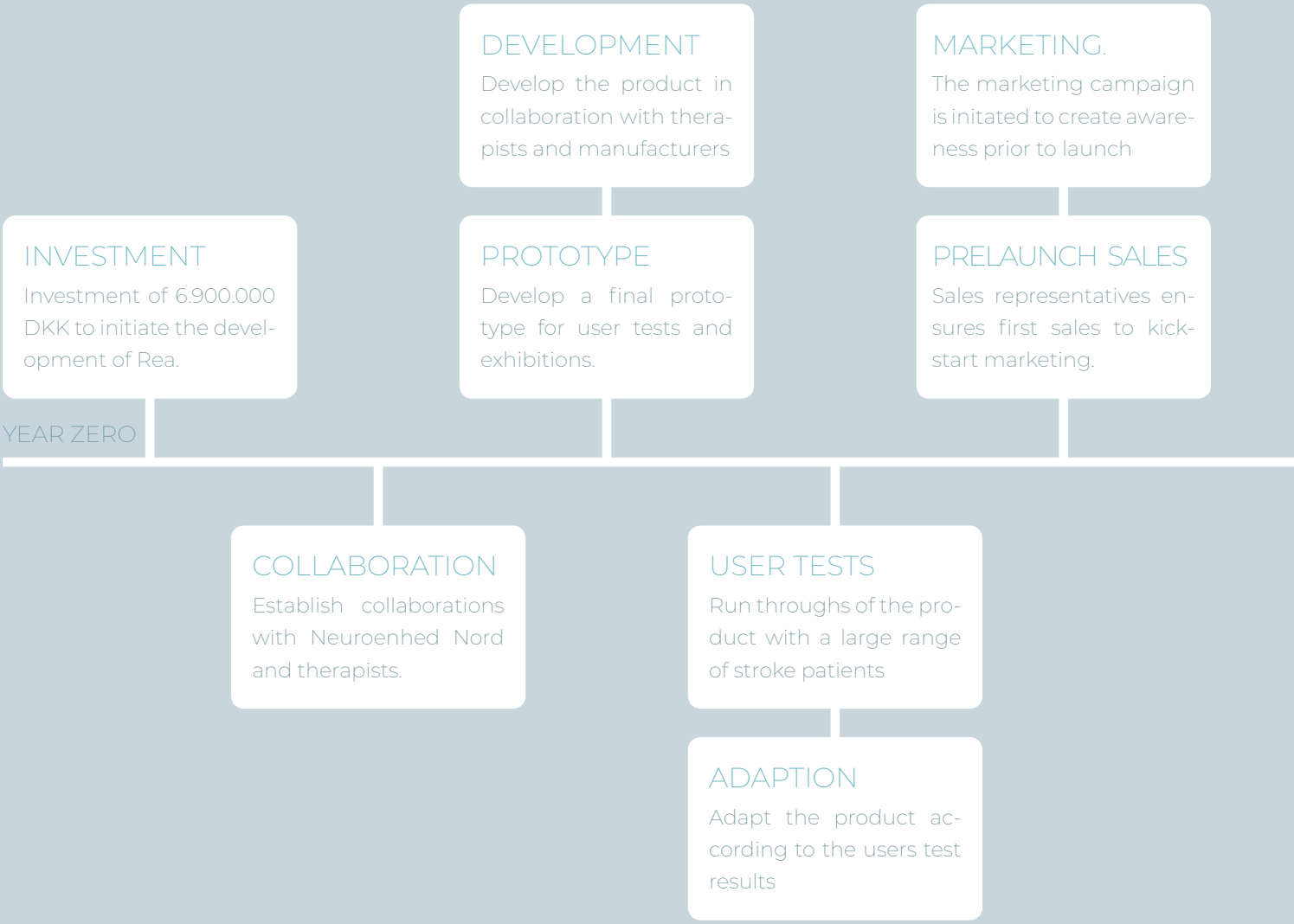
- Having fun while training
- Visible progress
- More effective rehabilitation

690 DKK

Monthly patient subscription

9.950 DKK

One time purchace for centers & therapists



Market strategy

ReSync as a startup has no financial resources, and will therefore rely on getting investors for the project. The most likely investor would be life science innovation who typically supports new healthcare products from northern Jutland. To get the word out about Rea, tharapists are the most valuable partners, as they will both serve as advisors for users during a programme with Rea, but also serve as a channel to recomend the product to new users and fellow therapists.

6.900.000 DKK

Estimated investment

YEAR ONE

YEAR TWO

YEAR THREE

YEAR FOUR

PRODUCTION

The first line of REA is manufactured for first sales.

OFFICIAL LAUNCH

REA is made avilable on the market. Resources will focus on sales.

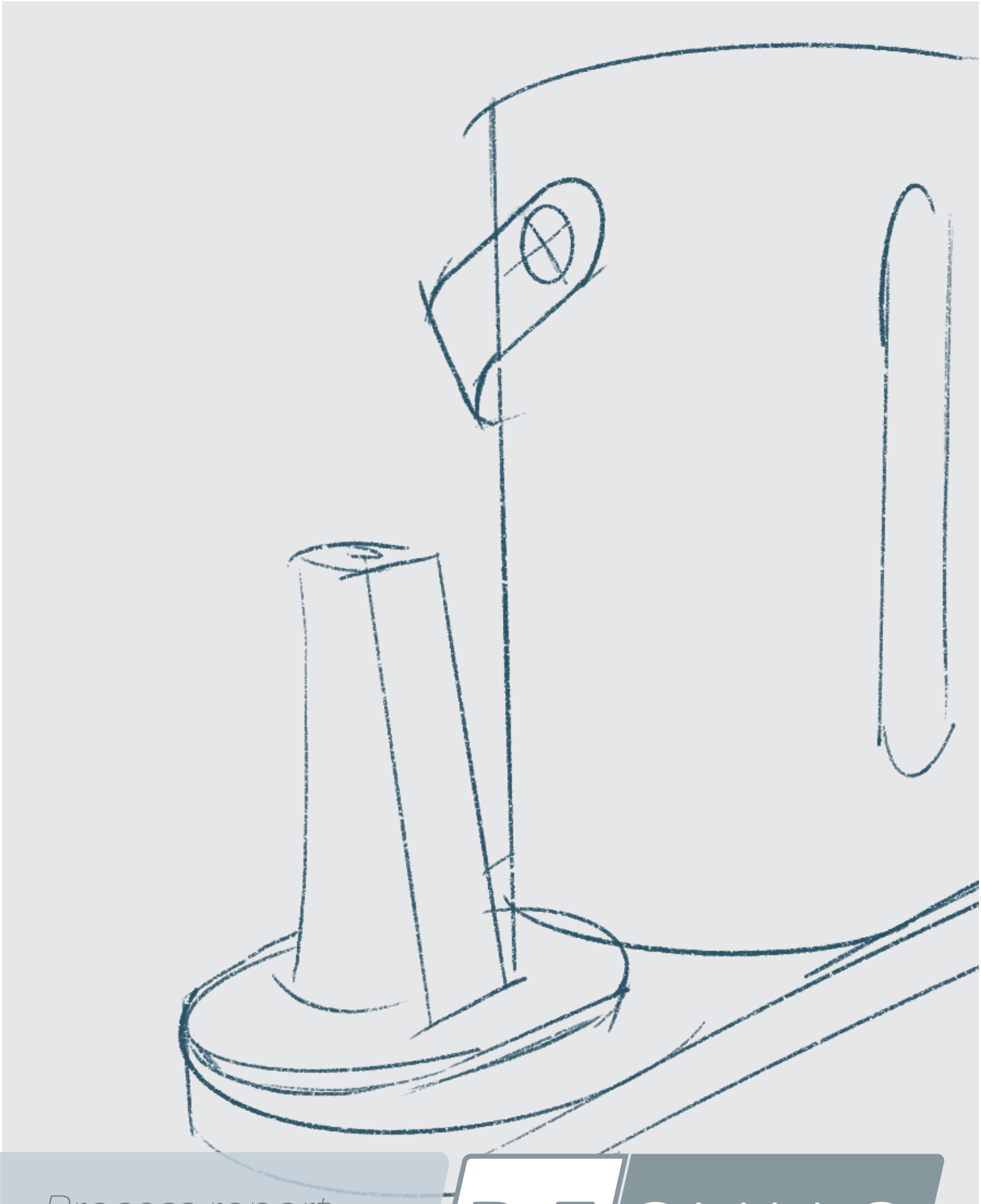
BREAK EVEN

The break even occurs enabling ReSync to pay back potential investors.

DEVELOPMENT

Initate the further development of expansions for the REA system.


AD NYE VEJE
AALBORG UNIVERSITET



Process report

Stroke rehabilitation

Aalborg university - Spring 2020
Industrial Design - MSc04 ID15
Sarah K.K. Lauritsen & Kirstine S. Appel

RESYNC

REA

TITLE PAGE

REPORT	Pocess
TITLE	ReSync - Rea
THEME	Stroke rehabilitation
PROJECT PERIOD	3/2/2020 - 3/6/22
PROJECT TEAM	MSc04 ID15 Spring 2020 Industrial Design Aalborg University
MAIN SUPERVISOR	Louise Møller Haase
CO-SUPERVISOR	Michael Skipper Andersen
PAGES	102

ACKNOWLEDGEMENT

The group would like to give special thanks to the people who helped drive the process forward:

Main supervisor Louise Møller Haase and co-supervisor Michael Skipper Andersen for supervision during the process.

Nicki Larsen from NeuroRehab, who helped give feedback, deepen knowledge of users, and to convey contact to other experts.

Occupational therapist Anja, for feedback on the cognitive aspects of the concept.

Development therapist Helle from Neuro enhed nord for feedback on framing.

User test participants Brian and Dorte for feedback on the interface.

Interview and questionnaire participants from the Facebook groups; Apopleksi - blodprop og blødning i hjernen and Hjernesagens netværk for voksne med hjerneskade for their feedback.

READING GUIDE

The project is presented in four reports;

- Product report: *Presenting the final product proposal*
- Process report: *Presenting the process leading to the product*
- Technical report: *Presenting the specifications of the product proposal*
- Worksheet report: *An internal appendix of activities and analyses performed during the process.*

This is the process report, which is a summarized documentation of the process consisting of six phases; Research, Project framing, Concept development, Interface development, Product development and Epilogue. The research within the report is a draw out from the total research amount which can be unfolded through the worksheets.

To ease readability, each section includes an objective and synopsis, describing the aim, process and outcome of each section. The report also contains four types of sum up boxes;

New framing of the project — Illu. 2

New knowledge gained — Illu. 3

Need identified in relation to interface — Illu. 4

Need identified in relation to product — Illu. 5

The references throughout the report are specified in accordance with the Harvard method [author, year] and illustrations a numbered consecutively “Illu. #”. Worksheets are referred to by their number (worksheet #) and can be seen in the worksheet report.

ABSTRACT

This master's thesis was made by ReSync (MSc04 ID15) from Industrial design, Aalborg university. The project was carried out during the spring semester, from the 3rd of February to the 3rd of June 2020.

This thesis covers the development of the product proposal REA, a stroke rehabilitation system, which enables and motivates stroke patients to perform self-initiated training, both at home and in early rehabilitation.

Through this project. it was explored how gamification could be implemented to motivate more frequent training, and how games could be utilized to guide patients through exercises.

Through a collaboration with a Neuro-specialized physiotherapist, the team gained insights into the rehabilitation process and -system in Denmark. This collaboration led to contact with other experts, whose insights helped to drive the design process forward along with continuous user feedback.

The resulting product, REA, enables self-initiated arm training by projecting an interactive interface onto any table by use of the integrated projector and depth sensor technology. Interaction is assisted by a handheld cursor, which enables support for the user's hand during training sessions.

By enabling self-initiated training, REA increases training frequency and maximizes training output, thereby giving the patient the best prerequisites to reach their highest possible level of function.

Sarah Krarup Kildahl Lauritsen

Kirstine Svenningsen Appel

Illu. 1

TABLE OF CONTENTS

INTRODUCTION

Stroke is the leading cause of physical disabilities worldwide [Schneider et al., 2016]. The repercussions after a stroke is significant for both the individual and for society in general, as the rehabilitation requires a large amount of resources [Flachs et al., 2015].

To get back to something resembling their original function level, it is necessary for stroke patients to repeat exercises and train their newly recovered functions and movements daily. Motivation for training is hard in itself for anyone, but even harder still for many stroke patients.

Often, they are troubled with an array of physical and cognitive injuries, and very slow progress in function level after the injury. This creates an even bigger barrier for training.

These challenges create the basis for an interesting and complex design problem, dealing with fascinating themes like motivation, age appropriation and the balancing act between the digital and physical aspects of a product.

APPROACH

PLANNING

MILESTONES

Planned milestones were used to section the process and set deadlines for results, before transitioning to a new phase.

SCRUM

Inbetween milestones Microsoft teams was used as a scrum board to keep track of tasks. The collums where organised by phase, and later category, to provide an overview of most important tasks in the current sprint.

DESIGN THINKING

This design process has been highly driven by frequent feedback sessions from potential users and experts regarding rehabilitation (physiotherapists, occupational therapist, development therapist). Testing problem framings and solutions through feedback served to drive the process forward, as it served to gradually narrow down the solution space and define the framing.

COLLABORATION

This project was made in collaboration with physiotherapist Nicki Larsen, who is the owner of NeuroRehab, a Physiotherapy clinic specialised in rehabilitation after neurological damage. He had previously been involved in development of electrotherapy products, and was happy to assist. This collaboration gave access to insights and contacts to other experts and the possibility to observe training sessions, which had a big impact in the design process.

NeuroRehab

Illu. 6

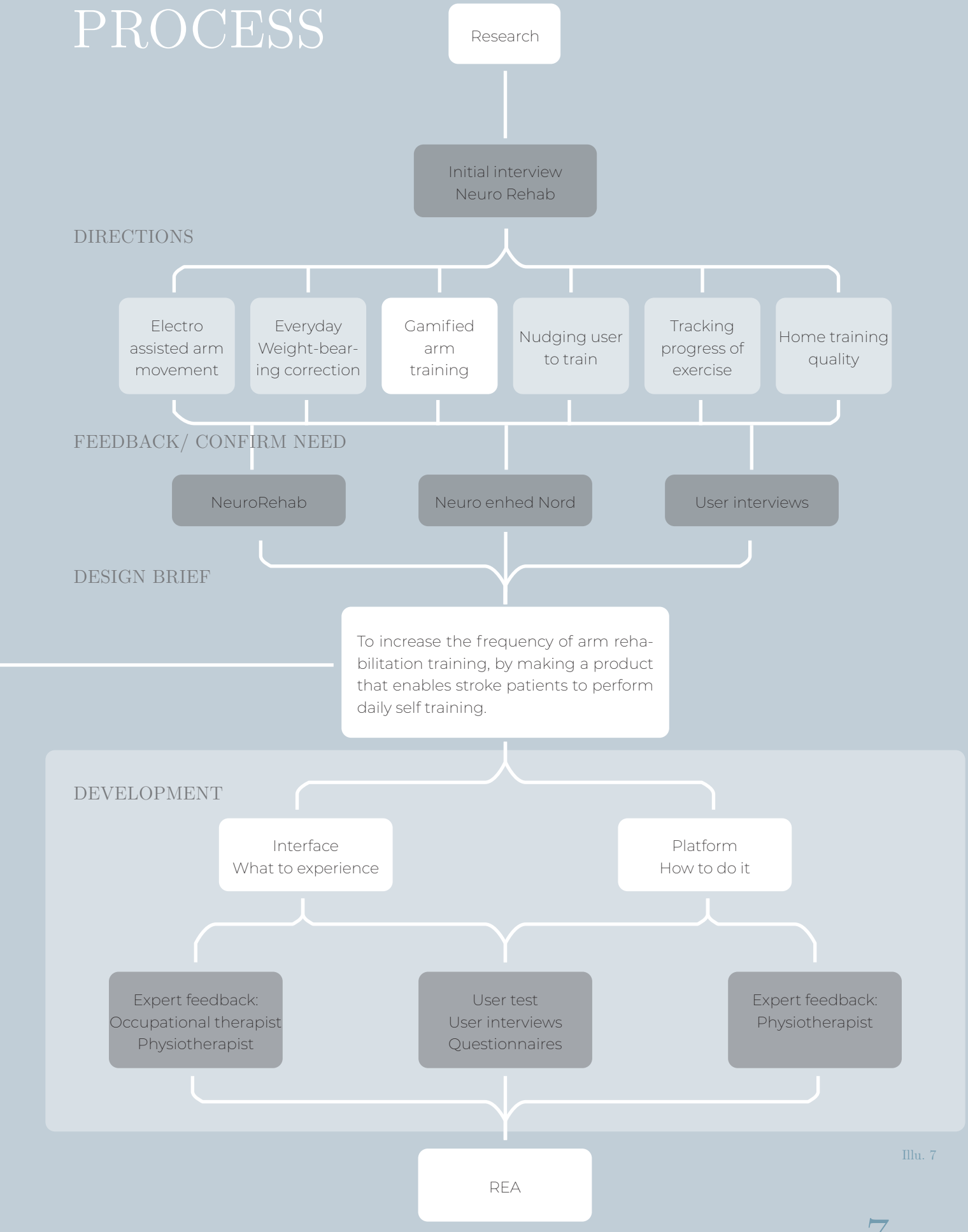
FRAMING

INCREASE TRAINING FREQUENCY

ENABLE HOME TRAINING

ENABLE SELF INITIATED ARM TRAINING

PROCESS



Illu. 7


INTERNATIONAL EDITION
Not authorised for sale in North America and the Caribbean
MUSCLES
FACEBOOK ANNONCERING
MUSCLES
Neurologi og neurorehabilitering
BASISBOG I FYSIOTERAPI
Bente Schibye
Klaus Kruuzen
MENNESKETS FYSIOLOGI
Bente Schibye og
pindespil
DAFFELS VARETHS

Illu. 8

RESEARCH

In this phase it is sought to create an initial understanding of strokes and what happens during rehabilitation. This will create an understanding which will be the basis for project framing and problem identification.

KEY ACTIVITIES

DESK RESEARCH
Scope
Stroke
Disabilities

MAPPING
Rehabilitation process

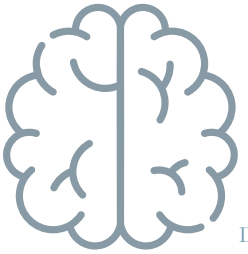
THE SCOPE OF STROKE

To get an idea of the market size and furthermore investigate whether there is a societal relevance for a product designed for stroke patients, it is relevant to look at the scope of the illness, and the personal and societal consequences.

Illu. 9

Stroke is the cause of 7% of all deaths in Denmark

[Flachs, E.M. et al, 2015].



Illu. 10

15.000 new incidents of stroke in Denmark each year

[Flachs, E.M. et al, 2015].

Illu. 11

Societal cost of 4.660 million DKK due to stroke care and lost production

[Flachs, E.M. et al, 2015].

Illu. 12

66% of stroke patients is limited in the daily life a year after.

[Flachs, E.M. et al, 2015].

Stroke in numbers

Stroke is the leading cause of physical disabilities worldwide, with decreased function in the legs and arm being the most common. [Schneider et al., 2016]. In Denmark 93.266 people are living with implications after a stroke and every year 15.000 new incidents are recorded. A large percentage will still experience disabilities in their daily life, even after rehabilitation has ended, examples being extreme tiredness, cognitive difficulties and physical limitations [Mayo et al, 2002].

Framing

From the data gathered, it can be concluded that strokes are a problem with a huge scope, both worldwide and in Denmark. The illness impacts people's personal lives, but also their ability to work and thereby the social economy. This highlights the relevance for designing a product for this group of people, as it is a persevering problem both through individual people's lifetime and through the continuous incidents each year.

There are two product opportunities within this sector; a product, which helps stroke patients in their daily life activities and a product, which aids stroke patients to rehabilitate their functions quicklier. In this project, the latter will be in focus as it will have a larger societal impact, to increase the possibility for the user to return to the working force.

Increase functionality after strokes

WHAT IS A STROKE?

The objective of this section is to get an basic understanding of strokes in terms of what causes it, how to prevent it and how it affects the person with the condition. This will create a foundation for what the limitations of the user are and which disability the product can help rehabilitate.

The cause

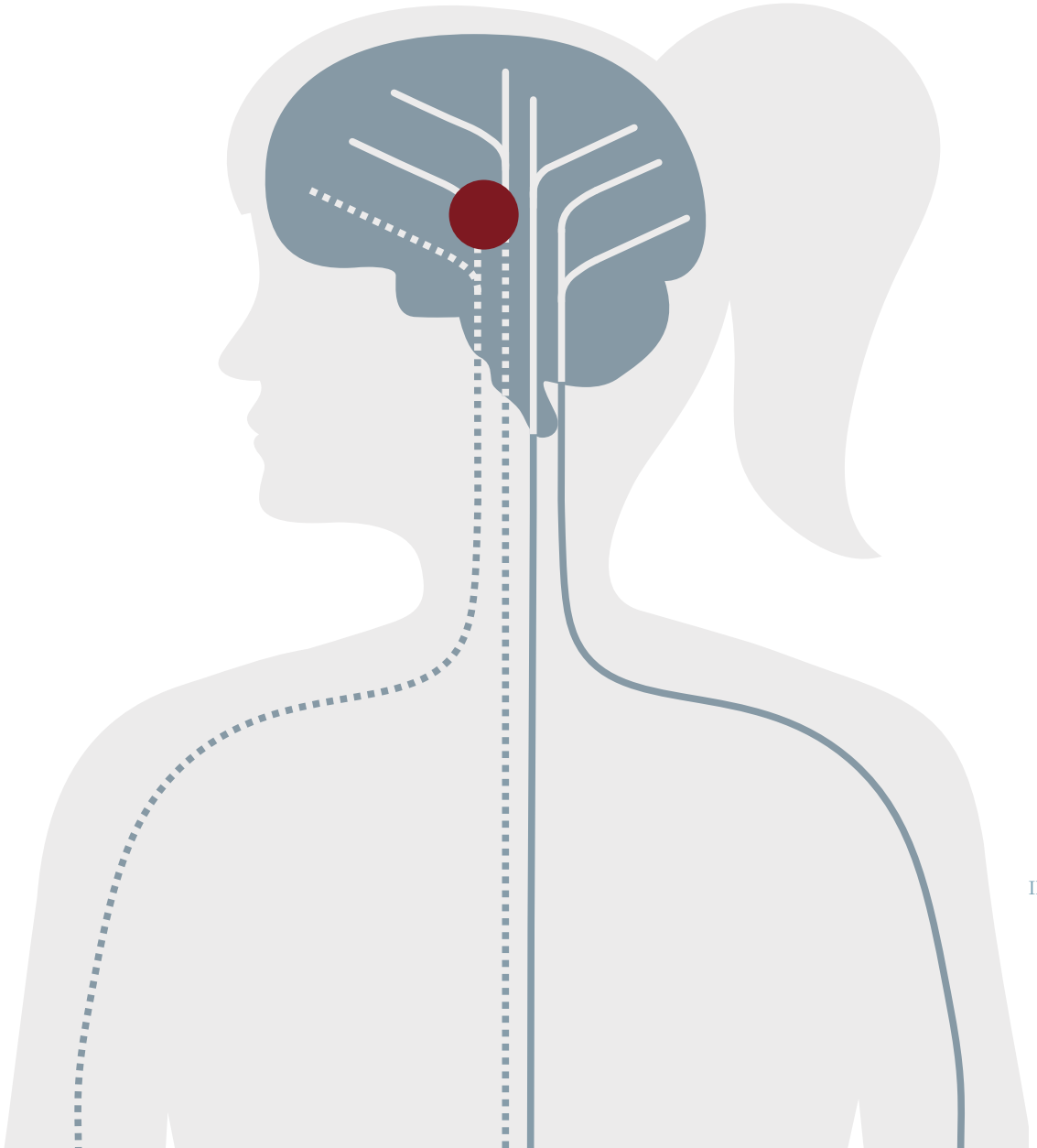
A stroke is a medical condition in which poor blood flow within the brain causes a loss of brain cells.

The brain cells function is to send electric signals to the muscles in the body, controlling each of our movements from speaking and eating to running and throwing a ball. The brain cells need oxygen and nutrients to function, which is supplied by the blood within the vessels. Therefore, when the blood flow in the vessels are obstructed or limited, the brain cells will start dying within minutes, leaving permanent injuries.

The poor blood flow can be caused by two conditions; A blodclot or a hemorrhage in the brain [Christensen, 2019].

Risk factors

Illu. 13



Illu. 14

Disabilities

When the brain cells die, the signal they send to the muscles and other cells within the body is disrupted. This leads to permanent disabilities, mostly located in the opposite side of the body compared the location of the stroke in the brain [Christensen, 2019].

The disabilities affect the level of function and the activities of daily living (ADL) for the patients [Ackerman et al., 2009] and depend on the location in the brain and the severity of the damage and therefore vary greatly from person to person. [Christensen, 2019].

Cognitive difficulties

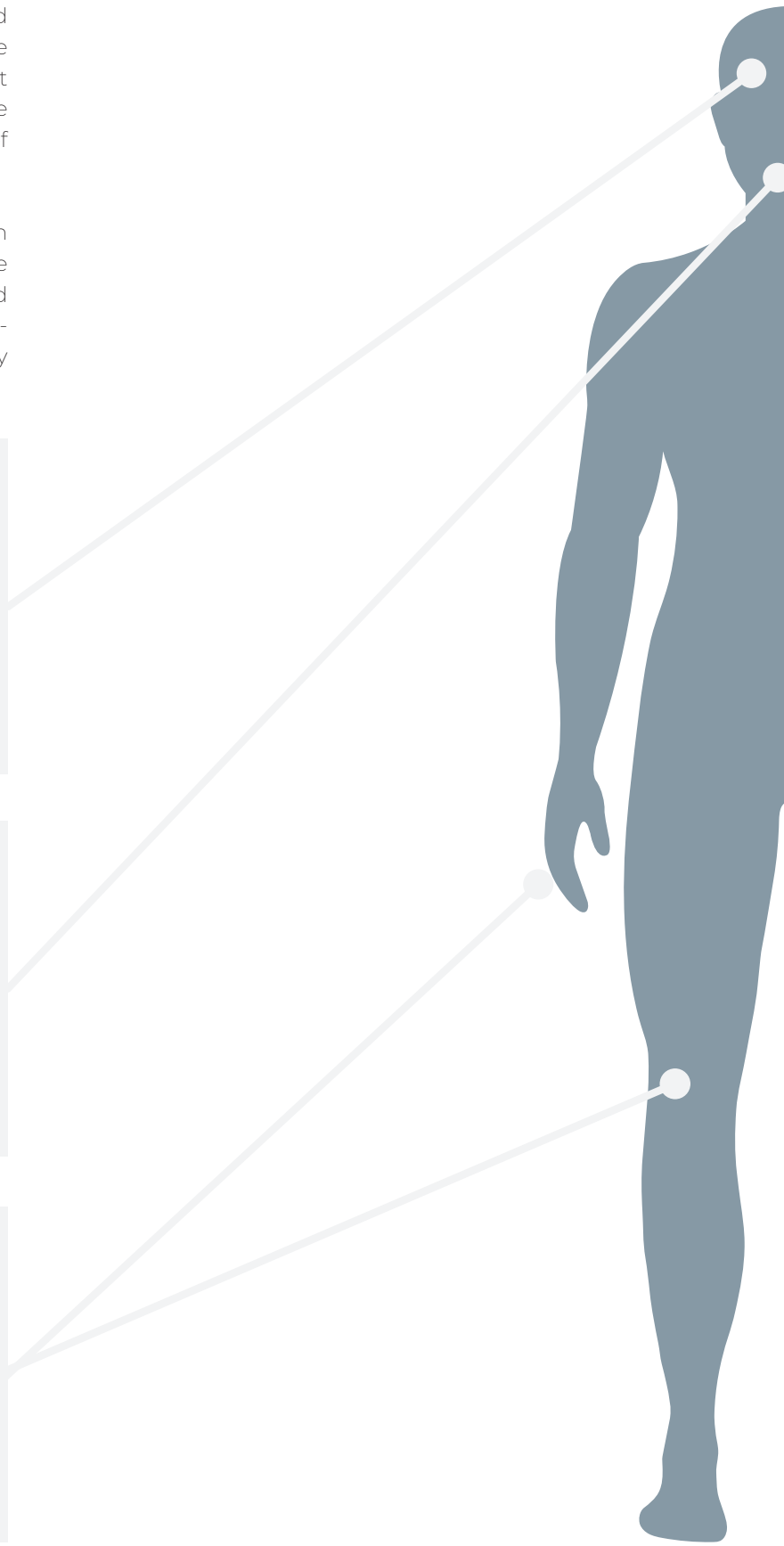
Difficulties within memory, concentration, planning and problem solving (executive function) are just some of the impairments that can occur after a stroke. This creates challenges throughout the day, leading to frustration and increased brain fatigue. [Stroke Association, 2018].

Aphasia

A language processing disorder. Affects your ability to understand spoken and written words/sentences, recall words and formulate sentences. This can be both expressive (not being able to speak) and impressive (not being able to understand others) [Hjernesagen, 2019]

Paresis

A decrease of function in one or more muscles. This frequently occurs in the arm or leg in one side of the body (Hemiparesis). The function decrease can range from fine motoric to gross motoric. The muscels might be spastic, which is further inhibiting movements. [Hjernesagen, 2019]



Illu. 15

Brain fatigue

An overwhelming tiredness within the body and brain. This can occur after simple activities like hanging up laundry or a simple conversation, as they have to focus on every movement and action. The severity varies from person to person. [Hjernesagen, 2019]

Visual impairment

The field of sight, the ability to determine distance, read and balance are some of the areas, which are decreased as a result of the visual impairment. This affects how the person interacts with everyday objects and creates challenges in designing products. [Hjernesagen, 2019]

Weight-bearing asymmetry

A tendency to shift weight-bearing onto to the unaffected leg, occur for most patients with hemiparesis. This leads to postural imbalance, a decrease in motor functions and a difficulty in performing activities of daily living (ADL). [Sackley, 1990]

Paralysis

Total loss of function in one or more muscles. The muscles can be either limb (hypotone) or tight (hypertone, spastic). This often occurs one-sidedly in the arm, leg or face (Hemiplegia). [Hjernesagen, 2019]

The outcome of this section was an understanding of the limitations and challenges a stroke patient faces.

Challenging factors like the cognitive limitations, the vision impairment, aphasia and brain fatigue should be taken into consideration in product development. Paresis, paralysis and weight-bearing asymmetry are areas, which could be potential focuses for a rehabilitation product.

The product should accommodate the limitations of the user

REHABILITATION PROCESS

To be able to make a product to aid in rehabilitation, it is important to get an overview of what it means to rehabilitate and how rehabilitation is being carried out today. The aim of this section is therefore to understand what happens in the brain in rehabilitation, which strategies are effective, and which offers are available for assisting rehabilitation.

> *REHABILITATION*
> *noun*
> *The action of restoring someone to health or normal life through training and therapy after imprisonment, addiction, or illness.*
> *[Lexico, 2020]*

The plasticity of the brain

The plasticity of the brain and how it functions as a network, is the foundation for rehabilitation. When stimulating the muscles affected by the stroke through various rehabilitation methods, new connections can be created between the brain cells and the muscles to replace those lost. Thereby regaining the functions lost after the stroke.

However, rehabilitation of brain damage of any kind is associated with great complexity, as what function can be regained is dependent on the placement and severity of the damage. Some may get close to their former function while others will see very little improvement [Andersen et al., 2012].

> *A rehabilitation program should combine specific cardio training, strength training and functional training*
> *[Andersen et al., 2012, p.70]*

Strength training

Within 1-2 weeks of immobilization, patients will experience a significant decrease in both muscle span and within the nervous system. Therefore, it is important to include strength training in a rehabilitation program, but it cannot rehabilitate any individual alone. [Andersen et al., 2012]

Cardio training

If the stroke patients do not start cardio training after the stroke incident, they will not be able to perform daily tasks within a few months. Therefore, it is also important to include cardio training in a rehabilitation program but cannot either be used alone to rehabilitate the patient. [Andersen et al.,

Functional training

Functional training is defined as exercises that either relate to daily activities or is goal oriented. Examples of this could be moving a cup towards the mouth or moving a object from one marked spot to another.

Without a goal and continuous increase in difficulty, there will only be insignificantly neuroplastic changes and the patient will not improve. Just 20 minutes of functional training leads to an functional improvement, but if the exercise is not repeated within a few days, the improvement will not last and only be temporary.

All together, functional training should be performed daily and vary in both difficulty and exercises performed to accommodate various tasks and users. [Andersen et al., 2012]

Illu. 16

From this section, it can be concluded that it is possible to rehabilitate after a stroke but it is essential that training is functional and repeated daily.

Strength training and cardio training is important to include but do not enable the patients to rehabilitate to a functional level alone.

Therefore, the focus henceforth should be to iensure functional training in the patients everday life. The next section will explore the current rehabilitation process.

Ensure daily functional training

Training should adapt to each individual patients in term of the exercises and difficult

Training needs to be functional and repeated daily to gain functional improvement

REHABILITATION ROADMAP

Through their rehabilitation, patients will come in contact with different institutions and therapists, to help them through the process from incident til end of rehabilitation. This process, which might take anything from a year to the rest of the patient's life, is mapped in this section

Stage one - Acute rehabilitation

After a stroke, the patient will be taken into intensive care to minimize the damage and thereby the loss of function. In the following days, intensive rehabilitation will start and include the first attempts to sit, stand and walk depending on damage.

It is critical to start rehabilitation right away, as the resulting recovery of function is highly dependent on how early it is initiated [Hjernesagen, 2019].

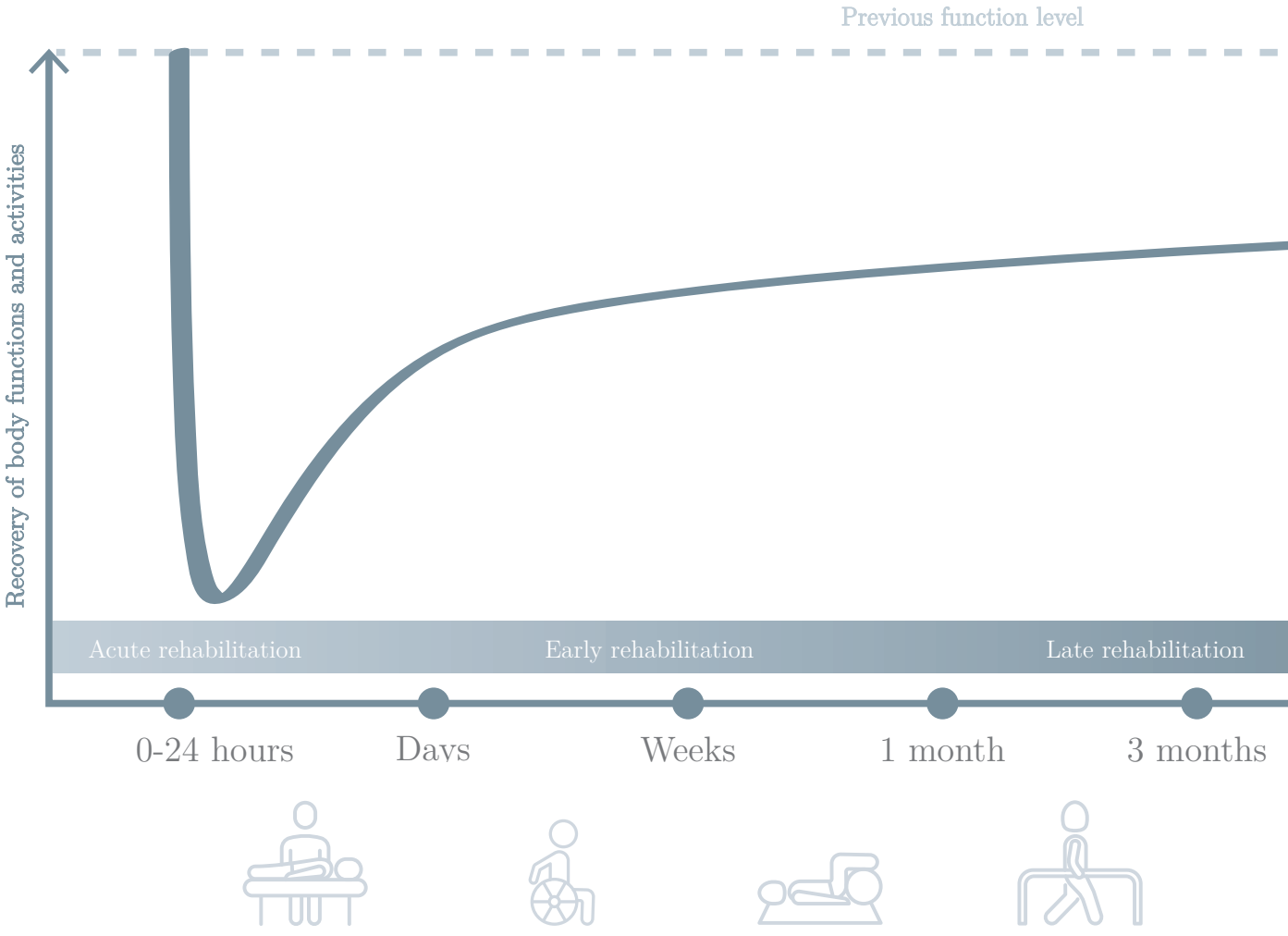
Some might recover completely in the first couple of days, while others will have a life-long handicap, depending on the severity and the placement of the stroke [Forchhammer, 2019].

Stage two - Early rehabilitation

After the intensive care at the hospital, many are in need of early rehabilitation. This might be people, that are not able to sit up, walk or use their arm. Rehabilitation can continue for months at a specialized rehabilitation center or with weekly therapy, funded by the municipality. [Hjernesagen, 2019].

The therapy used can either be; Physical rehabilitation (Standing, walking and activities of daily living) or Specialized therapy (Speech or eating)

The first three months is where the most function will typically be regained. After this the curve will slowly plan out. [Hatem et al., 2016]

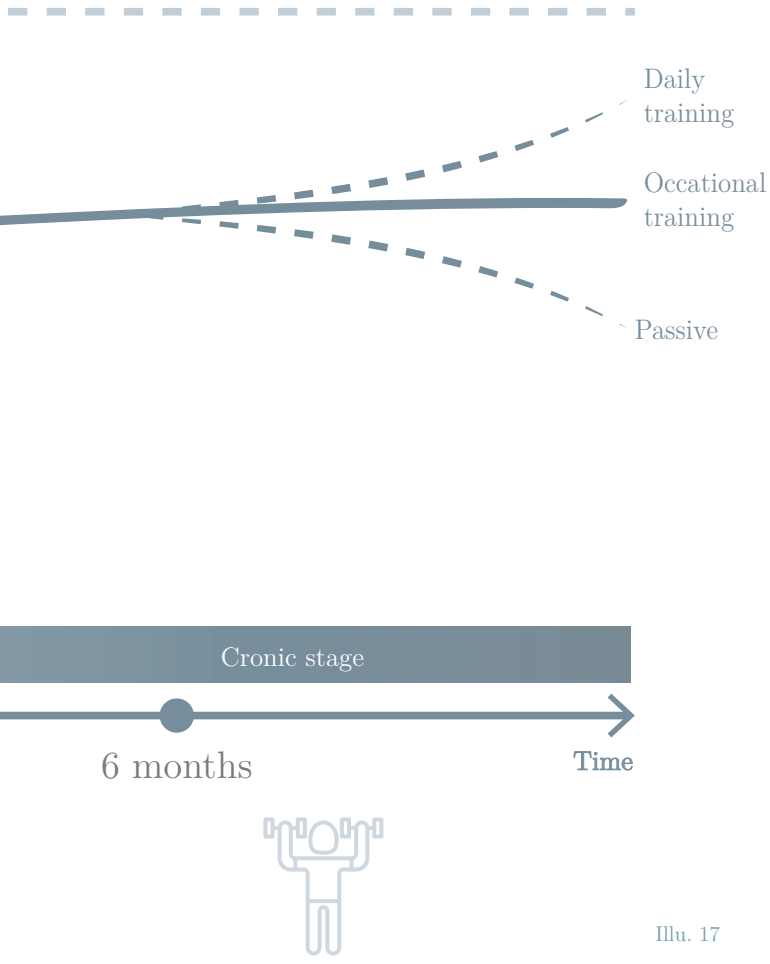


Stage three - Late rehabilitation

In the late rehabilitation stage, improvements can still happen for some, although more slowly [Hatem et al., 2016].

The level of function can either rise, plan out or decline depending on training frequency, efficiency and nature. If the patient still has a severe physical handicap ei. not able to take care of themselves without help or aids all 24 hours of the day, he/she is eligible for free physical theraphy.

This can either be individual or team based depending on whether the patient is able to cognitively/physically [Sundhedsstyrelsen, 2019].



Illu. 17

Physical therapy

Individual physical theraphy sessions will naturally be more focused on the individuals needs and progress, compared to group sessions, which will be adapted to a broader crowd. Group sessions might include elderly or people with other neurological illnesses as epilepsy or parkinson.

Training sessions range from 30 minutes for individual sessions and 60 for group sessions, 1-3 times a week. Furthermore, as a stroke is not characterised as a degenerative illness, many stroke patients receive little to no physical theraphy [Sundhedsstyrelsen, 2019], (worksheet 1.20).

Discussion

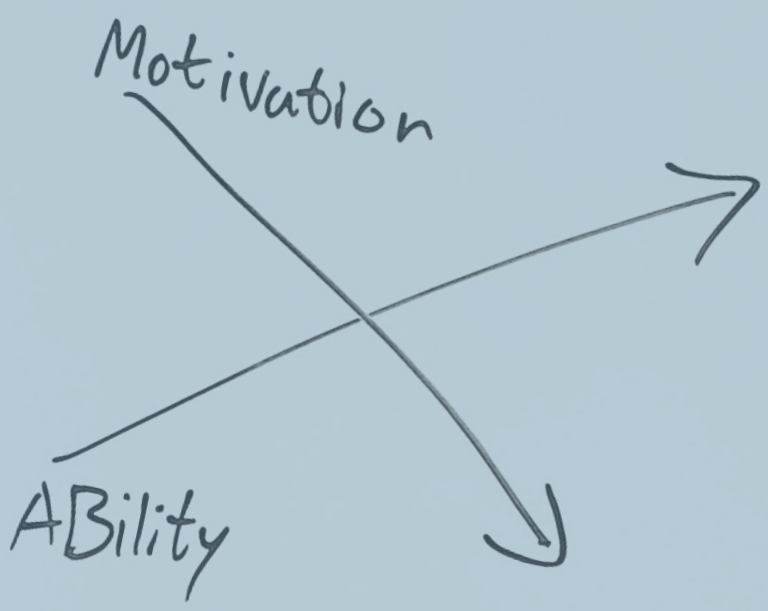
Consequently at this stage some do not receive enough training to continually develop, as they do not repeat exercises every couple of days, but only once a week .

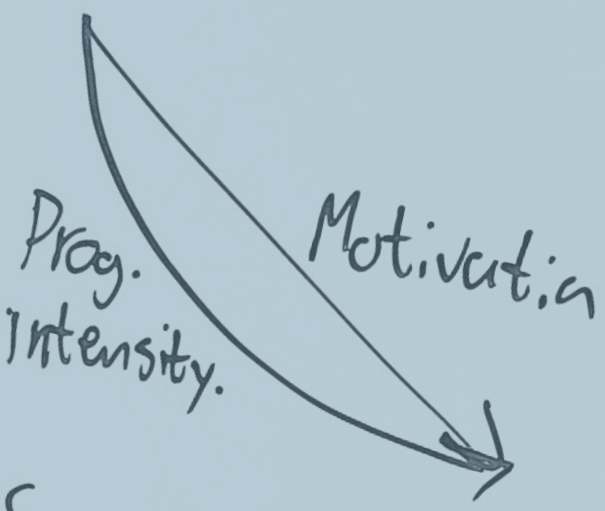
This occurs even though some still have the potential to improve their functions [Hatem et al., 2016]. Instead recovered functions will only be maintained, as weekly training keeps the patients from getting passive. In the worst case scenario some might actually get worse as a result of lack of repitions (Worksheet 1.12 and 1.16).

From this section, it can be concluded that it is essential that training is functional and repeated daily and that patients, do not receive enough functional training from physiotherapy alone. The framimg from this point on, will therefore be to explore how stroke patients can be enabled to train more frequently.

Ensure daily functional training in the late rehabilitation stages.

Stroke patients do not receive enough training in late rehabilitation

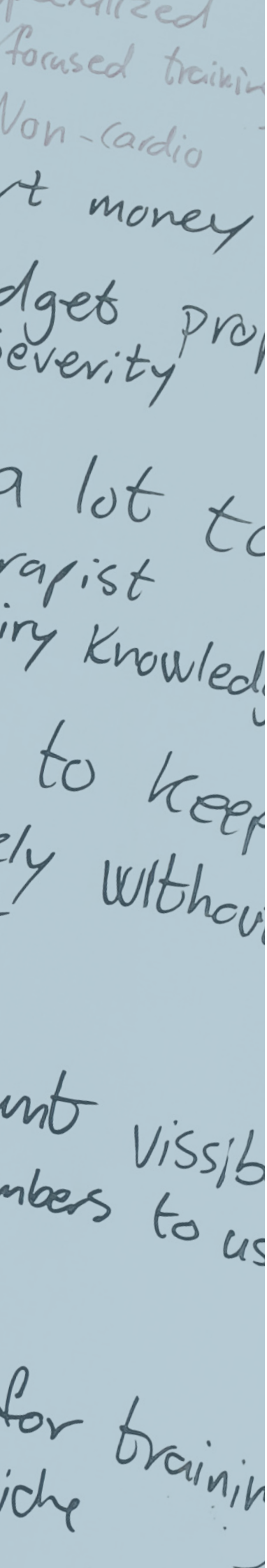




Someone has
o push you
n is more mot.
ctiona ex is good
↳ clothespin
cial;zed/focused
ing +
g + is coping
nas

18

• Suppor
• Eg. bu
With s
• Listens
Physiother
↳ Prima
• Not likely
training week
Physiotherapist
• Keeping equime
Confronts → reme
• Need directions
x2 ↳ good user gu
• ÷ network



PROJECT FRAMING

In this phase it is sought to explore challenges and opportunities within the context of post stroke rehabilitation. The goal is to get an overview of the strategic environment and its product opportunities to frame the insights into a full design problem.

KEY ACTIVITIES

INTERVIEW
Neurophysiotherapist
General physiotherapist
Development therapist
User observation
User questionnaire
User interview

DEVELOPMENT
Initial ideation sketching
Act it out video
Brain storm

DESK RESEARCH
Market analysis
Ability levels

Illu. 18

LATE REHABILITATION CHALLENGES

To understand the rehabilitation process further, two physiotherapists have been interviewed to define possible challenges for therapists and patients in late rehabilitation, from their perspective. (Worksheet 1.10, 1.13)

Interview

Illu. 19

Neurophysiotherapist
NeuroRehab

Interview

Illu. 20

General physiotherapist
FysioDanmark

Observation

Illu. 21

Training session at
NeuroRehab

Home rehabilitation

Due to the limited physical therapy sessions, patients are appointed simple daily exercises, which should be performed at home. An example of these exercises is sliding a cloth back and forth on a table. This creates a range of challenges (Worksheet 1.10).

Lack of motivation

The patients experience a lack of motivation due to lack of progress and the nature of the exercises. This leads to a lack of repetitions for each exercise, which is essential for the recovery.

Compromised quality of exercise

It is difficult to ensure and monitor the quality, but highly relevant as increased quality equals increased output.

Arm rehabilitation

The therapists experience that the arm can be deprioritized in comparison to the rehabilitation of the legs. This results in a lack of products within the area of arm rehabilitation, that are affordable and motivational (Worksheet 1.10).

Too expensive

Most products on the market has a price point of 80.000 DKK+, which is hard to overcome. The price of a product should be around 10.000 DKK for the therapists and 5.000 DKK for the patients.

Too simple

The simple products makes it hard to track the progress of the user in physical theraphy sessions and motivate the user to use the product.

Illu. 22

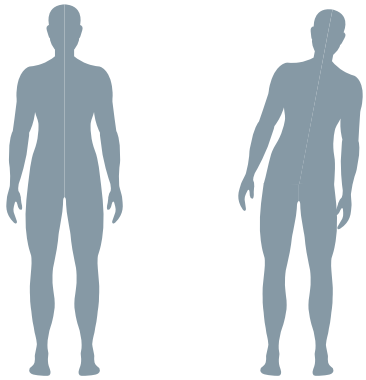
Illu. 23

Weight-bearing asymmetry (WBS)

A large range of the patients struggle with weight-bearing asymmetry. Most of the afflicted are able to correct their posture, but are not aware of it occurring.

Lack of correctional tools

According to the therapist, the current products on the market are focused on use within the physical therapy session and not on use throughout the day. (Worksheet 1.10).



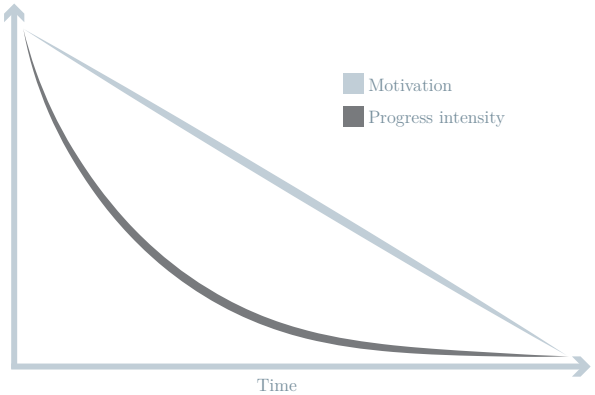
Correct WBS Right WBS

Illu. 24

Progress

In the late rehabilitation, progress will increase more slowly and in smaller steps than earlier. This decreases the motivational factor of the exercises as seen on the representation below.

Patients have a hard time understanding their progress if it is not exemplified visually. It is important to either visualise some progress clearly or the patients will not perform the exercises regularly (Worksheet 1.10,1.12).

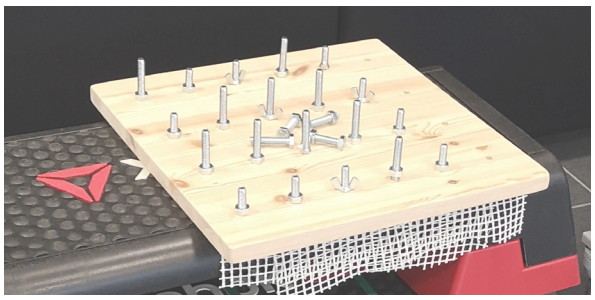


Illu. 25

Coping methods

The current coping strategies related to the lack of equipment for the arm, is the creation of simple homemade products by the therapists themselves.

The physiotherapists do not currently have any other coping methods to avoid experiencing the other problems discovered. (Worksheet 1.10,1.12)



Illu. 26

The main outcome of the research above, was a confirmation of the need for an increase of rehabilitation exercises. In relation to this, it was clear that there was a large potential for solutions adapted to home rehabilitation.

This would have a great impact on the number of exercises and repetitions the user could do daily. Additionally, the lack of products within arm rehabilitation and weight-bearing asymmetry correction, which could be interesting to explore further.

Ensure daily functional training at home in the late rehabilitation.

Maximun exercise output requires quality of the exercise

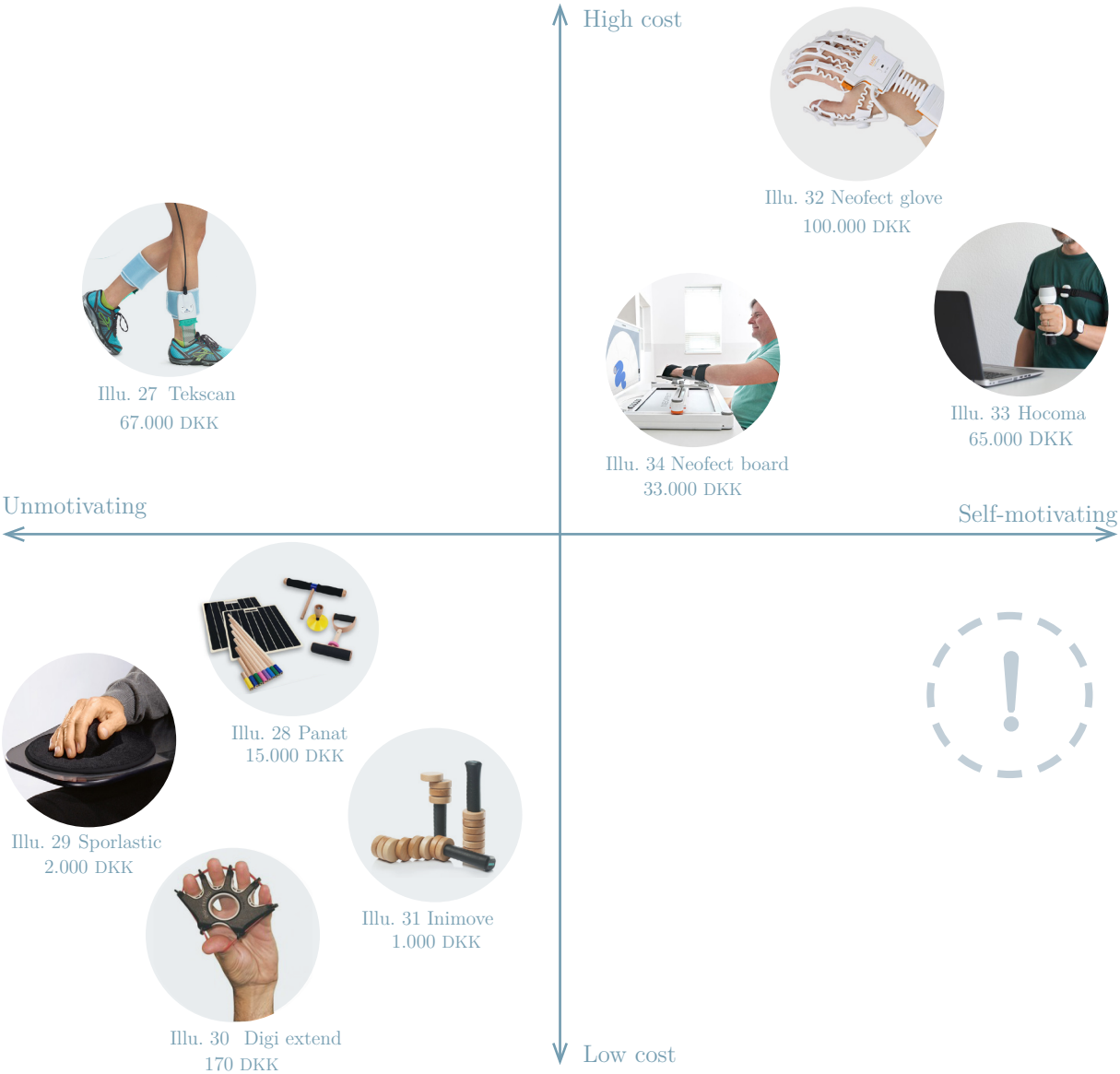
Training should motivate the user by eg. showing progress clearly

A new rehabilitation product should not cost more than 5-10.000 DKK

Physiotherapist has an interest in utilizing progress data in the sessions.

MARKET

In this section trends and existing rehabilitation products used in late rehabilitation have been analysed to get an understanding of the rehabilitation market. This was done to verify the holes in the market expressed by the physiotherapists, and to gather inspiration from new innovations on the market.



Motivation contra cost

When plotting the products currently on the market into a Cost-Motivation matrix, the expression of a need for simpler yet self-motivated tools are confirmed. Current products are clustered between High cost, motivational devices and low cost ultra simple tools.

Products in the top right include large machines, and small electronic controllers, focusing on creating a motivational factor for the user, and can be used without close monitoring by a therapist.

This is contrary to the other corner, where the products are simple training tools, that has to be thoroughly guided by a therapist, as they don't provide any guidelines in themselves.

This shows a potential do make something in the crossfield between expensive self-motivated products and low-cost therapist-motivated product. (Worksheet 1.14)

Illu. 35

Gamified training

Gamified rehabilitation products, market themselves by increasing repetitions of exercises due to the motivational factor counterweighing the lacking progress motivation. This contributes to self initiating, enabling the patient to train at home, increasing the repititions.

Few of these products focus on specific arm rehabilitation and none functions without a screen and digital gameplay (worksheet 1.14).

Illu. 36

Exoskeletons

Robotics and sensor technologies have entered the market of rehabilitation in the form of exoskeletons assisting movements, specialized controllers for games and sensitivity/massage machines.

The aspect of automatization of training seen in these solutions shows the desire for less one-on-one time which saves time for the therapist, but comes with a high price point (worksheet 1.14).

Illu. 37

Electrotherapy

Knowledge of this therapy form has matured in junction with technology, and devices assisting walking and grasping are available.

The walking movements seems to function better with electro therapy than arm/hand movement as the movements are more simple. (worksheet 1.12) Therefore, electrode placement for products focusing on the arm can be an issue in these products (worksheet 1.14).

The trend analysis gave new inspiration for possible directions within electrotherapy and gamification. Both seem to be very successful approaches to therapy, while still leaving room for improvement.

The analysis of the products currently on the market confirm the need for cheaper, but more motivational rehabilitation tools in the space between expensive machinery and simple wooden tools.

Market gap for cheaper self motivated training !

Potential directions: Electrotherapy and gamified training !

INITIAL IDEATION

The next step was to unfold the solution space surrounding a home rehabilitation product, define potential directions and verify these directions with the collaborating physiotherapist and users. The intended outcome was, to create a foundation for the further concept development and to increase the understanding of the problems.

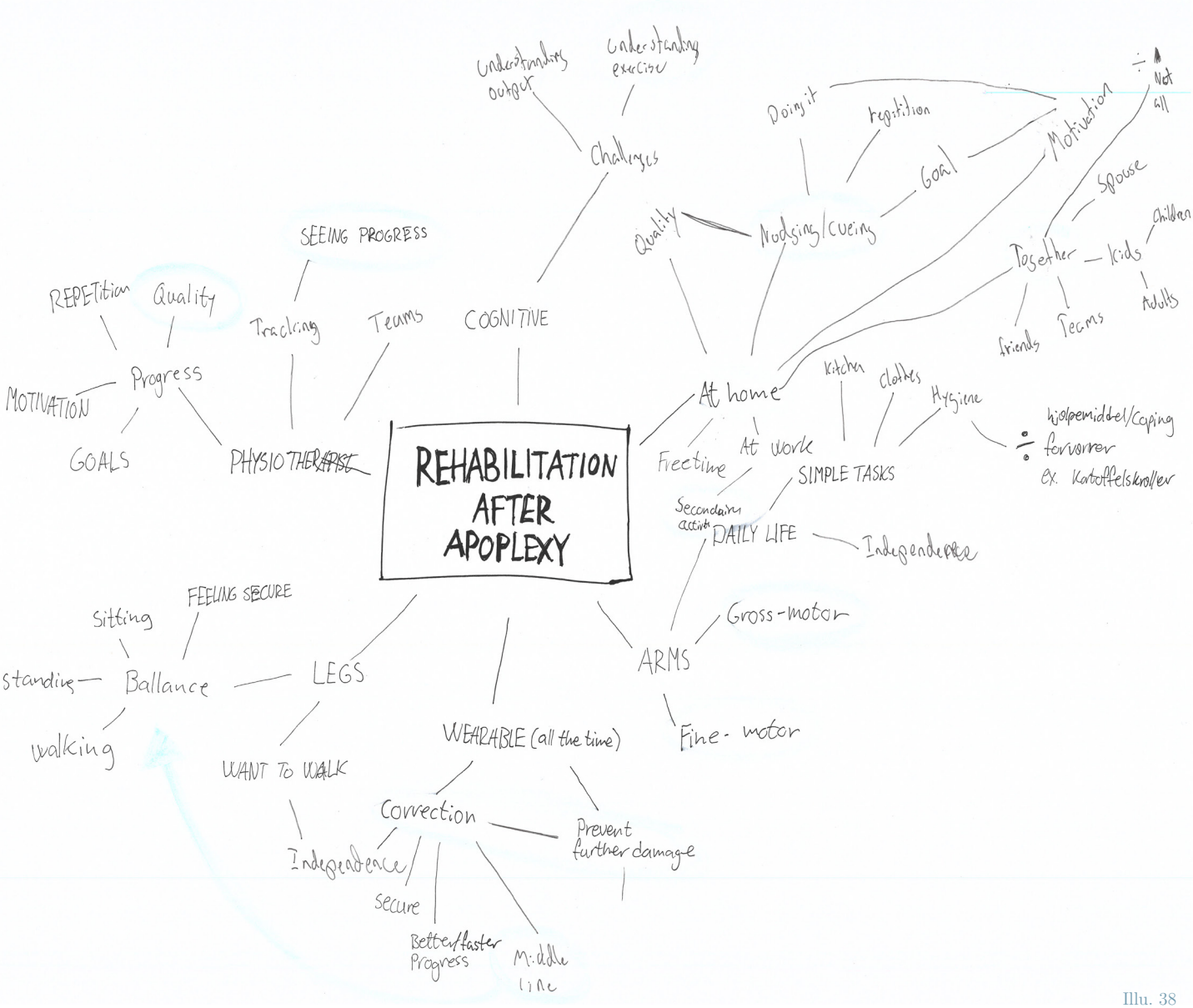
The creation of six directions

Based on the pre-established knowledge from the research, interviews and observations, a mind map was created (worksheet 1.11).

The mind map contained terms subtracted from the main theme "Rehabilitation after a stroke" and summed up the problems and opportunities discovered throughout the previous phases.

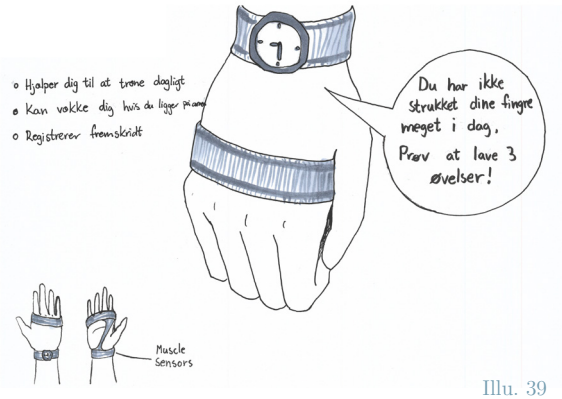
A quick sketching session based on the mindmap led to sixteen ideas, of which six directions were selected for further development. (worksheet 1.11).

The directions seen on the next page is not meant as outright concepts, but rather general directions for the further development of product concepts.



Illu. 38

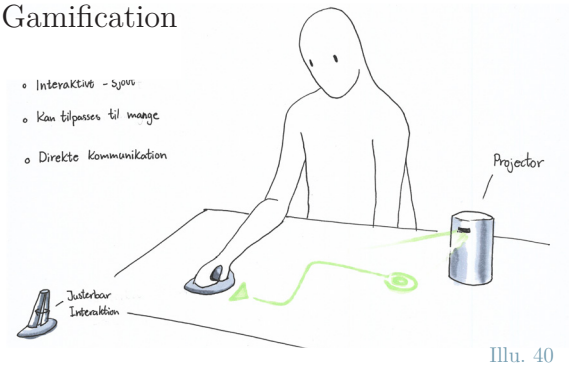
Nudging the user



Illu. 39

To increase the frequency of training at home the user is nudged by an external source to remember to train.

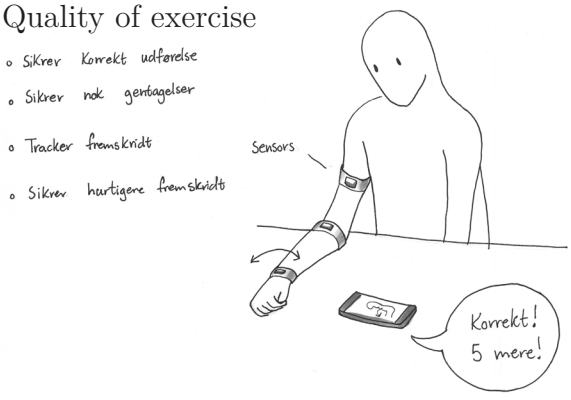
Gamification



Illu. 40

Increasing the “fun” element of the arm rehabilitation exercises to motivate the user to use the product more frequent.

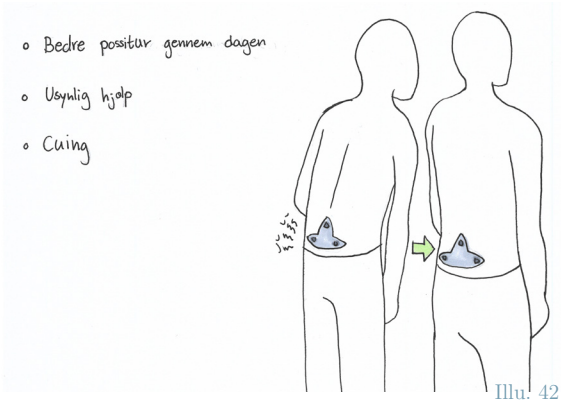
Quality of exercise



Illu. 41

Ensuring the quality of the arm rehabilitation exercise at home with technology like movement tracking.

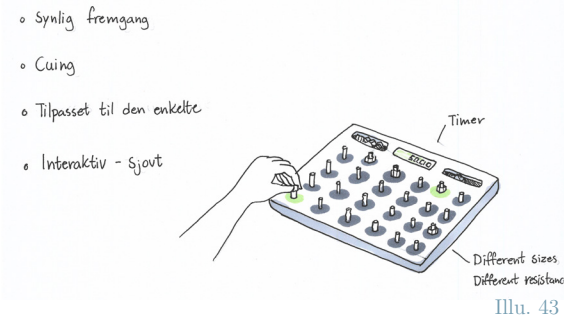
Correction of weight-bearing asymmetry



Illu. 42

Registrering and alerting when the symmetry is off, so the patient becomes aware and can correct themselves.

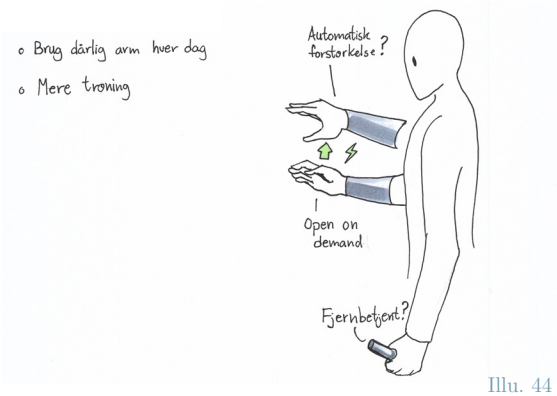
Tracking the progress



Illu. 43

Enabling tracking of the progress through a improvement in time, performing fine motoric arm rehabilitation exercises.

Electro controlled movements



Illu. 44

Utilizing electro therapy to control muscle movements aiding in everyday tasks and arm rehabilitation exercises.

PATIENTS PERSPECTIVE

To understand the problems from the perspective of the users, a questionnaire was distributed to the user group via relevant facebook groups (worksheet 1.15). Interviews with select people from the questionnaire were performed for more elaborate answers. (worksheet 1.16)

Questionnarie

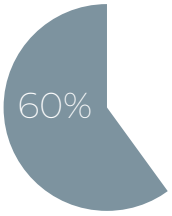
Illu. 45

137 users.

Interview

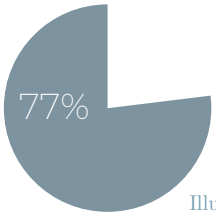
Illu. 46

Three users



Illu. 47

Users already own home rehab. equipment



Illu. 48

Users are doing or open for doing home exercises

Listens to the experts

The users noted that the training with regular physiotherapist feels unspecialised and not focused on individual needs as they train with people with various other afflictions.
Yet, the users all listen closely to advise from their therapists regardless of speciality and follow their recommendations. (worksheet 1.11)

Do not know where to start

The users stated that they would like to be able to use the arm more, but do not know how to start. (worksheet 1.16) This confirms the insight concerning lack of products for the arm, and the need for specific guidance during training (worksheet 1.11).

Progress matters

In the beginning of the rehabilitation, where the disabilities are worst, the users push themselves more. When they get discharged and have regained more functions, the motivation for training decreases as the progress curve flattens and they get more used to the disability and loose hope of improvement. (worksheet 1.11)

Ready for home rehabilitation

The high percentage of users either doing or open for doing home exercises validates that there is a market for a rehabilitation device targeted home exercises. Many of the users already had rehabilitation devices at home, but these were mainly focused on either strength or cardio exercises.

As determined continuously throughout this process, these types of exercises are not sufficient alone, which consolidates the need for more specialized home rehabilitation equipment. (worksheet 1.11)

Cost

The interviewees and 60% the users had purchased equipment for home rehabilitation. The price range of the equipment varied from 300 DKK to 5000 DKK. confirming the maximum price.

A interviewee, however, stated a reluctance to buy expensive rehabilitation devices (>1000 DKK) as they are viewed as temporary equipment for a temporary condition, but were interested in renting the equipment. (worksheet 1.11)

Potential in rental equipment !

Confirmed maximum pricepoint for patient of 5.000 DKK !

Potential in collaboration with physiotherapist. !

Confirmed that the training should motivate the user by eg. showing progress !

CONCEPT EVALUTATION

The concepts were presented for the users from the previous section and the collaborating physiotherapist to get feedback and narrow down the selection.

Correction of weight-bearing asymmetry

The direction had a large potential as both the users and the therapist pointed out the frequency of the problem and the users could see themselves using in their everyday lives. The therapist noted that the nature of the feedback is important and should be put into focus during development. (worksheet 1.12)

Tracking the progress

The tracking of the progress, is generally a good idea for both the users and the physiotherapist, but through the feedback it became clear that seeing the progress is not enough motivation in itself, and that additional motivational factors were needed.

Therefore, the direction is discontinued, with the potential to implement it as a feature in the final concept. (worksheet 1.11, worksheet 1.12)

Nudging the user

The direction is good as the users often need an external nudge, but they also need something to guide them through their exercises and this direction do not fulfill this, therefore it is discontinued. (worksheet 1.11, worksheet 1.12)

Gamification

The visual representation of the movements is good as the users need something visual to follow. The gamified element serves as a motivational factor and gives the possibility for a large variety in exercises and movements. The cursor is important to support the users hand (worksheet 1.12)

Quality of exercise

The physiotherapist noted that the direction itself is good, but that it is critical that the user is able to put it on correctly alone, which can be a challenge with the concept depicted.

The users were, in principle, interested in a device that could show them the exercise and correct them while performing it. Yet, they were not keen on performing conventional exercises at home, without other motivation. Therefore, this direction is discontinued. (worksheet 1.11, worksheet 1.12)

Electro controlled movements

The muscle structure in the the arm are small and specific to each movement. Creating a solution in this area is difficult, even for people who are educated within the specific field. As of this, the direction is discontinued. (Worksheet 1.11, worksheet 1.12)

The outcome of the section was a selection of the two directions; gamification and correction. These directions proved the most desirable for both the physiotherapist and the users.
Other directions has been discontinued with the possibility to implement features from them in the further concept development.
The physiotherapist pointed out that the user should be able to use the product without any aid, to enable use at home.

The users could benefit from a nudge/reminder to train. !

The users should be guided visually during arm rehabilitation !

The user should be able to use the product without aid. !

A cursor supports hand during arm rehabilitation !

The training should motivate the user by eg. showing progress and gamification elements !

VALIDATION

To choose a final direction, a development therapist from Neuroenhed Nord, a rehabilitation center focusing on early rehabilitation, was interviewed and the two directions were discussed. This led to a change in focusa and clear direction for the project.

Interview

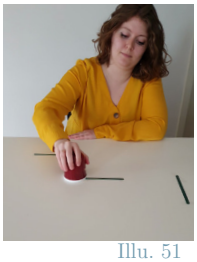
Illu. 49

Development therapist
Neuroenhed Nord

Video of interaction

To communicate the concepts, the therapist at neuro enhed nord was shown sketches of the concept, with additional videos showing possible interactions with the arm rehabilitation direction.

Illu. 50



Illu. 51

Illu. 52

Gamified arm rehabilitation

According to the therapist, there is a greater need for a motivational arm rehabilitation product. The market is generally larger and the problem is more evident with larger implications on the quality of life in comparison. It is a product that can be used long-term throughout the patients rehabilitation. (Worksheet 1.21)

As a result of this, the correction direction was disregarded for further development and gamification/arm rehabilitation was chosen as the final direction.

Change of focus

During the interview, it became clear the problems within the early stage at the rehabilitation center relates highly to that is registered in the later stages after discharge from the rehabilitation center. In both scenarios, there is experienced a lack of motivation and guidance for arm rehabilitation.

Therefore, the focus of the project shifted from creating a home rehabilitation product for late rehabilitation to creating a product that enables daily self training throughout all stages of rehabilitation.

The product should be portable and accessible, so the user is able to use it wherever and whenever. (Worksheet 1.21)

In addition to this, the development therapist pointed out that users in the earlier stages would not be able to lift their arm as freely as were shown. This directed attention to a need for clarifying the ability level of the intended user for the product.

As of now, gamified arm rehabilitation is chosen as the final direction and from this point on, specific user needs can be defined from gathered knowledge. The definition of this direction is a product for arm rehabilitation, consisting of two elements; an interface guiding the user, and a physical platform enabeling the movements.
Furthermore the user group has been widened to include early stage patients in the rehabilitation centers, thereby, moving the focus from solely home rehabilitation and into self training in general.

Ensure daily self initiated functional rehabilitation training of the arm.

Patients in the early stages would benefit from a product to initiate self training.

The product should be portable

ABILITY LEVEL

This section explores the stages of arm rehabilitation and defines the user framing within, to clarify the limitations and abilities of the user.

The stages of arm rehabilitation

The fugl-meyer and Brunnstrom approach are both methods of testing and mapping patients' physical ability level [Hoffmann, 2018].

The approaches give an indication of the order of which parts of physical abilities are regained. The stages in the approaches provide a way to pinpoint where to set the border between who could benefit from the product, and who would not be able to use it.

The two approaches describe the stages in slightly different terms, but the stages are generally characterised as follows [Crow and Harmeling-van der Wel, 2008]

Stage	0	1	2	3	4	5
Definition	Flaccid	Reflex activity	Minimal voluntary movements	Partially independent movements	Independent movements	Normal activities
Ability	No movement	Use arm for support	Simple gross movement	Coordination of arm	Moving objects	Full range
Exercise example	Moving the flaccid arm with functional arm	Activate arm through electro theraphy	Move hand from knee to knee	Move arm from one area to another	Move objects from one spot to another	Daily activities

Illu. 53 FUGL MEYER TABLE

Late stage 2 or greater

It was determined that the users in our focus group should be in very late stage 2 or greater in accordance to the Fugl-meyer approach.

This knowledge specifies minimum requirements to use the product, which limits the user group.

This group is able to perform voluntary movements of the arm, but are in need of support from a table or similar to perform these, as they might not yet have the strength to lift arm freely.

In the earlier stages, the user is not able to move their arm voluntary and therefore, not able to perform physical exercises on their own.

By getting an overview of the stages of arm rehabilitation the user group has been further specified to be patients in late stage two of the rehabilitation progress or later.

This knowledge enables a more precise way to distinguish between people of different ability levels.

The next step is to look into competing products, to determine how the product should stand out.

The user should be in late fugl-meyer stage 2 or greater to use the product.

The product should accommodate arm support during use.

COMPETING PRODUCTS

To figure out how to stand out on the gamified training market, the closest competitors have been analysed. The competitors provide a baseline to measure concepts against later in the concept development.

Main competitors

The main competitors for an arm rehabilitation product within the gamified sector in Denmark is MITII [Mitii, 2020], and the Armeo series by HOCOMA [Hocoma, 2020].

Both products include gamified aspects similar to the idea behind gamified arm training; A digital training program that motivates the user to move with the help of gamification elements.

Armeo series by HOCOMA

The armeo series consist of a digital program with games, that can be controlled using one of the three products; a robotic exoskeleton for very early paresis, a spring assisted exoskeleton providing support for the arm and a handheld controller for free movement training. [Careware, 2019]

Market approach

The products are made for stroke patients and other neurological diseases. Swiss HOCOMA have only sold two devices in Denmark [Hocoma, 2020]. The price range from 65,000 DKK excl. VAT, which might be the reason for the small market share, as few institutions in Denmark have a budget to prioritize such an expense. [Careware, 2019]

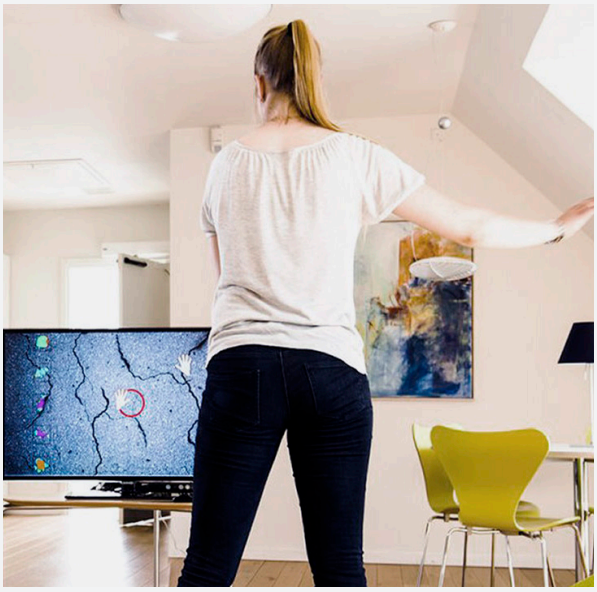
Illu. 54

MITII

The main setup of MITII is focused around a screen with a camera above with the user standing or sitting two meters away from the screen. The screen displays various games for the user to interact with by moving their hands in any direction in the air. This movement trains the movements of their arm in any direction while the games challenge the users cognitively [MITII, 2020].

Market approach

Mitii´s users are mostly people with cerebral palsy, ADHD, strokes and autism. Mitii is especially targeted children, hence the parents being the main customer segments in this approach. Mitii is a rental product and cost 7000 DKK for a 14 week period [MITII, 2020].



Illu. 55

How the concept can differentiate

Illu. 56

Simple setup

The initial setup of MITII takes 21 steps and requires using two hands. The daily setup takes six steps. The initial setup is rather comprehensive and could be difficult for users alone (worksheet 3.6). The concept should aim at single hand setup, an initial setup of 10 steps and a daily setup of maximum six steps ensure a simple competitive setup.

Illu. 57

Age neutrality

The initial target group for MITII was children with cerebral palsy. The consequences of this, is that the games tend to lean towards a childish interface. This was especially noted through an interview with th collaborating physiotherapist. This should be avoided in the concept as the target group is adults leaning towards 50+ years of age (worksheet 1.12).

Illu. 58

Reminding the user

MITII does not remind the users to train. Through user interviews, the importance of reminders for the users were evident. (worksheet 1.16)

This should be included in the concept to nudge the user towards daily exercise, either visually through the products presence in the room or through visual or auditory notifications from the product.

Illu. 59

Support of the hand and arm

MITII cannot be used by patients who are not able to coordinate their arms without support. (worksheet 1.21). The armeo series have options to support the arm during use, yet these are huge contraptions that are not suitable for use at home.

This is one of the main areas where the concept can differentiate by ensuring the support of the users arm and hand.

First setup of maximum 10 steps		Nudge/Remind the user to train	
Daily setup of maximum 6 steps.		Hand & arm support	
Single hand setup		Age neutrality.	

Illu. 60

DESIGN BRIEF 1.0

Key insights

Training need to be repeated daily to gain progress

The users do not perform daily exercise due to lack of motivation

There is a lack of arm rehabilitation equipment

Mission

To increase the frequency of arm rehabilitation training, by making a product that enables stroke patients to perform daily self training.

Vision

Our goal is to improve the rehabilitation process for stroke patients, and enable them to reach their best possible level of function.

Illu. 61

Primary user

Stroke patients
Average age: 45+
Parese in one arm
Full function in other arm
Small to moderate cognitive difficulties

Secondary user

Rehabilitation therapists
(physio-, occupational- or neurotherapists)
Rehabilitation of stroke patients
Difference in competence level

Primary user situation

Self Training
From diagnosis to late rehabilitation
At home and in rehab facility

Secondary user situation

At facility or in own practice
Introduce primary user to product
Tracking progress of users ability for better treatment outside of self-training

USER NEEDS

In this section the knowledge gathered in the previous phases are converted into user needs. This list is not the full set of user needs, but only the ones that were relevant to guide the further concept development. The full list can be seen in worksheet 1.17. The user needs has been separated into two groups, as the concept consists of both a physical part, and an interface part.

User experience vision

The user should be motivated to use the product everyday both from within himself and by outside nudges

The product should help the user set goals and give positive feedback to the user, reinforcing a positive experience.

The user should experience using the product as fun and engaging, while removing focus from the fact that he/she is actually doing exercises.

Using the product should be intuitive without seeming demeaning or childlike.

#	THE INTERFACE SHOULD	SOURCE	PAGE
1.1	Visually guide the user to perform functional arm exercises	Rehabilitation process Concept evaluation	15 27
1.2	Motivate the user by visualising progress	Late rehabilitation challenges Patients perspective	21 26
1.3	Motivate the user through gamification elements	Market Concept evaluation	23 27
1.4	Accommodate exercises of varying difficulty	Rehabilitation process	15
1.5	Ensure quality of the exercise	Late rehabilitation challanges	21
1.6	Be simple due to cognitive difficulties	Disabilities	13
1.7	Be age neutral	Competing products	31

INITIAL MARKET

Positioning and price

From the interviews with users, is was evident that the users listened to advice from their therapists. Therefore, it is relevant to aim towards a distribution collaboration with the therapists and associated clinics. To make this collaboration attractive, the therapist and clinics could gain a commision for products sold through them.

Rental

In addition to selling the products directly to the users, another option is either renting the product to them directly through ReSync or selling the product to therapists, who are renting or lending them out from their practice.

Both approaches of selling and renting was of interest for both the users and the therapists.

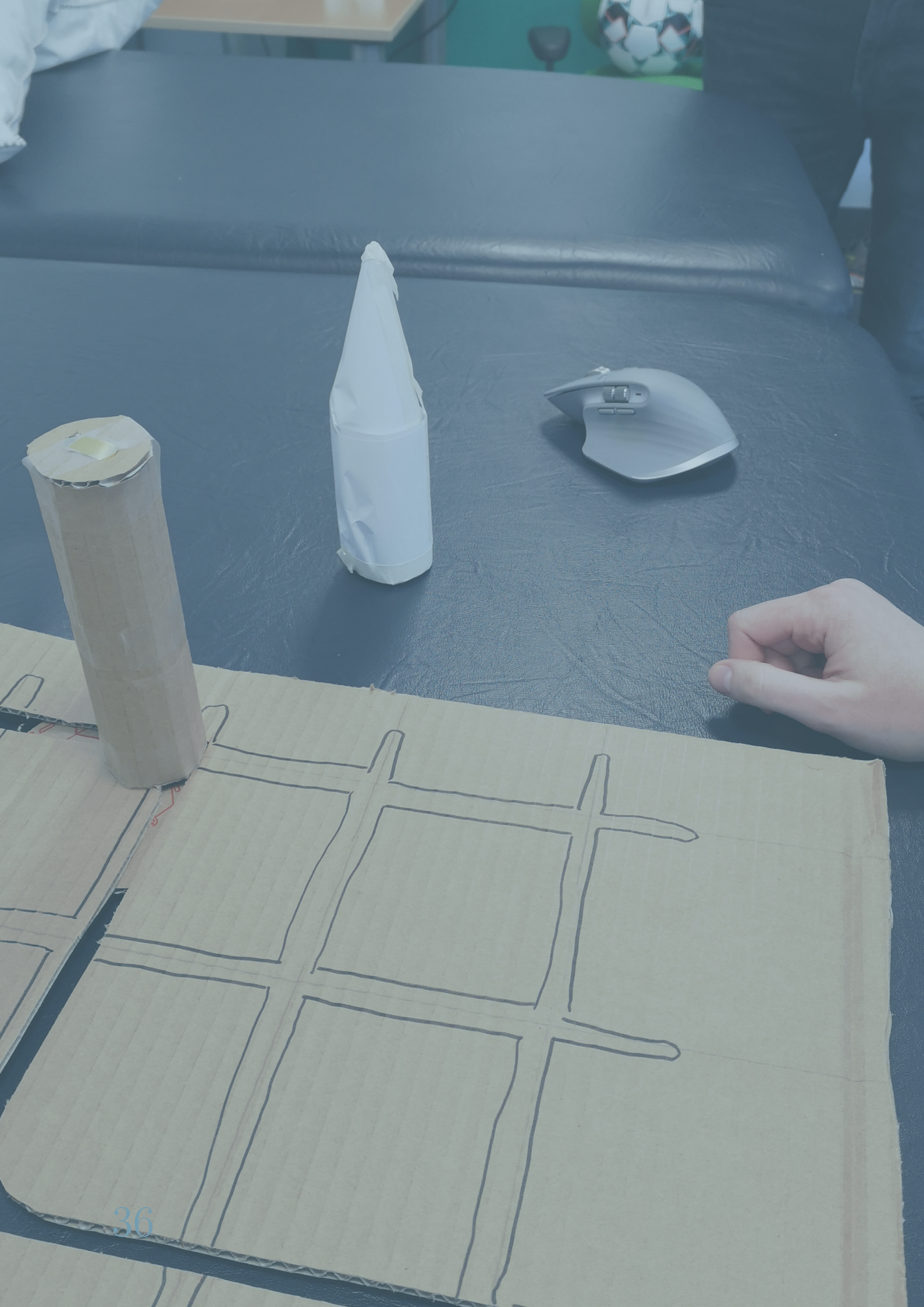
Pricepoint

The users has expressed a maximum price point of 5000 DKK with some users only willing to pay 1000 DKK. The reason behind this low price point is the fact that some users view the product as a temporary object and not something they permanently want to own. This could speak against product sales and more towards rental.

On the other hand users also expressed that if a product really helps, when you are at your lowest level of ability, there are no upper limits to price.

The therapist has expressed a desired price point of maximum 10.000 DKK for a product for use in the practice. However, with the opportunity of renting the product to patients, this price could potentially increase.

#	THE PRODUCT SHOULD	SOURCE	PAGE
1.8	Nudge/Remind the user to train	Concept evaluation	27
1.9	Track progress of the user	Late rehabilitation challenges Patients perspective	21 26
1.10	Enable use without aid	Concept evaluation	27
1.11	Ensure arm support during use	Disabilities Ability level	13 29
1.12	Be portable	Validation	28
1.13	Support hand during use	Disabilities Initial ideation	13 27
1.14	Enable therapist to acess progress data	Late rehabilitation challenges	21
1.15	Accommodate first setup of maximum 10 steps	Competing products	31
1.16	Accommodate daily setup of maximum 6 steps	Competing products	31
1.17	Enable single hand setup	Disabilities Competing products	13 31



CONCEPT DEVELOPMENT

In this phase the idea will be developed into a concept using the design brief as a guide. The concept consists of different layers, being interface, exercises and physical product. To get to a point where it is possible to explore how the physical product should be, the surrounding factors of how the product should motivate and train the user will first be explored.

KEY ACTIVITIES

INTERVIEW
Neurophysiotherapist

DEVELOPMENT
Morphological table
Physical level chart
Interface sketching
Platform sketching
Prototype platforms
Act out exercises
Storyboard

DESK RESEARCH
Motivation
Gamification
Exercises

Illu. 62

Illu. 63

MOTIVATION

Even though the direction is based upon gamification, it is important to understand not only what the gamification principles are but also the underlying reason why it is motivating. Therefore, in this section, the motivational and gamification principles is researched and analysed to implement these in the concept.

Nature of motivation

According to psychologist Csikszentmihalyi [Csikszentmihalyi, 1990], motivation can be separated into two different types;

Extrinsic motivation

Doing a task to gain or avoid something. It is not the task, but the goal that is rewarding. This motivation is more short-lived and requires the validation of others. [Oppland, 2019]

In conventional training the motivation will be purely extrinsic for most people, as the goals are to get better, avoid decline, and fulfill the expectations you and others have of you. This makes the actual act of training more of a means to an end, and it might feel like a duty.

Most existing rehabilitation products have not focused on the motivational factors of the product. Examples of these products are Dr. Winkler handtrainer [Danish care supply, 2020], Mobilas [Sporlastic, 2020] and LapTool [PANat, 2020].

These products rely on either extrinsic motivation from the physiotherapist, personnel, family members or the user self. Therefore, this approach is not a sustainable main motivational factor.

Intrinsic motivation

Doing something because you enjoy it. The task is rewarding in itself. The user experience being in a flow state. This motivation has a long lifetime but often require a complex product. [Oppland, 2019]

One of the most popular intrinsic way to motivate the user in is by gamifying the training. Through the gamification, the user is entertained throughout the process, which creates a distraction. In addition to this, the progress of the user is also gamified to clarify the goal and the progress.

This creates a desire for the user to improve their progress in the game and thereby improve their skills. Examples of this is MITII [Mitii, 2020], Vita mind [VitaMind, 2020] and Armeo Senso [Reha-Stim, 2020].

As the Intrinsic nature of the gamification creates a large motivational factors for the users, it is relevant to investigate how to implement gamification in a product.

Gamification

Gamification is the process of implementing game mechanics into a non-game context. The aim with this process is to motivate the participation, engagement and loyalty of the user, ensuring continuous use and optimized output from the subject or activity [Egenfeldt-Nielsen et al, 2019].

The essential principles of gamification

Show progress

Validate the users ability by showing them progress

Examples

levels, bosses, advantages, better equipment

Long and short term goals

To ensure a continuous feeling of progress, include multiple levels of objectives.

Examples

50 point in X and 100 points in mission Y.

Rapid, clear, frequent feedback

Show a clear link between input and output to create a learning curve.

Examples

You missed the jump mark, therefore you lose

Reward effort

Reward to user to consolidate good abilities and behaviors

Examples

Points, highscores, badges

Special considerations for user group

Short obtainable goals

Within this user group, as there is such a big gap between previous and current level of function, patients sometimes set unrealistic goals eg. obtaining full function. It is especially essential within this user group to set short realistic goals, that are attainable, for them to experience a sense of progress [Worksheet 1.21].

Well balanced challenges

Within this user group, there has to be extra focus on fitting the task to skill level of the individual user, as the exercises should be easy enough to avoid frustration, but hard enough to challenge and engage the user. [Worksheet 1.12, Worksheet 1.16]

Rapid, clear, frequent feedback

The feedback should come as close to the action performed as possible and clearly indicate, which action is rewarded. The reward should be as simple as possible, so the subconscious parts of the brain can understand. Therefore, the reward could be a simple auditory or visual signal (a short “beep” or flash). [Andersen et al., 2012]

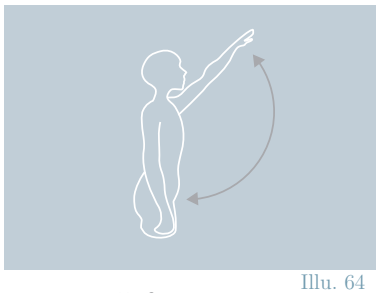
Synopsis

As the main goal of the product is to enable the users to train by themselves, the product should focus on implementing gamification elements in the interface and gameplay to motivate the users through intrinsic motivation.

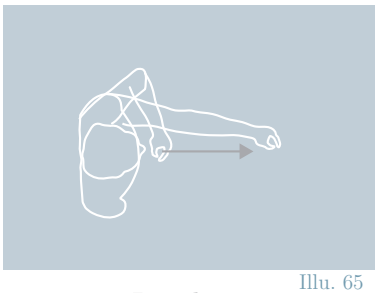
EXERCISE SELECTION

The next step is to find out which exercises the user should perform to obtain progress in their rehabilitation. A range of exercises were researched through desktop research and observations (worksheet 1.18) and discussed with the collaborating physiotherapist to find the most essential exercises. (worksheet 2.3)

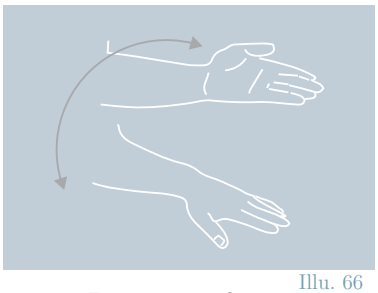
Typical theraphy exercises



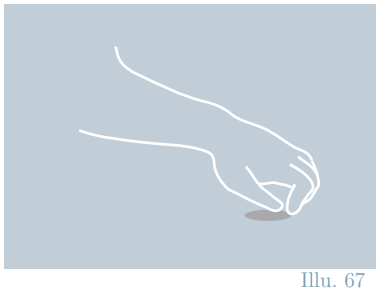
Illu. 64
Lifting arm



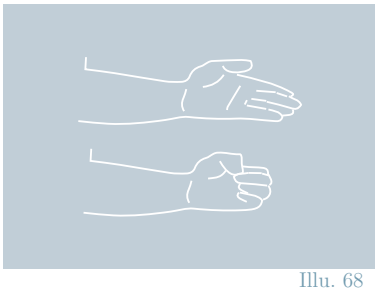
Illu. 65
Reaching



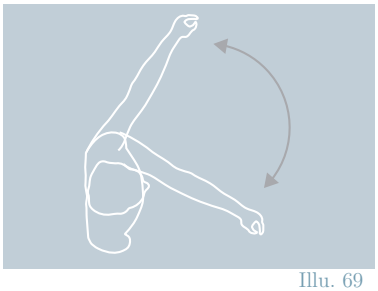
Illu. 66
Rotation of arm



Illu. 67
Fine motoric



Illu. 68
Grasp and release



Illu. 69
Shoulder rotation

Focus on reaching exercise

According to the physiotherapist, the reaching exercises should be in focus as this is the biggest challenge for the user.
It is a combination exercise, which enables the user to move a large range of muscles at once instead of just focusing on a single muscle. Furthermore it trains precition and eye hand coordination. Thereby, increasing the exercise output. The other exercises are relevant as well but either later in the rehabilitation or to a smaller degree. (worksheet 2.8).

Disregard quality of the exercises

The main quality criteria of the exercises is the avoidance of compensatory movements. This occurs when the patient is leaning forward instead of reaching forward.

It is difficult to avoid compensatory movements at home, as the users should be corrected without disturbing them in the moment of the movement and directly criticizing them.

The physiotherapist made it clear that the focus should not be on avoiding compensatory movements, but rather focus on the aim to increase the frequency of exercises the patients can perform by themselves, as this is what is essential. (worksheet 2.8)

With that said, the physiotherapist still has an interest in getting data of the exercise to put this data to use when planning physiotherapy sessions. The most important information for the physiotherapist to track is the reaching distance of the user throughout the exercises. (worksheet 2.8)

Level	1	2	3	4	5	6	7	8	9	10
FM stage	Late 2	3	3	3	3	4	4	4		5
Exercise	Reach		Reach Shoulder rotation		Reach Shoulder rotation Rotation of arm		Reach Shoulder rotation Rotation of arm Grasp	Reach Shoulder rotation Rotation of arm Grasp and release Fine motor		Daily tasks
Movement	Elbow extension & flexion Shoulder flexion		Elbow extension & flexion Shoulder flexion & rotation		Elbow extension & flexion Shoulder flexion & rotation Pronation & supination		Elbow extension & flexion Shoulder flexion & rotation Pronation & supination Finger flexion	Elbow extension & flexion Shoulder flexion & rotation Pronation & supination Finger flexion & extension		Full mobility
Range	Short	Long	Short	Long	Short	Long	-	-		-

Illu. 70 Physical levels chart

Physical levels chart

It was possible to create a chart of the exercises (Exercise) suitable within each stage of the fugl-meyer approach (FM stage) and map them into a general exercise level system (Level) (worksheet 2.7). The fugl-meyer stages was divided into smaller segments, to better distinguish between small differences within each stage. (worksheet 2.8)

Within each, the physical movements performed in relation to the exercise is defined (Movements). The difficulty of the exercises depends on how far the arm is from the body (Range).

The physical levels can be used to define the difficulty of the exercises to maintain users motivational interest.

The product should not try to compete with the physical therapy session but rather collaborate with these.

This means not focusing on correcting the quality of the exercise and instead focus on increasing repetitions while tracking the movements for evaluation in the physical therapy sessions.

INITIAL INTERFACE

With the motivation factors, and the exercises defined, the interface could be explored. In this section an initial suggestion for the interface was made to understand the requirements of the physical product. To evaluate the interface, it was discussed with the collaborating physiotherapist.

Table of gamifications elements

To explore the implementation of gamification in the interface, a chart with inspiration from a morphological table was created with the principles of gamification.

The chart was used as quick brainstorm on both physical and digital elements. These elements could be used in different combinations, both in the interface- and product development. The chart explored questions like: How can the user receive feedback? and How should progress be visualized? The chart can be seen in worksheet 2.2

Suggestion

To create an interface suggestion (seen on the right), the interface needs seen below and elements from the table of gamification elements mentioned above, were picked out as guidelines and inspiration under the sketching and development. [worksheet 2.4]

Evaluation of therapist

Multiple targets at the same time as seen on storyboard 8, could be a problem for some users depending on their level of cognitive ability.

In relation to this, there should be a limited amount of text and an as simple interface as possible with large icons and minimal choices. The importantance of avoiding a childish interface with many playful elements and patterns was confirmed. [worksheet 2.8]

The therapist deemed the suggestion suitable for the users in terms of these parameters.

The suggestions was approved by the therapist with a few pointers to correct and a note that the various cognitive abilities should be looked further into in interface development. A the digital platform is defined, the physical platform can be explored.

Age neutrality.

Showing progress of the user.

Reward of effort.

Long and short term goals.

Rapid, clear, frequent feedback.

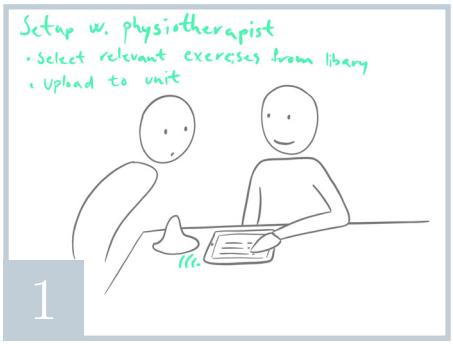
Visual guidance for the user to perform reaching exercises.

Limited use of text.

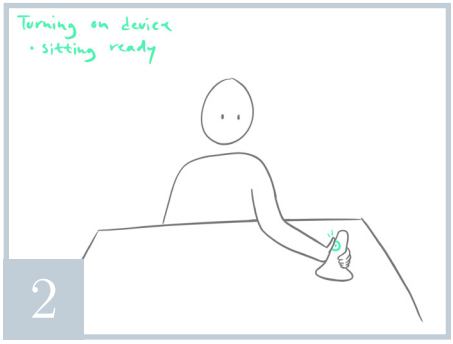
Limited choices.

Exercises according to cognitive ability

Single target.



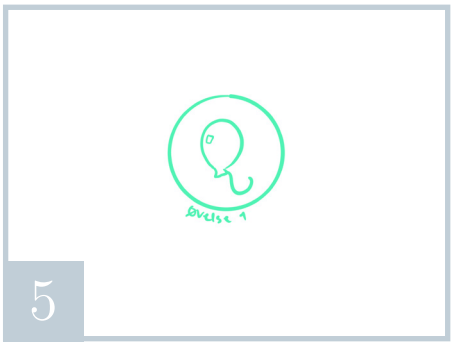
Setup with therapist & selection of exercises



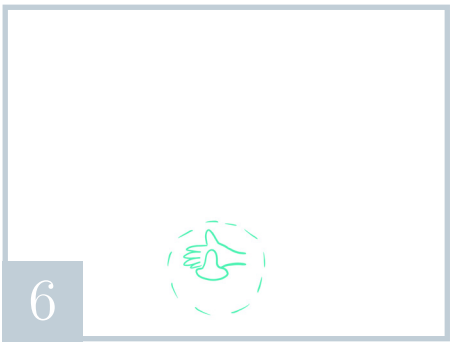
User sits at table with the cursor and turn on the device

Personal welcome screen

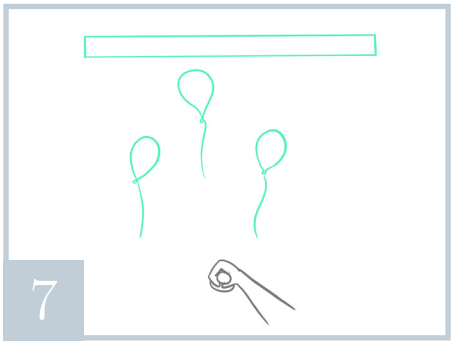
Homescreen with exercises and progress



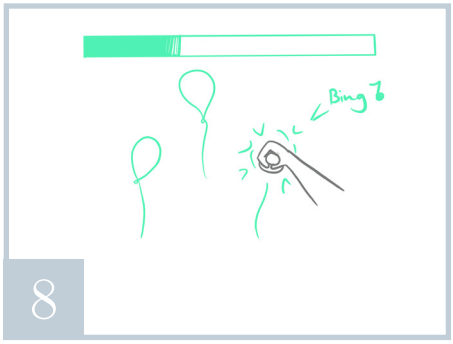
First exercise is selected



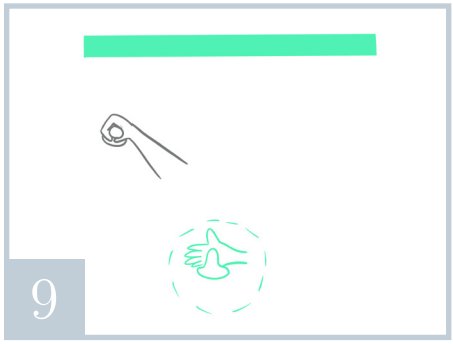
The user places his hand and cursor as the guide shows



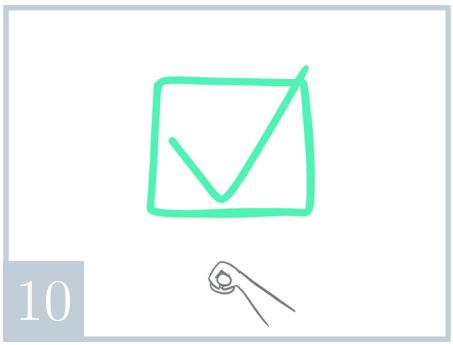
The exercise starts with a count-down bar



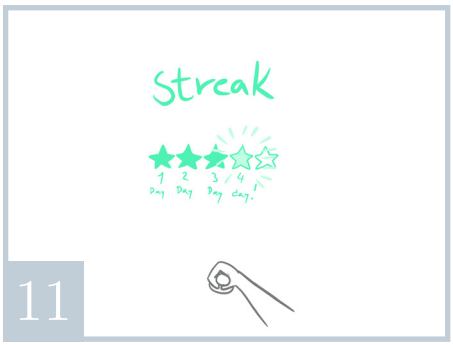
The user pops the balloons with the cursor.



Exercise is done and user moves the hand back



User recieve validation of exercise fulfillment



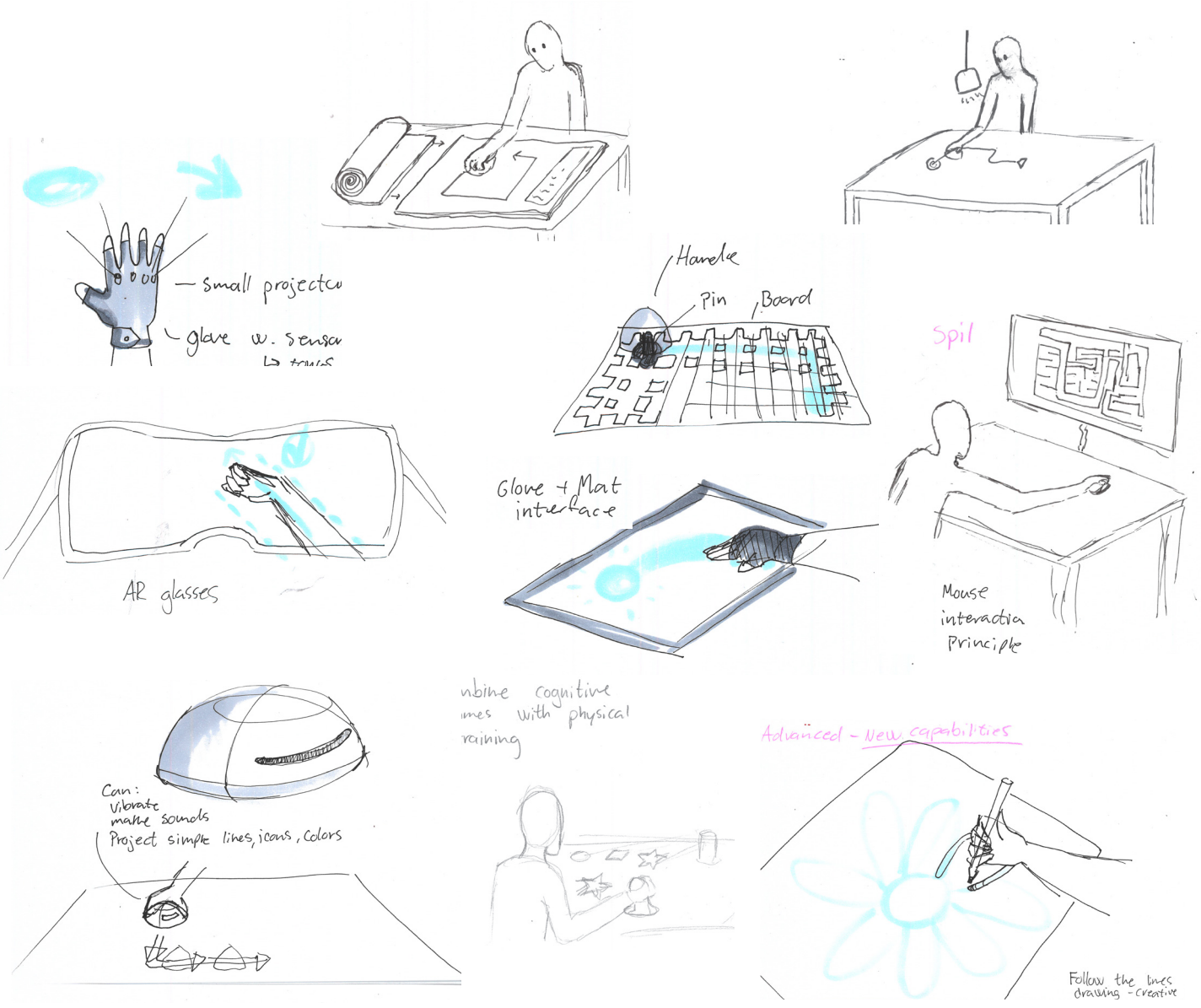
User can see their streak

User can now select another exercise or finish the session

Illu. 71

PLATFORM EXPLORATION

With a basic idea of what the user should experience on the interface, the physical platform that the users interact with, could now be explored through sketching.

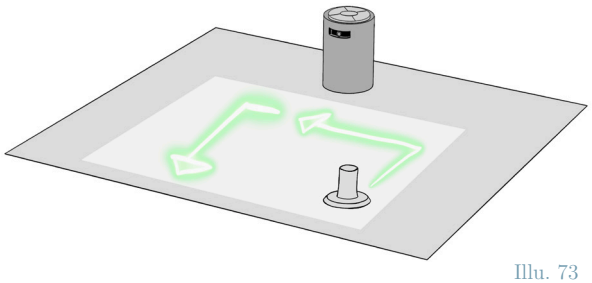


Illu. 72

Platform sketching

A sketching session with inspiration from the morphological chart (worksheet 2.2), feedback during user interviews (worksheet 1.11) and the registered user needs regarding the product, lead to a variation of platforms, that the user could use to see and interact with the digital interface.

The concepts were discussed in terms of: Easy set-up, one hand use, technological feasibility and age barriers to technology (worksheet 2.6). Four concepts were selected for further development and technology research, to explore considerations in relation to the development of the concepts.



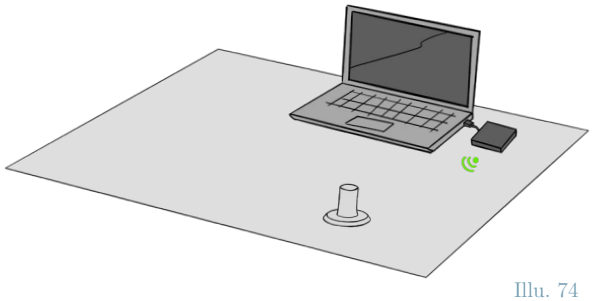
Illu. 73

Table projector

A projector standing on the table in front of the user projecting, the interface onto the table. The cursor is the main interaction point and sends placement information to the projector.

Consideration for product development

Will the users hand overshadow the image? Will the image be distorted due to the short throw ratio and large projection angle?



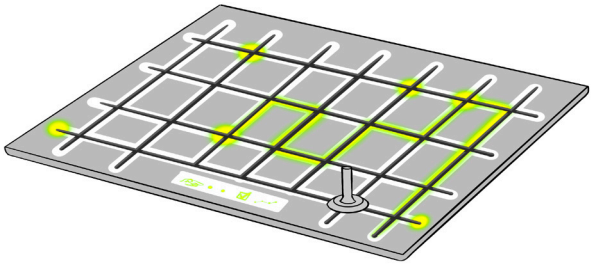
Illu. 74

Screen

A portable device which could be hooked up to any screen, to show the digital interface, and a cursor to navigate on the digital interface

Consideration for product development

Is the interaction between the movement of the cursor and the movement on the screen to abstract for the more severe cases and initial stages? Is the setup too complicated compared to other concepts?



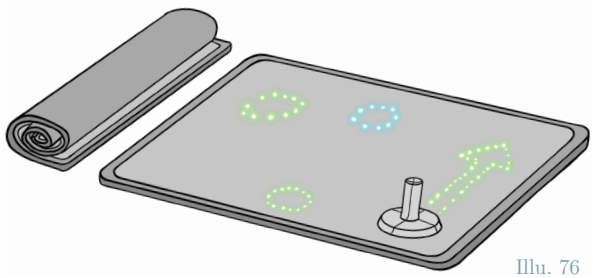
Illu. 75

Grid board

Cursor is able to be moved in a grid, making motions linear and controlled. Visual interface will be displayed in grid lines or in between

Consideration for product development

Is there a clash between the simplified interface and aspect of fun? Will locked movements limit or enhance training efficiency? Will use feel limited and patronizing or instead add a feeling of control and confidence?



Illu. 76

Mat

A flat soft rollable mat showing the interface through simple dots or lines.

Consideration for product development

Is it possible to create a dot or line based interface that the users are able to understand instant or will it create more frustation than motivation?

CONCEPT TESTING

To determine which of the four platforms should be selected for further development, a simple cardboard mock up of each was created. Each of these were presented to the collaborating physiotherapist for feedback and tested out according to single handed setup (worksheet 2.10). Below the main points are listed for each concept.

Illu. 77

Table projector

Advantages

Easy too move.
Free space for exercise variations
Easy to adjust parameters.

Disadvantages

Hard to control quality

Illu. 78

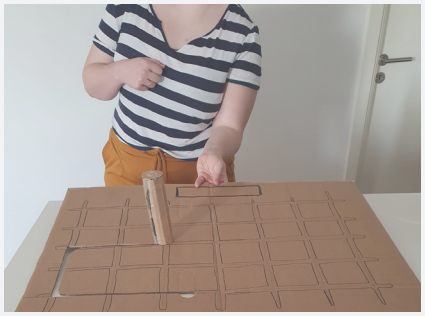
Mat

Advantages

Free space for exercise variations
Easy to adjust parameters.

Disadvantages

Difficult to reroll the mat.
Hard to control quality
Limited interface possibilities



Illu. 79

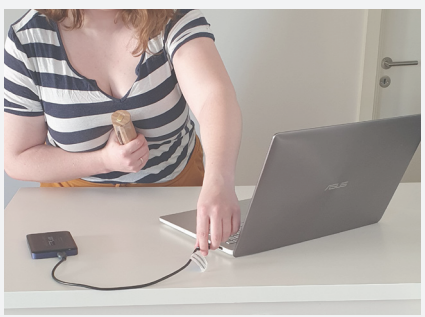
Gridboard

Advantages

Easy to interact with
Control of movements.

Disadvantages

Limits the variations of exercises
Difficult to move with a single hand
Limited interface possibilities



Illu. 80

Screen

Advantages

Free space for exercise variations
Easy to adjust parameters.

Disadvantages

Complex setup
Lacking portability
Two points of attention is too comprehensive

Illu. 81

Cursor

As all the concepts included a cursor, a few variations of this were discussed. The concepts included three cursors: A vertical grip, a horizontal “mouse” grip, and a conical grip. The idea was that a user with a very tensed up hand would be able to open it by pushing it down over the cone.

Feedback

Focus should be on an upright hand position, as this position is easiest for the user.
The cursor should include hand fastening as the user might not be able to maintain a grip.
The cursor should not necessarily be cone-shaped to help the grasp but rather for ergonimical reasons. The cursor and product in general should be easy to clean with soap and water at home and with hand sanitizer for physical therapy sessions. [worksheet 2.8]

Selection

Based on the feedback and test, the table projector concept was selected for further development . It created a dynamic platform for the user to freely move across the table and the ability to add a large range of exercises, while the user is able to set it up and interact with it using a single hand.
This platform furthermore enables large degrees of freedom when designing the interface.
Overshadowing was a concern, and was therefore tested. It was concluded that to avoid overshadowing the projector should be placed in front of user (worksheet 3.1)

The outcome of this section was the selection of the table projector as the physical platform. The next step was to to define the features of the concept and further specify the user needs before diving deeper into interface development as the physical limitations and opportunities of the product were now defined.

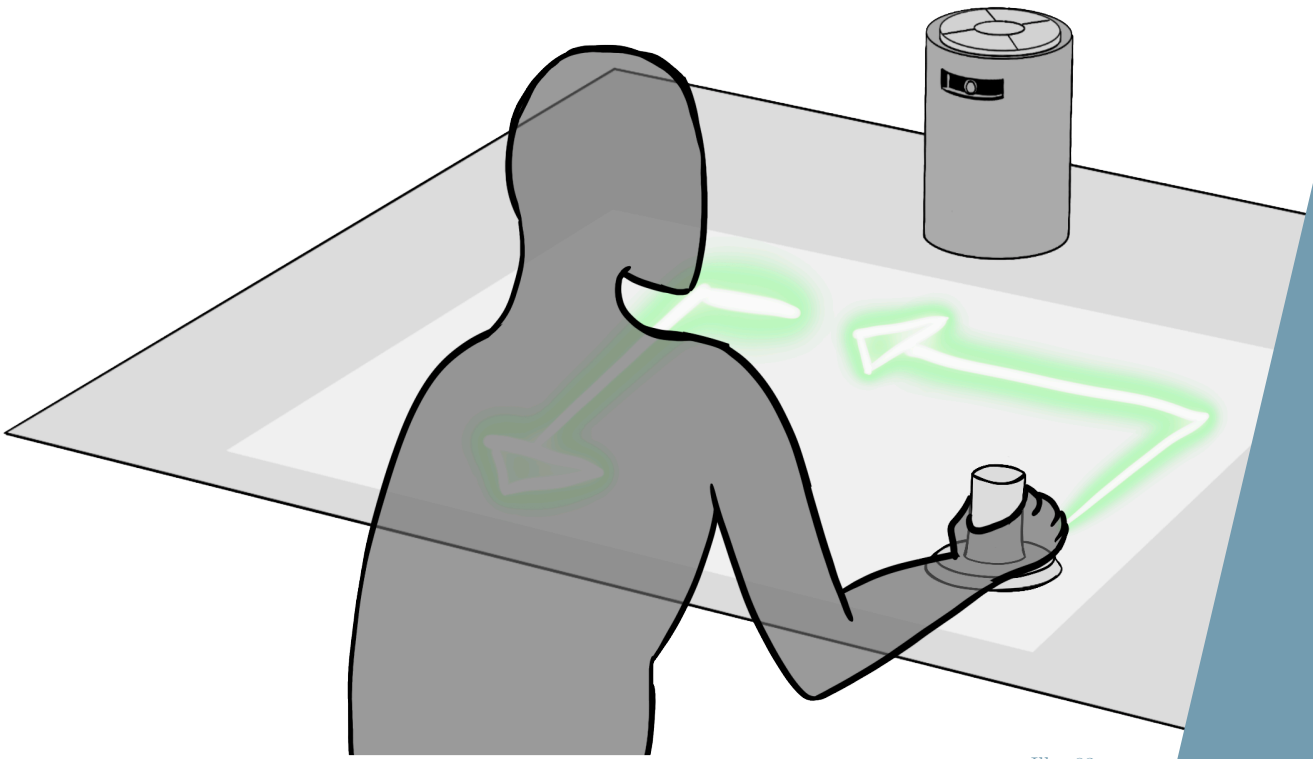
Projection of interface onto table		An up-right hand position	
A single point of attention.		Cleaning with a damp cloth, soap and sanitizer.	

RESYNC

REA

Illu. 82

REA is a home rehabilitation product, focusing on arm training. The product consists of a table projector, which projects an interactive interface onto a table, and a cursor to support the users hand during use. The interface visually guides the user through functional exercises, and utilizes gamification elements to motivate the user intrinsically. To also motivate the user extrinsically, the user is able to plan training sessions with their therapist and recieve daily notifications for these. The product tracks the users progress and communicates this visually, both to the user and their therapist.



Illu. 83

The therapist introduces the stroke patient to the product and does a test run to determine their physical level.

The therapist selects suitable exercises on an application and plan training sessions with the patient.

The patient takes the product home

The product notifies the user of training sessions

The patient perform the exercises at home

The patient brings the prod uct back to a therapy session and recieve feedback

DESIGN BRIEF 2.0

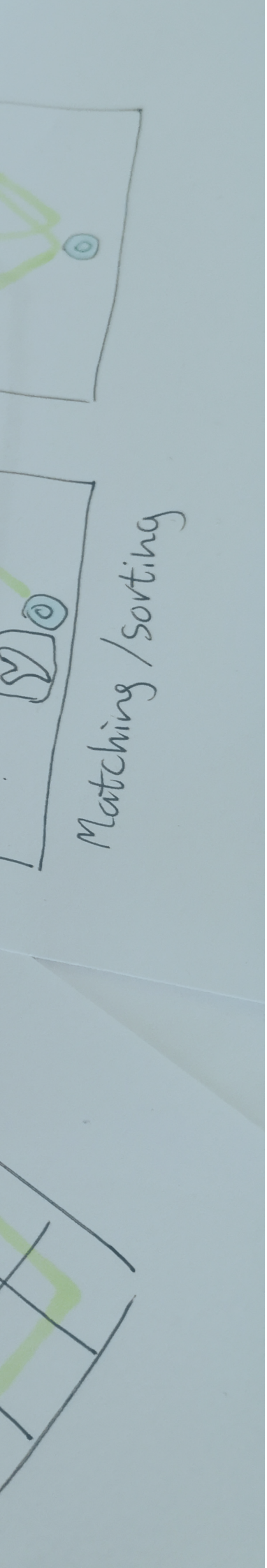
Rental

The nature of the product depends on a collaboration between the user and a therapist. Therefore, to accommodate this relationship the product should be based on rental. This is validated through the fact that multiple users see the product as a temporary solution and not a permanent tool. Therefore, a large range of user will not be inclined to purchase the product. The users will rent the product for a specific amount of time, recommended by their therapist, either through the therapist himself or through ReSync. This creates a range of needs as the product should withstand multiple users throughout its lifetime. The needs are numbered 22-25 and can be seen on the next page.

#	PREV.	THE USER INTERFACE SHOULD	SOURCE	PAGE
2.1	1.1	Enable the user to perform reaching exercises	Exercise selection	40
2.2	1.1	Guide the user visually		
2.3	1.2	Show progress of the user	Motivation	39
2.4	1.3	Reward users effort	Motivation	39
2.5	1.3	Accommodate long and short term goals	Motivation	39
2.6	1.3	Give rapid, clear, frequent feedback	Motivation	39
2.7	1.4	Accommodate exercises according to physical levels	Exercise selection	41
2.8	1.4	Accommodate exercises according to cognitive abilities	Initial interface	42
2.9	1.6	Accommodate Limited use of text	Initial interface	42
2.10	1.6	Accommodate Limited choices	Initial interface	42
2.11	1.7	Be age neutral		

#	PREV.	THE PRODUCT SHOULD	SOURCE	PAGE
2.12	1.1	Project interface	Concept testing	47
2.13	1.10	Enable single hand setup		
2.14	1.11	Ensure arm support during use		
2.15		Enable single point of attention	Concept testing	47
2.16	1.14	Enable therapist to access progress data	Exercise selection	40
2.17	1.9	Track reaching distance of user	Exercise selection	40
2.18		Withstand cleaning with damp cloth, soap and sanitizer	Concept testing	47
2.19		Secure hand in upright position during use	Concept testing	47
2.20	1.15	Contain maximum 10 steps in first setup		
2.21	1.16	Contain maximum 6 steps in daily setup		
2.22		Have a scratch resistant surface	Rental	34
2.23		Have a sturdy appearance	Rental	34
2.24		Have transportation storage	Rental	34
2.25		Withstand being knocked over on a table.	Rental	34
2.26	1.8	Nudge/Remind the user to train		


Blocks
Follow lines to draw
Fill out surface or drag'n'drop
Sorting
Order
Grid
•Short reach /shoulder



INTERFACE DEVELOPMENT

In this phase, the interface part of the concept will be developed further and detailed. The updated designbrief and the interaction visions will be used as a guide, in order to specify precicely what the user should experince during use.
This interface is developed before the physical product, as it is the main element in motivating the user, and the main interaction point between product and user, and thereby sets up requirements for the physical product.

KEY ACTIVITIES

INTERVIEW
Voxpop
User feedback
Neurophysiotherapist
User tests
Occupational therapist

DEVELOPMENT
Gameplay sketching
Cognitive chart
Interface sizing

DESK RESEARCH
Game analysis

Illu. 85

GAMEPLAY SUGGESTIONS

To motivate the users to return several times a week, simply incorporating gamification elements into the activity is not enough. The exercises should be based on activities the users enjoy to do. The aim of this section is to explore this and implement it into concrete interface suggestions.

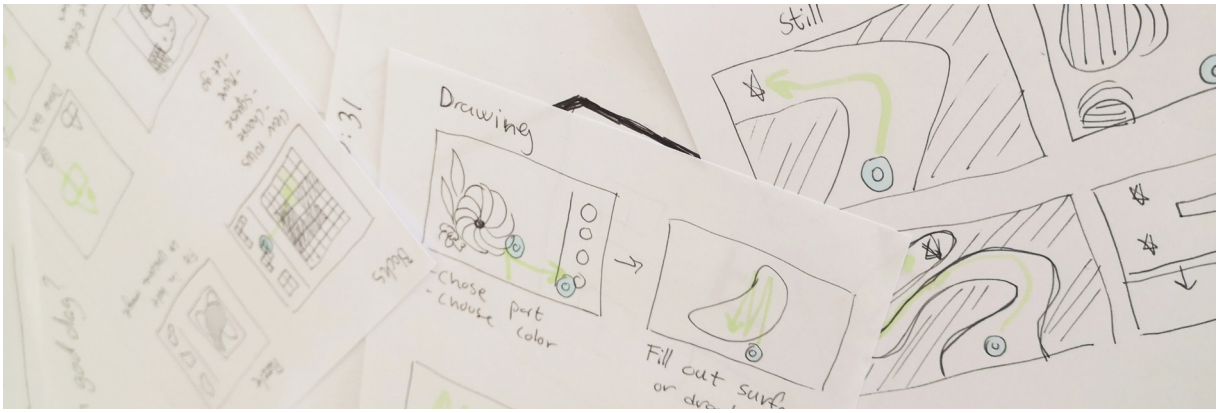
Voxpop

Illu. 86

26 users
Stroke facebook group

Three directions

The users were asked what they enjoy to do in their freetime in a post in a facebook group dedicated to stroke patients (Worksheet 3.2). Their answer was analysed and categorized (worksheet 3.3) and led to three directions of general interests; Cognitive workout, mindfulness and games. A sketching session (worksheet 3.4) of exercises and games led to a gameplay suggestion for each of the directions.



Illu. 87

Suggestions

Simpe games

The exercises in this suggestion are based upon simple games. Upon starting the interface, the user get thrown directly into a series of three games, which must be completed to fulfill the daily exercises. The games will vary each day and adapt to the ability and speed of the user. The users will be presented with any progress in the gameplay

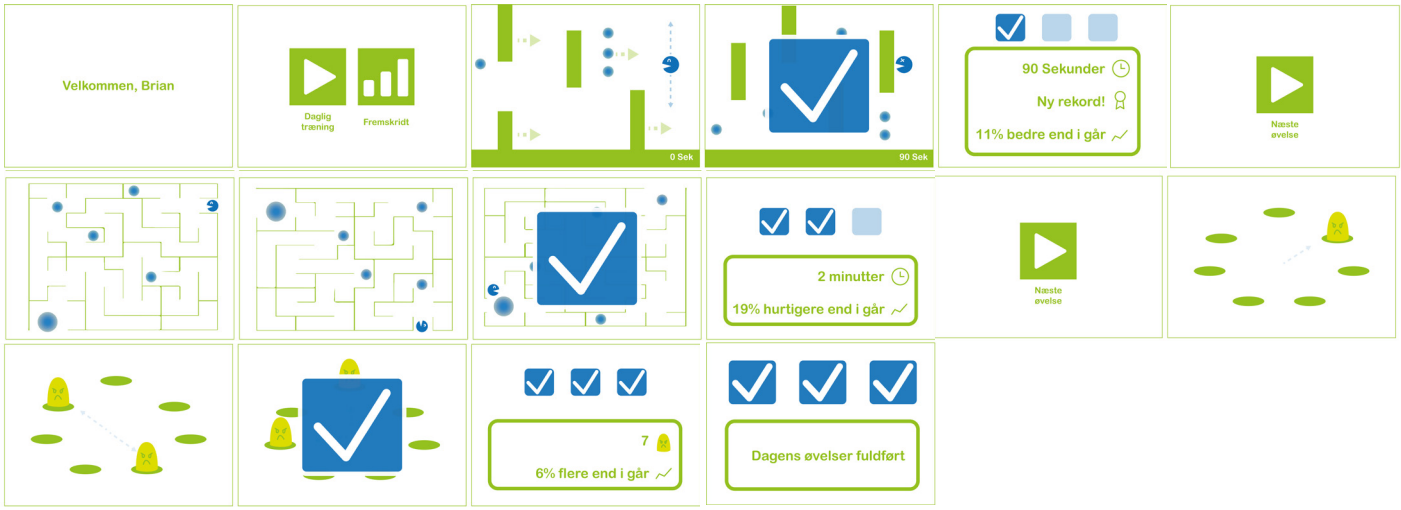
Cognitive workout

These exercises are based upon cognitive challenges. The exercises in each category changes day to day, so the user will not get bored of the repetitions When the user have completed an exercise, he or she can see an overview of their presentation.

Mindfulness

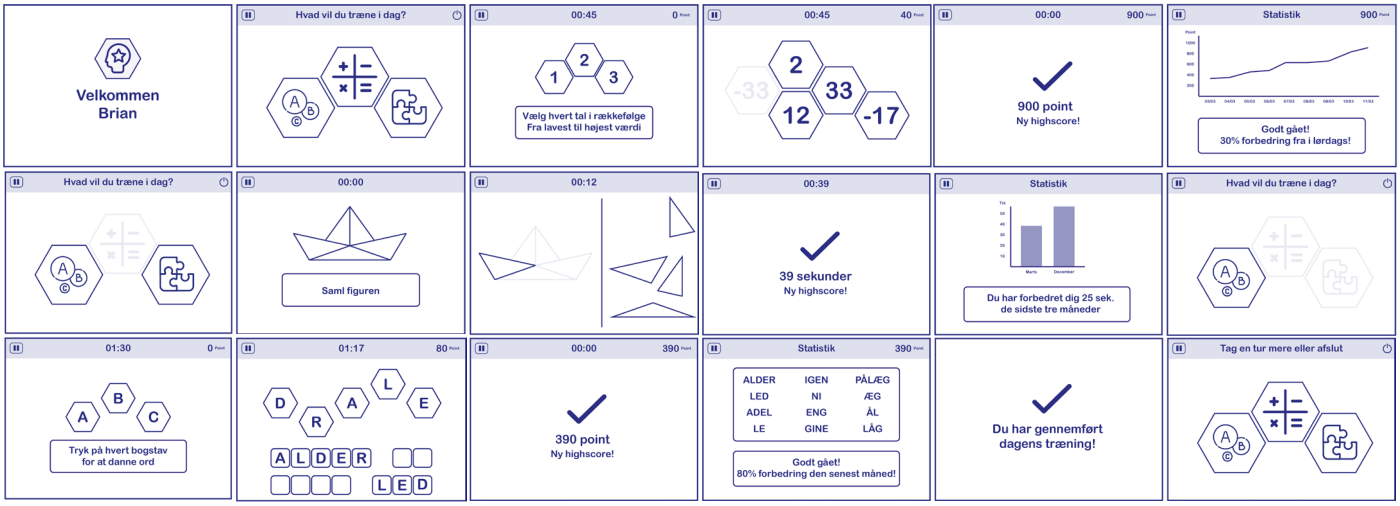
The exercises are based on relaxation and creativity. The users are able to select various exercises, where they can color or draw figures, patterns and shapes. The user can save their projects and resume them later or start new one. Finished creations can be seen in gallery.

Simple games



Illu. 88

Cognitive workout



Illu. 89

Mindfullness

Illu. 90

INTERFACE EVALUATION

To get feedback on the concepts they were presented to 13 stroke patients by e-mail and phone interviews, along with questions like for example whether or not they could see themselves using something like this every day (Worksheet 3.5).

Fun and motivation

Playing games, winning and getting constant feedback on improvements, no matter if it was focused on cognitive or games, seemed motivating and fun to the users. The mindfullness did not seem motivating for the users, especially not in the early stages as it would be exhausting in it self.

> *Training with the arm gets boring quickly, if it is just repetitions with weights. Combining training of the arm with cognitive workout, mindfulness or games, is much more rewarding*
>
> *Lisbeth, 60 years*

The importance of progress

Getting constant feedback on how you are doing, gives hope and a feeling of progress for the users in an everyday life, where they often feel like nothing is going forward or improving. This feedback supports the idea that the concept could be an improvement to the users everyday life.

> *It is important for me to see that i get better. I need to be able to measure myself along the way*
>
> *Mette, 39 years*

Daily feedback

As the physical progress is slow moving and might only be visible, over the course of weeks, the users expressed interest in that the cognitive/game based progress feedback (points, time, etc.) should be in focus throughout the daily workout, only with occasional option to track the physical(fx reaching distance).

> *Training the arm by performing small fun tasks seems quite brilliant*
>
> *Leif, 51 years*

Daily communication of cognitive progress

Occasional communication of physical progress

Brain fatique

Common for several of the points are the importance of accommodating brain fatigue. This should be implemented by enabling the user to pause and resume the game at any time and account for performance drop due to this.

> *I would do cognitive games in full speed for an hour and sleep rest of the day. I talked to my therapist, who said ”max. 20 min”, which helped my brain fatique*
>
> *Merete, 47 years*

The mindfulness concept has been disregarded for further development as a result of user feedback. Both game and cognitive workout will be continued as these are suited for different stages of the rehabilitation.

The effectiveness of implementing gamification elements to motivate users was approved, with feedback on progress being the most important aspect.

Disregard sudden performance drop in progress feedback.

Time constrained training sessions

Pausing and resuming games at any time

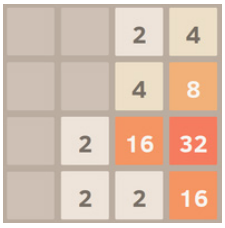
A LOOK INTO GAMES

This section will dive deeper into gameplays to find which would be suited to both the platform and the users. Since game development is not part of the core competencies of the project group inspiration is sought from existing games. The collaborating physiotherapist aided in the evaluation. (worksheet 3.11)

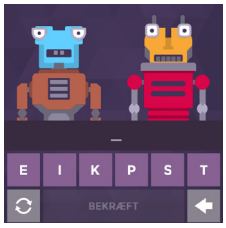
Selection of existing games

Existing games with simple gameplay and interfaces were selected for analysing. Each game was acted out to define the movements and interactions needed to play the game if transfered to the projector interface (Full analysis can be seen in worksheet 3.10).

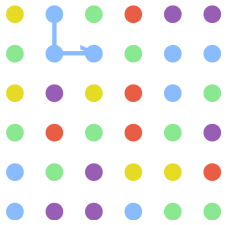
Bejeweled Illu. 91



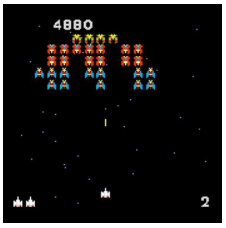
2048 Illu. 92



Babble bots Illu. 93



Dots Illu. 94



Galaga Illu. 95

Cognitive games

Upon exploring, which games are cognitively challenging, it became clear that all games, no matter if it is categorised as a game or a cognitive workout, contains some sort of cognitive challenge.

Therefore, instead of looking at the division of game and cognitive workout, all the games will be looked at as cognitive games.

Clicking

In several of the games, the player had to select a specific “tile” between many tiles or click and drag objects to perform actions. It is not possible for most users in the early rehabilitation stages to coordinate their finger movement into a click/squeeze movements. To embrace the biggest possible group of users in the initial interface development, games which require selection of object centered in between other selectable objects or click and drag is therefore disregarded.

The cognitive workout and games categories have been combined into one category called cognitive games due to both categories including cognitive challenges. The exercises should be based on non-selecting interactions to accommodate the biggest user group. The next step is to research the cognitive levels to understand how the capabilities of each level distinct from each other.

Cognitive difficulties

To make sure the games selected were appropriate for all users, they were presented to the physiotherapist to get feedback. This led to a deeper understanding of the groups cognitive difficulties.

A large range of the games, initially thought to be simple, required a relatively high cognitive ability. When the movements of the exercises challenges the user physically, their cognitive capability is decreased as they have to concentrate on moving. Therefore, the cognitive challenge should be lower than initially expected.

If the cognitive level is too high, the user will use a significant amount of time sitting still and thinking, which inhibits the user from doing the repetitions. The main focus should be physical repetitions with the cognitive being a tool to increase motivation and guide the user.

Games according to cognitive levels.

Games should not require selection of objects centered in between other selectable objects or click and drag.

DEFINING THE LEVELS

In this section, the cognitive levels will be explored and mapped to better distinguish between the wide differences in capabilities of the user group. Mapping is done in collaboration with the collaborating physiotherapist and an occupational therapist based on their knowledge of the users.

Cognitive chart

The following levels are based on observations throughout the project and the experience of the physiotherapist and occupational therapist. The representation and division is simplified for the purpose of communication and easy disinquisment between the capabilities. (Worksheet 3.11)

The five cognitive levels can along with the physical levels determine the nature of the exercises and difficulty of these when using the product. The next step in relation to this is to develop the final exercises and map the difficulties according to the two both the cognitive and physical levels tables. Before this, however, the interface needs to be further developed in terms of sizing and aesthetic.

Level	1	2	3	4	5
Function	Pure reaction	Reaction and feedback	Simple cognitive	Medium cognitive	Hard cognitive
Cognitive gains (plus previous)	Mental agility	Coordination	Focus	Problem solving	Math Language
Interactions	Hit a target Follow	Dodge Follow	Sort shapes Match shapes	Counting Understanding words Enhanced shape sorting	Calculating Spelling Memory Enhanced shape sorting
Guidance	Intuitive	Visual guide	Visual guide	Abstract visual guide	Abstract
Related games	Whack a mole Fruit ninja	Pong Space invader	Bejeweled Dots	2048 Tetris	Wordfeud Sukodu

Illu. 96 Cognitive chart

Clarification of the terms

Function - The basic cognitive difficulty

Interaction - The nature of the tasks performed

Guidance - The level of guidance the user receive - like cues to to what to connect.

Cognitive gains - Which cognitive ability is challenges

Input - Anything that happens on the interface that requires a reaction

Mental agility - The ability to act on a simple input

Coordination - The ability to act on inputs and instantly distinguish between different variations of input

Focus - The ability analyse surroundings (high amount of input) and act according to the information

Problem solving - The ability analyse and act on more complex information

Math and language - The ability to solve problems in regards to complicated systems

INTERFACE DESIGN

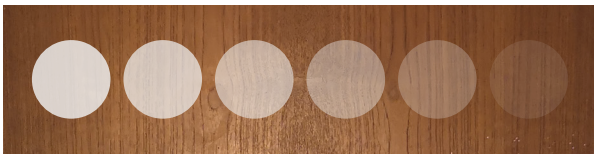
Before moving on to the final game development, the interface size and aesthetic needs to be determined as this creates both a direction and a range of limitations for the interface.

Testing of colors

It is important to determine what range of colors is feasible to use in the projection. This is relevant as the product is used at the users' own home and should therefore accommodate various tables and tablecloth colors. (Worksheet 3.15)

Illu. 97

From a color test, it could be concluded that objects should be a bright grayscale to remain easy distinguishable and the background of the game should be black to make the transition between table and interface seamless.



Illu. 98

Visual language

The style of different simple game apps were compared to figure out which parameters of the the visual language could be adjusted to accommodate age neutrality and a simple user interface, while still maintaining an easy understandable interface.(Worksheet 3.8)

Illu. 99

Illu. 100

Illu. 101

Illu. 102

Illu. 103

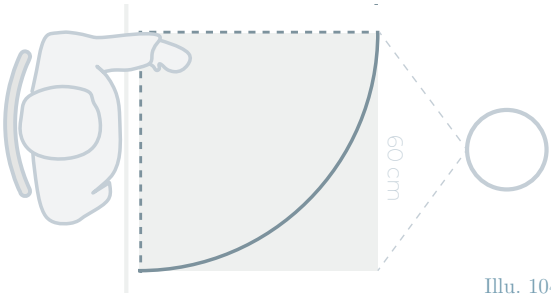
Using detailed objects in the game can create a complicated game interface that might be hard to comprehend for some users. On the other side of the spectrum, only using simple geometric shapes limits the object's ability to visually communicate to the user. (Worksheet 3.8)

The main communication in the game should be visual as some users is limited in understanding text. Therefore, the interface in the game should aim at using simple and geometric shapes with some detailed icons to easily communicate gameplay.

Sizing of the interface

It is essential for the exercises that the user can fully extend their arm on the interface to reach the maximum training output. This was determined from the reaching distance of three men and two women, when sitting normally at an average dinner table. (Worksheet 3.16)

The maximum reaching distance was registered as 60 cm from table edge to where the center of the grip should be, which was deemed sufficient by the collaborating physiotherapist, based on his experience. Therefore, the distance to objects should range from 0 cm to 60 cm from the user, depending on physical level, demanding a interface of minimum 60 cm in width and 60 cm in depth. (Worksheet 4.16)



Illu. 104

Black background

Colors in bright grey scale.

Distance from user to in-game object should range from 0 cm to 60 cm depending on physical level.

Minimum 60 cm wide and 60 cm deep interface

INTERFACE CONCEPT

As all the parameters of the interface had been determined, an initial concept of the interface could be made. The concept was made using a flowchart with basis all features and situations the interface should accommodate.

Flowchart

To get an overview of the interfaces in the product, and how it should function, all possible situations and underlying actions were made into flowchart. The flowchart showed the process from initiating the product to finishing the daily exercises, which was the basis for making a graphical representation.(Worksheet 3.9).

Interface detailing

A range of the interfaces can be seen below. The rest can be seen in worksheet 3.12. The interfaces have limited choices and contain little to no text to accommodate the cognitive difficulties of some users. However this might be a challenge to the users, in terms of understanding the exercises. This will be further investigated through user tests.

Welcome screen

To accomodate use in therapy or in early rehabilitation centers the user interface can be set up for several users at once to segregate progress data.

Illu. 105

Settings

In settings, the user will be able to change their name, turn the sound on/off, change which arm to train and plan the training sessions.

Illu. 106

Homescreen

When starting the product, the user will see the homescreen with their name. On the homescreen the user can choose between three daily exercises, progress or settings. When a daily game have been played it will turn grey and can not be replayed before the next session (if planned).

Illu. 107

Planning

To accommodate the extrinsic part of motivation, and nudge users, daily training sessions can be scheduled in the planning setting. This is done by selecting the day, the time and the duration of the exercises. This could be done in collaboration with a therapist for those unable to do it alone.

Illu. 108

Showing progress
The user will be able to see the progress of their performance. They can see both their physical and cognitive performance progress over time. Cognitive progress is included to ensure a continous feeling of improvement when physical progress is moving slowly.

Fulfillment & encorouagement
At an end of the exercise, the users will see check marks, meaning the exercise is completed and a short message similar to “Well done”. The message will change for each exercise from a large library of praises.

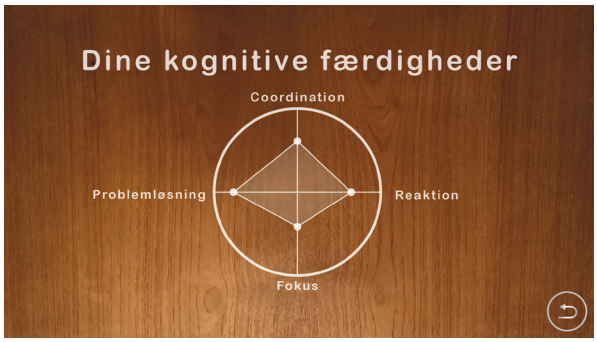
Daily progress
The user will be able to see an instant progress of their performance compared to previous performances, either within the specific exercise or in general based on the average performance.

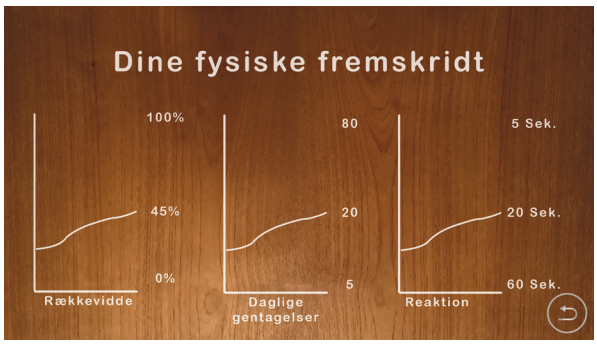
Positioning and countdown
To make sure the user is positioned in the right way before the exercise is begun, it will not start before the user has positioned the cursor in the “ready” spot.

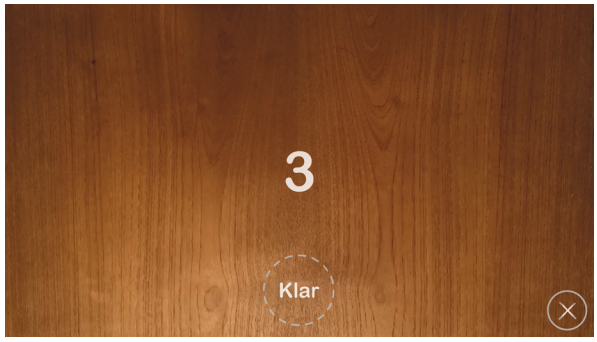
Brain fatigue
To accommodate brain fatigue the user is able to pause the exercise at any time. Furthermore the user is able to time how long the sessions should be, so the sessions can be fitted to his energy level.

Performance drop
It is furthermore the intention that the system registers sudden drops in performance and exclude it from development data, if it stands out according to usual progress and performance.

Application
The app will enable the therapist to connect to each patients product and access progress data for several users. It will also enable helping the user with setting up and changing settings. Additionally, the app enables more advanced users to look at detailed progress data, and to set up training notifications on the phone. This is an add-on with the product being fully functional without a phone to accommodate users who are not able to use it.





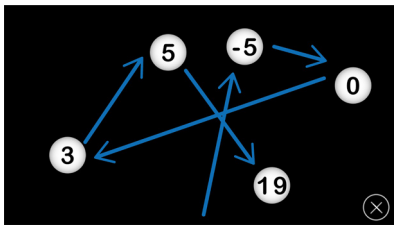


Illu. 109

GAMEPLAY DEVELOPMENT

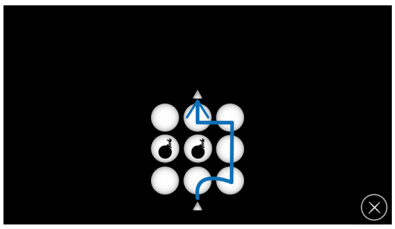
As the interface had been defined, a range of gameplays could now be developed. The games were developed with inspiration from existing games, with an offset in the current understanding about physical and cognitive levels.

Low to high - L



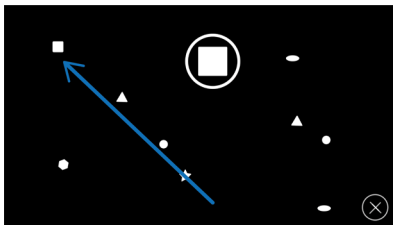
Illu. 110

Mine watch - M



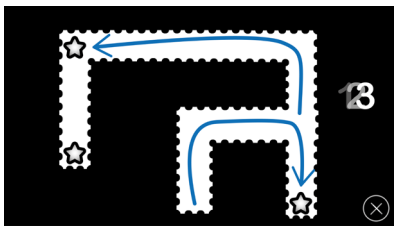
Illu. 111

Rush match - R



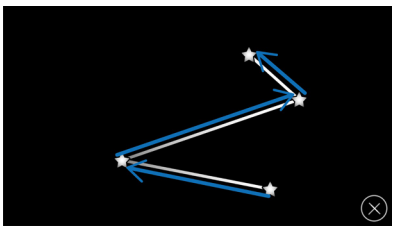
Illu. 112

Star chase - S



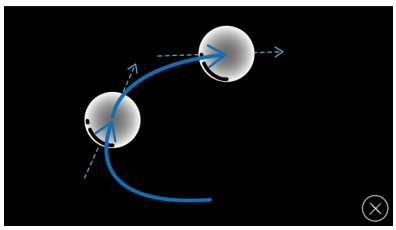
Illu. 113

Zodiac - Z



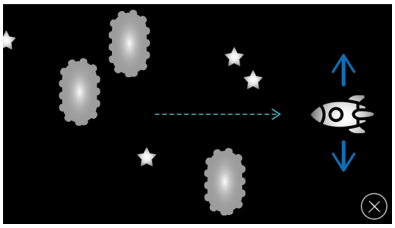
Illu. 114

Bubble pop - B



Illu. 115

Astro space - A



Illu. 116

Exercises

Seven games were developed, with the option of adjusting each in level to follow the users development illustration 110-116) (Worksheet 3.14).For example increasing cognitive level could be done by increasing number of elements to occupy attention, while the physical difficulty could be increased by enlarging reaching distance. An example can be seen on the next page.

The increase and decrease of the levels is intended to happen automatically depending on the users performance over time. The closer you are to a normal function, the more challenging the games become as it assists in a feeling of normality, progress and a sense of extra challenge.

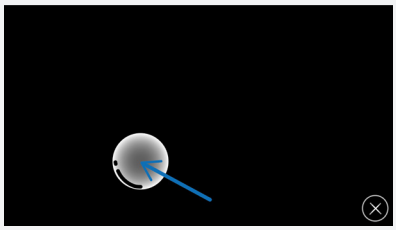
Performance criteria

Performance criterias is a range of parameters used to track the performance of the users e.g. mistake counts and time. The criterias define suitable levels for the user and the progress communicated to the user.

Looking into the performance criteria, it became apparent that it was difficult to distinguish between cognitive and physical development with criterias like time. For example doing an exercise faster could mean an improve in both physical reaction and cognitive reaction. How to cope with this, will have to be investigated further later by through discussion with an expert.

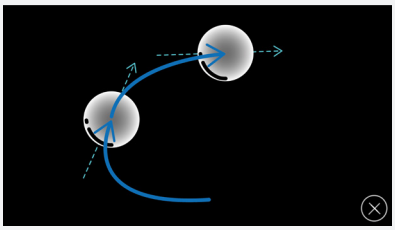
Level example

Cognitive 1 - Physical 1



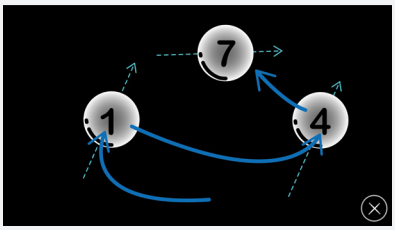
The objective is to hit and pop the bubble. The short distance and the single object count is first physical and cognitive level.

Cognitive 2 - Physical 2



Increased object count and moving objects increases cognitive levels. Increased distance and moving objects increases physical level.

Cognitive 4 - Physical 2



Adding the challenge of counting and selection in a specific order increases the cognitive level.

Illu. 117

Physical

Cognitive	1	2	3	4	5	6	7	8	9	10
1	B Z S	B Z S	B Z S	B Z S	B S	B S	S	-	-	-
2	B Z S A	B Z S A	B Z S A	B Z S A	B S A	B S A	S	-	-	-
3	B S A	B S A R	B S A R	B S A R	B S A	B S A	S	-	-	-
4	-	L R	L R	L R	L M	L M	M	-	-	-
5	-	L	L	L	L M	L M	M	-	-	-

Illu. 118

Level mapping

With relatively few game examples, almost all combinations of cognitive and physical levels within gross motor development could be reached. (Worksheet 3.14)

Excluding some levels or combinations was deemed acceptable as it is difficult to embrace all users with a single product. The difficulties of users vary significantly, thereby requring totally different interactions for some users compared to others. This means that products for the weakest users would rarely fit the strongest user and vice versa.

The following was excluded;

Physical level 1 and cognitive level 4 and 5 combination

Users in physical level 1 will experience a significant concentration strain performing the physical movements, disabling them from performing cognitive challenging exercises meanwhile. The cognitive aspect of the is necessary for motivation, but the main challenge is and should be physical development. (Worksheet 3.14)

Physical level 8+

To challenge physical levels above level 7, it would be necessary to include other exercises than reaching, like pronation or fine motoric training, which the current physical platform do not support.

A user with a physical level of 8 and above that, could still benefit from the cognitive levels and continue using the product, however the physical aspect in the product would no longer be challenging, and therefore not add to development (Worksheet 3.14).

USER TESTS

This section will describe the user testing of the interface and feedback on whether it in fact was easy to understand and if the games fulfilled the need of motivating the users.

User tests

Illu. 119

Two late stage users

Contact

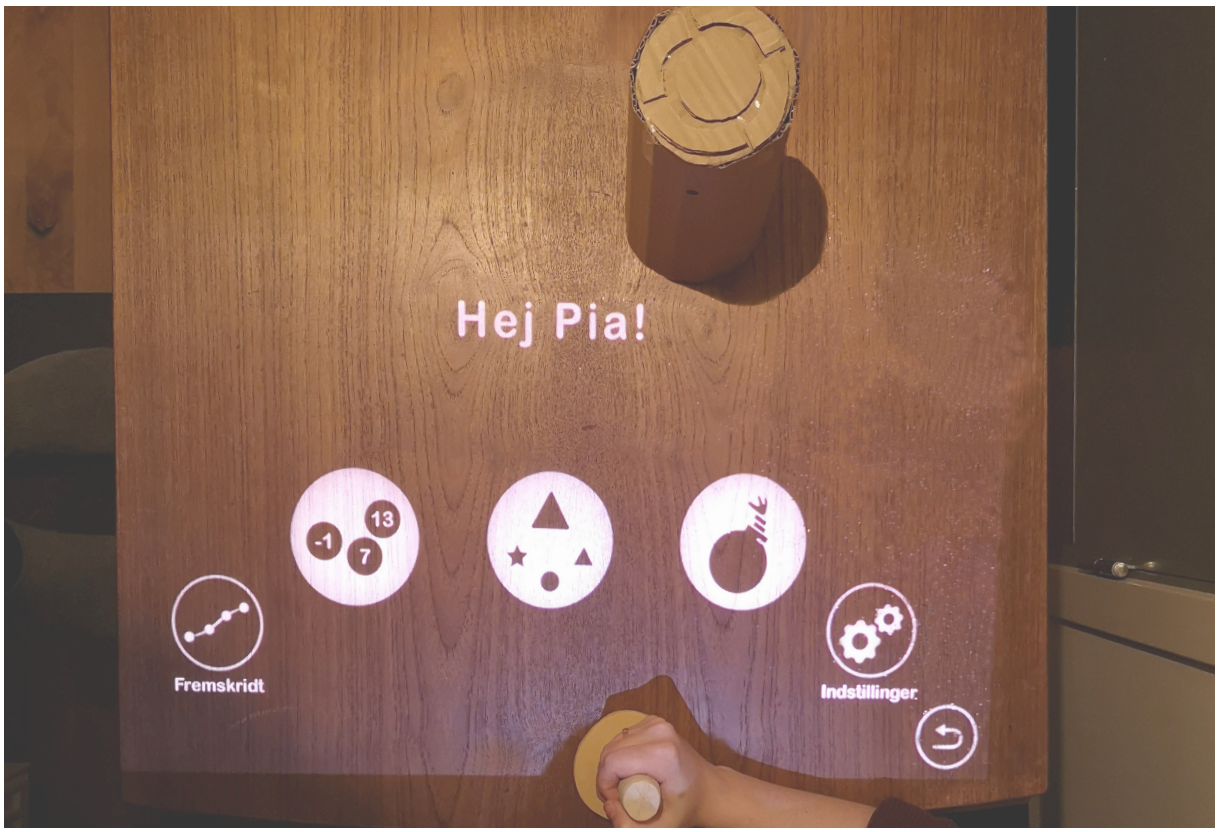
To test the interface, users from the facebook inquiry and earlier user interviews were contacted.

The available users were in the later stages of the rehabilitation with little to no gross motoric disablement in the arm at that time. Therefore, the testing could only draw conclusions from their previous experience. It was the intention to test on users in the early stages but this was not possible due to concerns regarding the coronavirus.

Test setup.

The interface was projected in front on the user using a slideshow on a computer, and an ordinary projector. The slides were shifted by a group member according to the users movements.

During the test the users were asked what each icon meant and directed to fulfill small tasks with a cursor mock-up like changing their name and initiating and playing through exercises.



Illu. 120

Illu. 121

Fun to play
The users understood the overall interface and the icons and liked the idea of mixing arm and cognitive training, noting that it was fun to play. One of the users would like having it now in late rehabilitation, just for cognitive training, while both agreed it would be most relevant two-three months after the stroke. (Worksheet 3.13)

Increased distance to interactions elements
The user were less likely to see the interface elements, that were very close to them, probably due to the users arms resting on the table and a person's natural viewing distance/angle. An example being the return/approve button placement. Therefore, there should be an increased distance from the user to the interface elements. (Worksheet 3.13)

Short exercise description
The users had a hard time understanding the game without a description first, but after a short description they completed the games with ease. Therefore, each exercise should start with a short explanation, which could be a challenge for early stage users and should be tested on these in further development. (Worksheet 3.13)

Easy to slide
One of the tests were done on a table with a plastic tablecloth, which could be hard to slide the cursor across. This should be accounted for in the cursor development.

Free range of duration
Late rehabilitation users would be fine playing for half an hour while in early rehabilitation users would probably be spent after 2 minutes. The product should allow the user to define any session duration.

Presence
Having a product of this size standing visibly in the home would be fine and function as a reminder for training sessions according to the users

The user test generally showed that the interface was easy to understand and fun to use as was the intention. The users' feedback deepened the understanding of which users the product would be most relevant for, and new user needs regarding both the product and the interface were registered. The next step was to discuss the interface with a specialist in cognitive development to be able to apply the last corrections to the interface.

Description of exercise before execution	Increased distance to interface elements from user
Adjustment of exercise duration.	Easy movement over any surface

OCCUPATIONAL THERAPIST

This section will explore the nature of the feedback the user receives and the data behind this. To get a deeper understanding, an occupational therapist was interviewed as a specialist within the cognitive part of the rehabilitation together with the collaborating therapist. (worksheet 3.17, 3.18)

Interview

Illu. 122

Occupational therapist
Anja Nielsen

Occupational therapist

An occupational therapist is a part of a patient's rehabilitation process, but with focus on the cognitive aspect and daily life in the home.

The concept and the more detailed interface was presented to the occupational therapist, which prompted a deeper discussion about the nature of the feedback and data the product could and couldn't collect. (worksheet 3.18)

Simple, but not degrading.

She applauded the interface aesthetic as it, in her opinion, accommodated the users without being to childish. She noted that there is a fine line between a interface too complex and too simple for these users and the interface succeded in this balance (worksheet 3.18)

Exaggerated feedback

She expressed the importance of instant feedback when performing the exercises. Feedback for this user group should be exaggerated compared to normal too keep the users attention fixed on the activity

By her definition, every interaction in the interface should be accompanied by visual or auditory feedback, preferably both. (worksheet 3.18)

Therapist

After speaking with the occupational therapist, the importance of a collaboration with a therapist was further highlighted. The use of a therapist contributes to contextualizing the data and adapting the exercises to the user with the application to ensure maximum output. (worksheet 3.18)

Progress feedback

As discovered in gameplay development, the occupational therapist noted that it was a challenge to distinguish cognitive from physical performance data. Since the physical training should be the focus, she found no reason to give precise feedback on cognitive progress. To analyse the cognitive levels and specific improvements, a therapist would have to stand beside the user and look at him to distinguish between physical and cognitive barriers to fulfill a task. To her knowledge users would be just as happy getting game specific progress feedback like improved time without the need for specifics about what might be the cause behind the improvement. (worksheet 3.18)

Visual and auditory feedback on each in-game interaction

The product should include a speaker.

PROGRESS PARAMETERS

Based on the feedback and the previous interface development, it could now be specified what data should be tracked to show progress to both the user and therapist.

Parameters

The physical progress is divided into to two parameters; reach and reaction time and will be recieved occassionally. Beside the physical progress, the users wil also recieve daily progess.

Illu. 123

Reach

The reach defines how much of the surface the user is able to reach. This is tracked by registrering whether the user tends to miss targets past a certain distance.

This is displayed in percentage for the user as the increase will be more significant in percentage, but can be accessed in centimeters for the therapists as this will be more useful in the therapy session.

Reaction time

The reaction time defines the time it takes the user to select an object and is measured from the moment the movement is initiated til the moment the object is selected.

This determines how quickly the user is able to effectively move with their afflicted arm and is displayed in seconds for both the user and the therapist.

Daily progress

It was chosen to show the progress data as game specific feedback instead and focus on the cognitive solely as a way challenge and motivate the users.

The daily progress will be communicated through game performance within each game, examples being; time spend, points, number of errors etc.

Illu. 124

Daily communication of game progress

INTERFACE ADJUSTMENT

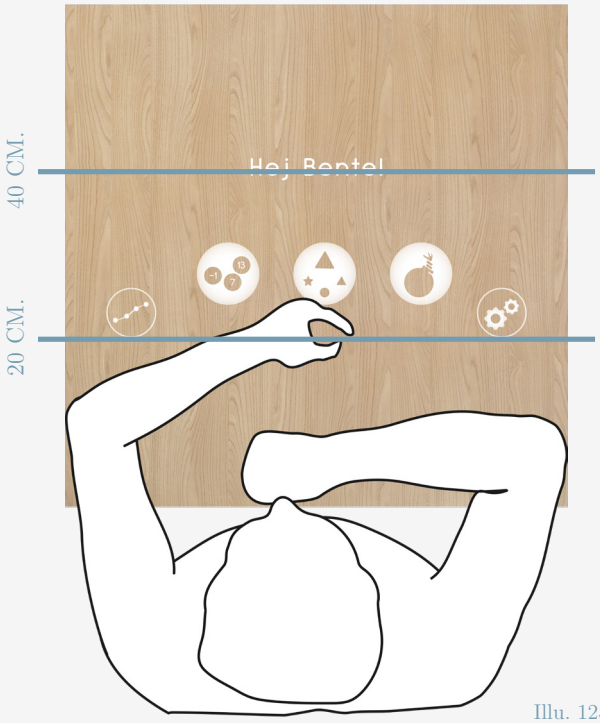
From the user test and expert feedback in the previous sections, several adjustments to the interface had to be made.

Element size and placement

The size, and placement of some objects had to be adjusted, to make all objects within proper visibility and reaching distance.

Through the user test and testing in the team, these parameters could be set up for the design:

- 20 cm free space directly in front of user for arms.
- Interaction objects in menu should be placed closely to the 20 cm. Mark. (minimal reach required).
- Distance between objects should be increased to limit error selections..
- Size of text should be slightly smaller than the first proposal.
- Text should be placed closely to the 40 cm mark for best readability.



Illu. 125

Guide pages

A small guide to games were necessary before exercises to understand what to do. These guide interfaces will also be used for messages to nudge the user to sit upright, to help ensure the most expedient training session and accurate data.
To accommodate those users, who are not able to understand elaborate text, the option for voice direction is available in settings.

Illu. 126

Illu. 127

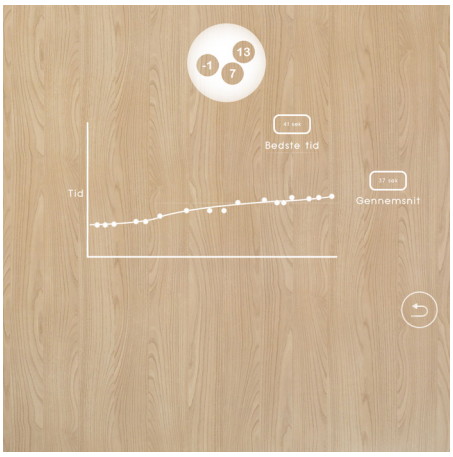
Illu. 128

Adjustment of progress data

Both the physical- and game-progress screens were adjusted to visualise only one parameter at a time, with a more detailed display of instances played and average performance via graphs. This helps to give the user a positive and easily understandable impression of his/her progress.

Illu. 129

Illu. 130



Illu. 131

Training duration

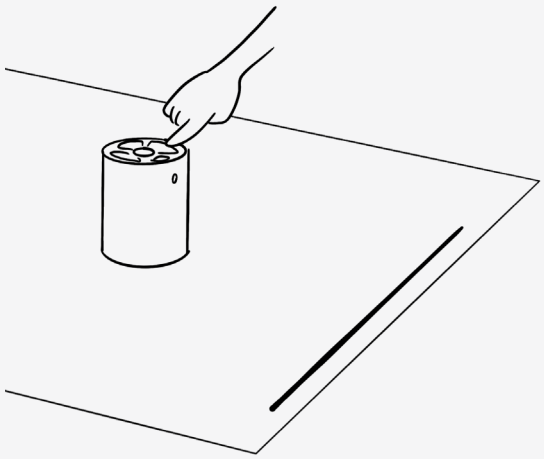
To further accomodate brain fatigue training sessions should be freely adjustable, between 2 minutes and 45 minutes.

Alignment

To ensure correct placement of the projector the interface should display a line upon start-up to enable alignment to the table edge (see illustration to the right).

Instant feedback

To accomodate instant feedback during games, sounds of a positive nature should be utilized to communicate correct movements [RICHERlandTV, 2016], errors [FoolBoyMedia, 2016], and game comletion [Eponn, 2018]. Likewise animations should be used to give feedback upon interactions. An example could be a bubble popping once touched.



Illu. 132

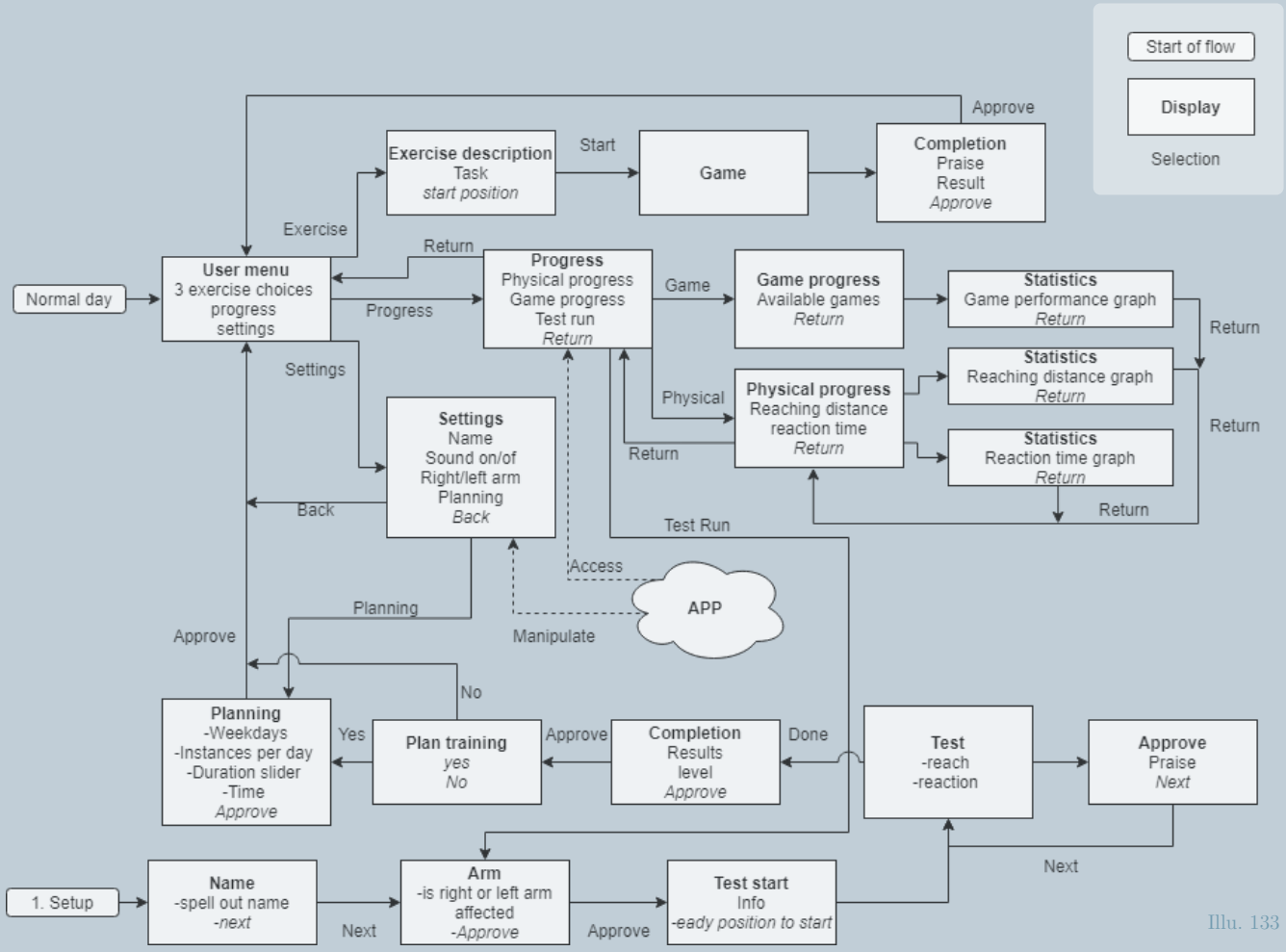
20 cm free space directly in front of user for arms.

Text should be placed 40 cm in front of the user for best readability.

Interaction elements in menu should be placed closely to the 20 cm. Mark.

Acommodate voice direction

PRODUCT INTERFACE FLOWCHART



Illu. 133

APPLICATION[H]

Product interface

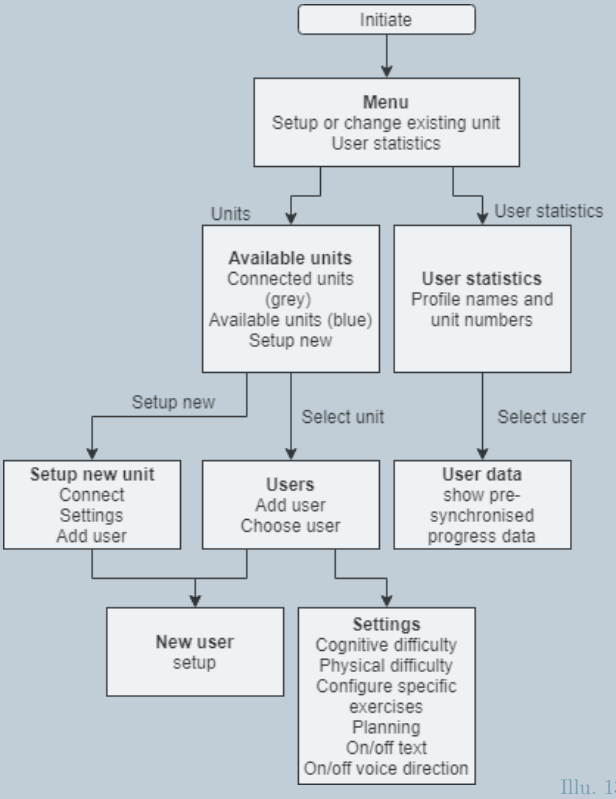
In the flowchart above the final architecture of the interface is represented. Both the flow for a normal day of training and the first setup is displayed.

Application

The final flowchart for the application can be seen to the right. The points of communication with the patients product can be seen in the product interface.

The application is be able to access and retrieve individual patients progress data for review by their therapist in order to target difficulties in regular sessions.

The therapist and advanced users will be able to make manual changes to levels and available games.



Illu. 134

INTERFACE REQUIREMENTS

This section presents the requirements collected throughout the interface development, which were the guidelines for the design of the final interface.

#	THE INTERFACE SHOULD	SOURCE	PAGE
3.1	Adapt games according to physical levels	Exercise selections	41
3.2	Disregard sudden performance drop in progress feedback	Interface evaluation	56
3.3	Time constrain training sessions	Interface evaluation	56
3.4	Enable pausing and resuming games at any time	Interface evaluation	56
3.5	Occational communication of physical progress	Interface evaluation	56
3.6	Adapt games acording to cognitive levels	A look into games	57
3.7	Games should not require selection of objects centered in between other selectable objects or click and drag.	A look into games	57
3.8	Have a black background	Interface design	59
3.9	Be colured within a bright grey scale.	Interface design	59
3.10	Accommodate distance from user to in-game objects in a range from 0 cm to 60 cm depending on physical level.	Interface design	59
3.11	Be minimum 60 cm wide and 60 cm deep	Interface design	59
3.12	Show a description of exercise before execution	User tests	65
3.13	Enable adjustment of exercise duration from 1 min to 45 min.	User tests	65
3.14	Visual and auditory feedback on each interaction	Occupational therapist	66
3.15	Daily communication of game progress	Progress parameters	67
3.16	Text should be placed 40 cm in front of the user for best readability.	Interface adjustment	69
3.17	20 cm free space directly in front of user for arms.	Interface adjustment	69
3.18	Interaction elements in menu should be placed closely to the 20 cm. Mark.	Interface adjustment	69
3.19	Acommodate voice direction	Interface adjustment	69

PRODUCT DEVELOPMENT

In this phase, the physical aspect of the product will be developed in the form of a projector and a cursor. Since the digital interface have been defined and the requirements for this is clear, the physical product that creates the interface can be developed.

KEY ACTIVITIES

DEVELOPMENT

Product sketching
Projector dimensioning
Battery sizing
3D modelling
Prototyping
Tjalve structure variations

DESK RESEARCH

Styleboard
Technology
Material selection

Illu. 135

INITIAL SKETCHING

To find an aesthetic direction for the product, and ideate on possible designs a styleboard was made to guide the ideation. This was followed by a sketching session, which led to a range of product considerations. (Worksheet 4.1)

Styleboard & key phrases

To begin the ideation on possible designs, a range of reference products were selected to create a styleboard with key phrases describing the desired aesthetic value. The key phrases can be seen below with a selection of the reference products.

Illu. 136

Dynamic
Grab and go

Illu. 141

Illu. 137

Soft with an edge

Illu. 139

Ready for rough use

Illu. 142

Illu. 138

Illu. 140

Playful yet stylish

Illu. 143

Sketching

The styleboard, sentences and the user needs served as inspiration for sketching. The sketching was done both in 2D and 3D. (Worksheet 4.1)

Key ideas

Integration of the cursor in the projector to create a unity.

A cutout in the projector, creating a lighter expression of the projector.

Simple geometric shape and not too ergonomic looking to avoid exuding healthcare.

Special markings on the front of the projector to signify the direction of projection.

A look into technology

Implementing some of the ideas might be problematic as they would take up quite a lot of space in the projector, making it bigger as a consequence.

Furthermore, there were some insecurities regarding whether the projector could stand on a table as this would reguire a very short projection range.

Alternatively, the projector would need a foot stand, on the table or the floor, changing the product architecture entirely.

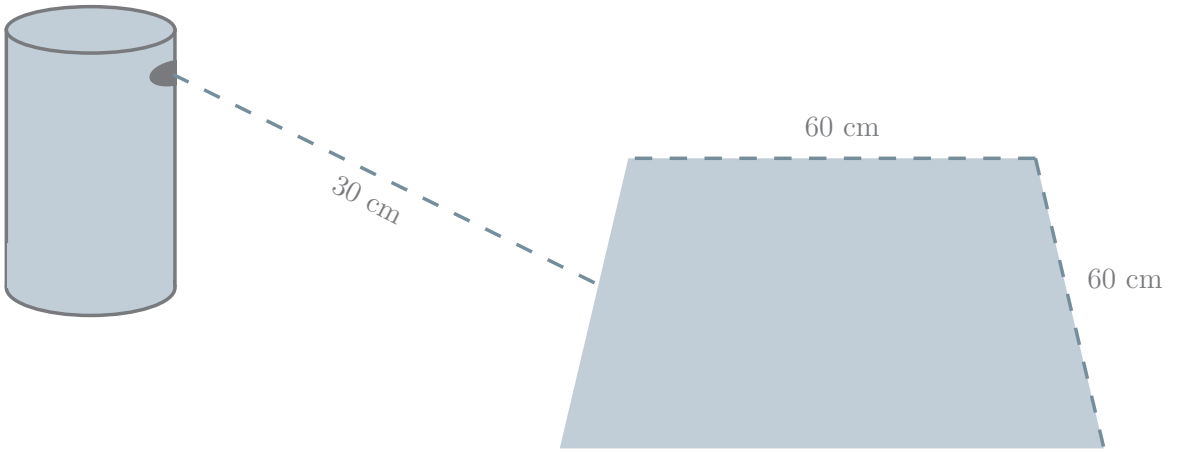
To specify the possible product architecture it was decided to investigate the projector technology before choosing a direction.

This ideation served to share thoughts on the desired aesthetic and expression of the product. Before choosing, however, it was decided to further specify the possible product architecture by researching projector technology.

Illu. 144

PROJECTOR

The product need some kind of projector to project the interface onto the table. To create an estimation of the size and the price of the product and validate the intended technology within the product, a specific set of requirements has been set up to select a projector.



Illu. 145

Throw ratio

The throw ratio is the main defining factor in selecting the projector and for whether or not the projector is able to stand on the table as the concept.

The throw ratio describes the ratio between the width of the projection and the distance from the projector to the projection. To create a projection of 60*60 cm on a average dinner table, the throw ratio should maximum be 0,29:1. Calculations can be seen in worksheet 4.2

Other requirements

In addition to throw ratio, there are other requirements that can guide in selection of a projector. These were determined through research and tests, which can be seen in worksheet 4.2.

The protector should aim at be at least 200 lumens in brightness with a contrast ratio of 1000:1 and preferably more and a resolution of 800x600 or more to ensure a clear and sharp interface. (worksheet 4.2)

Projector selection

LG PH450UG ultra short throw projector with throw ratio 0,29:1, were determined to be the best choice for now. [LG, 2016]

The projector is currently discontinued for production, but sold at multiple sites for 2.777 DKK [Proshop, 2020]. When looking in to the newer models of similar projectors, most of these has increased specs (resolution, contrast ratio etc.), that increases the price point, but is unnecessary in this product.

As technology in this field is in rapid development, it can be assumed that the technology in the projector would most likely be cheaper now, four years after release. In addition to this, the projector has multiple components (chassis, power outlet, buttons etc.) that will become unnecessary when implemented within the product.

Therefore, the pricing of the product will be overestimated to some degree, ensuring a cheaper product in the end.

Brightness: 200 lumens - Contrast ratio: 1000:1 - Resolution: 800x600	Overestimated price
Minimum throw ratio of 0,29:1	Room for 130 x 200 x 80 projector within the product.

TRACKING

To further get an idea of the size and placement of the most important components and thereby the resulting product architecture, the sensor technology was defined.

Five options

For the user to interact with the interface, the concept need a projection mapping of the hand's movements relative to the interface. This means that when you touch a specific point on the projected interface, the tracker locates your hand position in relation to the projected area and translates this to a position within the interface. Thereby, allowing you to select an object on the interface by touching the projection on the table.

There are multiple technologies to accommodate this tracking; Infrared overlay, Infrared scan, Infrared pen and Ultrasonic pen. The technologies is explained in depth in worksheet 4.2.

Selection

The infrared scan has been selected for the tracking technology. It enables the product to track other movements of the user in addition to the hands movements relative to the interface.

This creates an opportunity of tracking the compensatory movements of the user, which was previously expressed as a desire for the physiotherapist. The tracking of this can now be noted along with progress data, for the therapist to take into account when assessing the data.

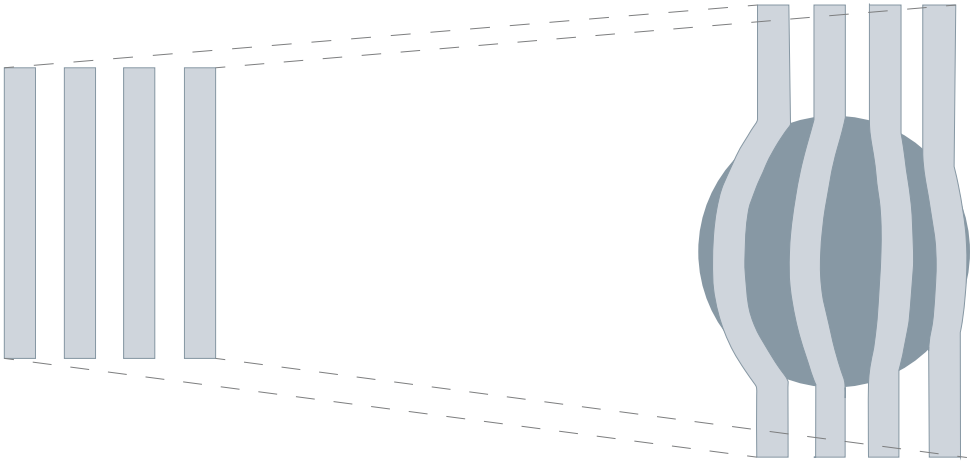
Infrared scan

The light emitter within this camera, emits a infrared light with a changing pattern. When the light hits an non-transparent object eg. a finger in the space in front of the camera, the light is displaced according to the shape of the object.

This light is picked up by the camera within the device, which compiles the displacements of the light into a placement of the object in the 3D space. This technology i collected within a single device that can be placed on the table right next to the projection. [Intel, 2020].

This technology is also called camera depth and is relatively new. It is widely known from Microsoft Kinect [The Verge, 2020] and similar product, but it gaining popularity within the other markets due to the high effectivity and relatively cheap implementation.

The original use of the technology has mainly been in the three dimensional space, but it regularly utilised for creating touch surfaces, for example by microsoft in 2013 [Anthony, 2012]. The price is about 500 DKK [Intel, 2020].



Illu. 146

Depth camera should register an area of 60*100 cm (including user) 30 cm away

Possible to register compensatory movemets

CURSOR ERGONOMICS

To set up guidelines for the sizing and shape of the cursor ergonomics were researched and tried out via prototyping, to determine how to make a comfortable grip suitable for both right and left hand use without straying too far from the wish for an aesthetically pleasing and non degrading design. (worksheet 4.3)

Balancing the design

The cursor should have a relaxed, yet firm grip with minimal tension in the hand. The grip design should focus on balancing pure ergonomics and a simple design to avoid exuding healthcare while still maintaining a good grip.

Grip exploration

To explore various grips, inspiration was sought in different tools and products found in the home. The tools all had a symmetrical grip as the cursor should accommodate disabilities in both hands. The tools and products were analysed and used as inspiration for modelworking.

Illu. 147

Requriements

From the tests, a range of requirements for the cursor and grip could be concluded to ensure a comfortable and secure hold. These can be seen below.

Grip shape should be conical, to avoid slipping and provide a rest for the hand	Base shape should be slightly conical.
Grip diameter should be 45mm at the base and 25 mm at the top.	Minimum base diameter should be 85 mm.

Grip modelling

For the final test seven models of grips and six models of bases were made to be combined freely. The grips were tested by sliding them across tables, to act out the interaction. The test was done by two men and woman, both left- and righthanded to provide different opinions and hand sizes.

From the test it became apparent that none of the base models provided wrist support, giving a uncomfortable wrist bend. Wrist support is important to hold the hand in a straight relaxed position. Therefore, the base should be at least 70 mm from grip center to edge.

Illu. 148

Grip height should be at least 110 mm, but maximum 120 mm.

Surface texture on grip to avoid slipping.

Lenght from grip center to wrist edge of min. 70 mm.

The grip should weigh 400 gram.

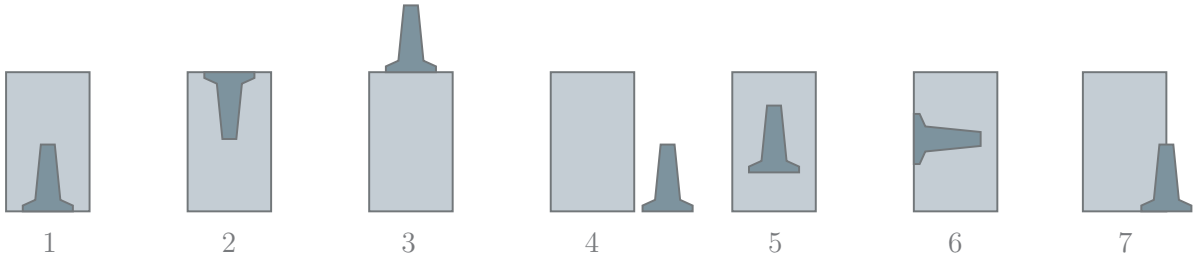
SECOND SKETCHING

As the product architecture had now been settled by specifying the two key technological components, and the basic requirements for the cursor was now in place, a second dive into the aesthetics could be taken.

Tjalve structure variations

The first step was to explore the unity in integrating the cursor and the projector, as this had a great impact on the aesthetic of the product. Tjalve structure variations [Tjalve, 1979] was used to explore variations.

This gave an overview of the possibilities and the positive and negative implications of each. The choice of a direction was however decided on the basis of a whole other idea which arose from the exploration. (worksheet 4.4)



Illu. 149

System design

The method led to the discussion of viewing the product as a system, with the current cursor being just variety of possible cursors within the system.

As of now the system only accommodates gross motoric training, but this could be changed in the future development. Cursors accommodating pronation/supination and fine motoric training could be added to encompass a larger range of arm rehabilitation. Therefore, the cursor should be viewed as an intechangeable factor with the projector as the common platform.

Consequently it is chosen to disredard integration of the cursor, but instead explore how the elements could relate to each other in form.

Narrowing down

A deeper dive into the keyphrases led to form and material parameters more specific for the projector to ensure a well considered project.

This led to a sketching session on the projector design from which six designs were selected for further detailing.

Form parameters

Massive
Feeling of security, unlikely to tip over.

Simple shape
Geometric shapes

Soft edges
Can withstand being knocked over

Material parameters

Scratch Proof
Too avoid worn out look

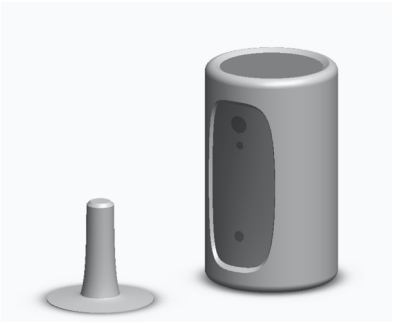
Rubbery texture
Can take a hit - protecting inner fragility.

Colorful details
Playful details exuding “active/play”

Shock resistant material

Scratch resistant material

Design one



Illu. 150

Design two

Illu. 151

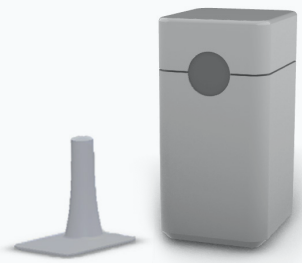
Design three

Illu. 152

Design four

Illu. 153

Design five



Illu. 154

Design six

Illu. 155

Cursor design

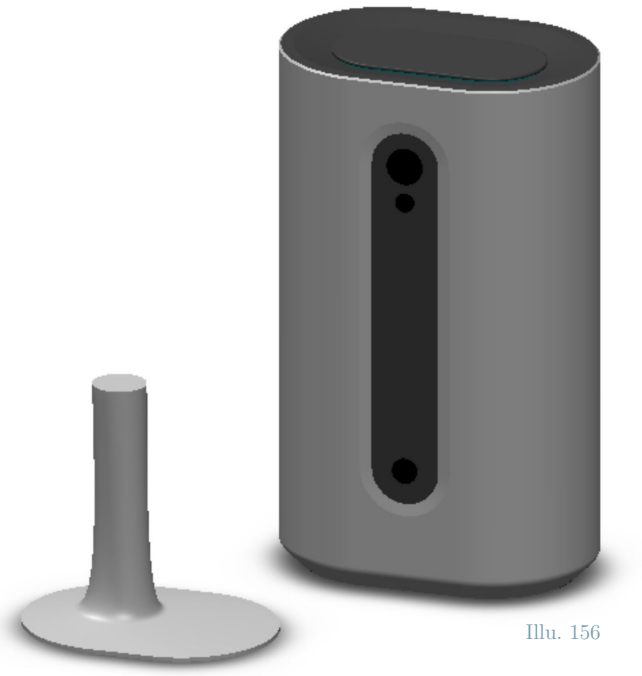
Each of the six designs have a matching cursor with the shape of the projector to create a relation between the two components. The shape on the cursor have been elongated to support the wrist.

The final design

The main shape of the final design has taken inspiration in design four. The oval shape creates a direct connection to the cursor.

The final design has a inner shell with a protective cover of rubber, with inspiration from design one. On top of the projector, there is an elevated control panel with on/off and volume, which emits light and sound, with inspiration from design three. The light is used for notifying the users of training sessions without being to intrusive.

The slim line in the front hides the projektor and camera, with inspiration in design two.



Illu. 156

DETAILING

To finish the design, 3D modelling was started and a mockup was made to get an idea of the size of the product. Several smaller aspects of the concept was tested using interaction tests to compare solutions.

Interaction

To start the detailing of the product, the interaction with the projector had to be defined. To do this a mockup of the projector was made and used to act out the intended user scenario.

Home station

The mockup was bigger than anticipated, which started a discussion about the placement in the home. It was no longer something most people would just have standing on their dining table.

Illu. 157

It was essential for the planning functionality of the product, that it had a place in the home, where it could be seen on a daily basis and that the user was able to move it back and forth easily.

Therefore, the projector should be battery powered and have a home station for wireless charging and storage. Removing the hassle of connecting/disconntecting cables, which might be difficult with one hand.

This solution also created a home base for the cursor, and made it easy to bring the product to therapy sessions (worksheet 4.7).

Illu. 158

Projector handle

To enable the user to move the projector around at home and for general transport, the projector should have a handle.

This was explored through 3D modelling and one hand tests using quick mockups of everyday objects to mimic the handle placement and the level of control related to the handles (Worksheet 4.6).

The most functional solution was a “bucket”-handle (illu. 160), which made it possible to have a firm well balanced grip with full control, while also adding a dynamic aesthetic to the product.

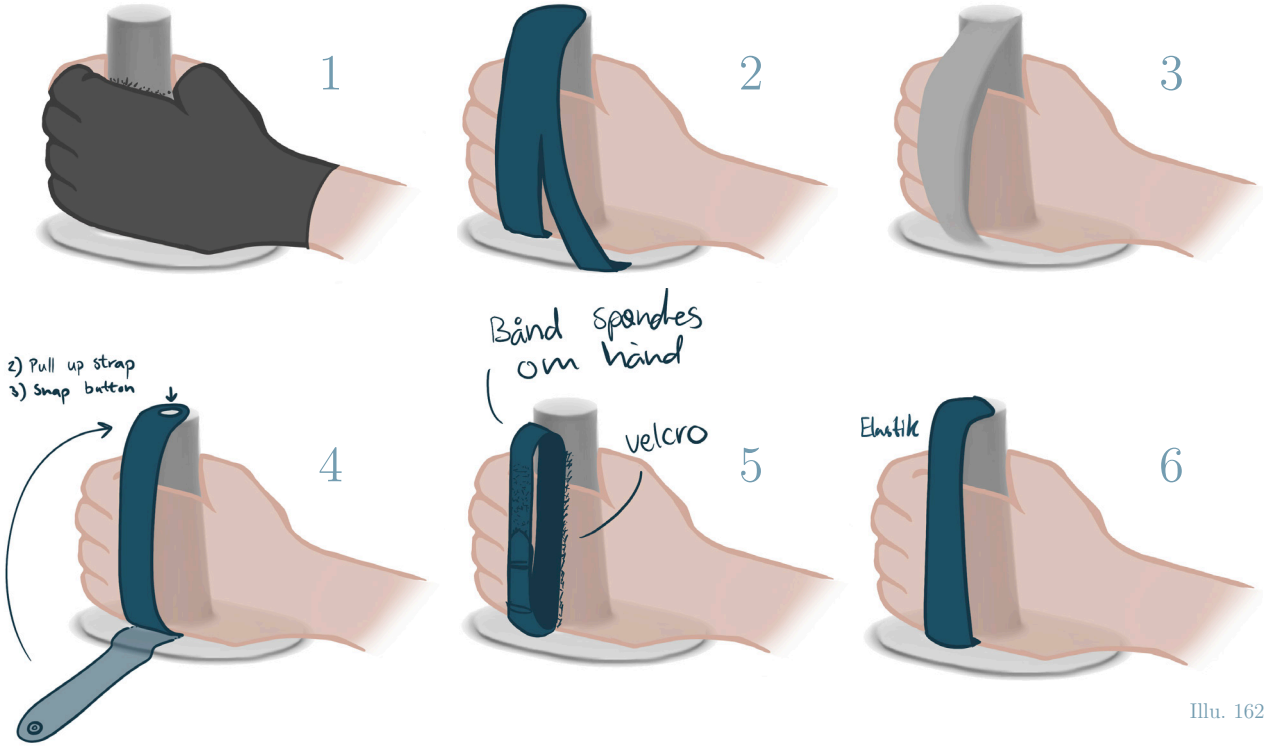
This solution made the handle detachable, enabling the user to easy change to a new handle, if worn out.

Illu. 159 Illu. 160 Illu. 161

Hand securing

To accommodate patients with a weak grip solutions were explored though mockups and testing. As there was no possibility to test on weaker users, a physio- and occupational therapist was consulted regarding the solutions (Worksheet 4.9).

Solution 4 was selected as this was the easiest way to secure the afflicted hand, as it could be placed and secured afterwards in one easy motion by the other hand.



Illu. 162

Transport

As the system is primarily a rental product, it is important for the product to have sturdy packaging, which can be used to store the set when handed out to users.

The packaging also doubles as a way to transport the product to and from the therapist if used at sessions (worksheet 4.8).

A hard case solution was chosen to provide a designated and protective place for all parts.

Illu. 163

Battery powered

Wireless charging

TECHNOLOGY

This section will further explore the technology in the device. See worksheet 4.10 for deeper analysis concerning the technical components.

SBC control unit

The projector and other components in the product need a control unit to organize the information. The unit must be able to process and store complex data to accommodate the feauteres of the projector and depth camera. A single board computer (SBC) like a raspberry pi should therefore be embedded in the product to fulfill these tasks. [Farnell, 2020]

Bluetooth

The therapists and some users, will need to connect to the device to extract more detailed information than communicated in the interface. Therefore, there is a bluetooth module in the product as this is easy to setup and initialize. The SBC has a built in bluetooth module, therefore an additional component is not needed. [Farnell, 2020]

Speaker and amplifier

The speaker and amplifier within the product is two small but important parts. It enables the user to get feedback during exercises and could be expanded to be used as guidance. A 4 ohm speaker [Adafruit, 2020] and a fitting amplifier has been selected for the product. [Alibaba, 2020a]

Fan

The components in the product need a fan to cool them down when operating. Both the projector and the depth camera has a fan within their chassis. As these are the heaviest operating items in the product, these fans should be sufficient to cool down the other components in the projector.

LED

The projector needs a light source to notify the user of training sessions and charging state. This should be a slim LED strip [Alibaba, 2020b]

Buttons

The device needs four buttons for interaction; Turn on/off, bluetooth and volume up and down. To make it easy to clean the product and make the buttons relatively discrete, capacitive touch sensors has been selected for the turn on/off button and two volume buttons. [Alibaba, 2020c]. The bluetooth button is a tactile push button to function under the sleeve. [Alibaba, 2020b]

Battery

To enable the user to use the product anywhere, the product should have a built in battery. The projector already has a battery within itself, so this can be utilized to power the rest of the product.

The projector has a battery time of 2,5 hours, which means the battery size is around 6325 mAh (worksheet 4.10). Through calculations, the battery proved to be sufficient to power all components and enabling use for an hour (worksheet 4.10), which is deemed acceptable as this is the lenght of an average physiotherapist session (p. 17).

Transformer

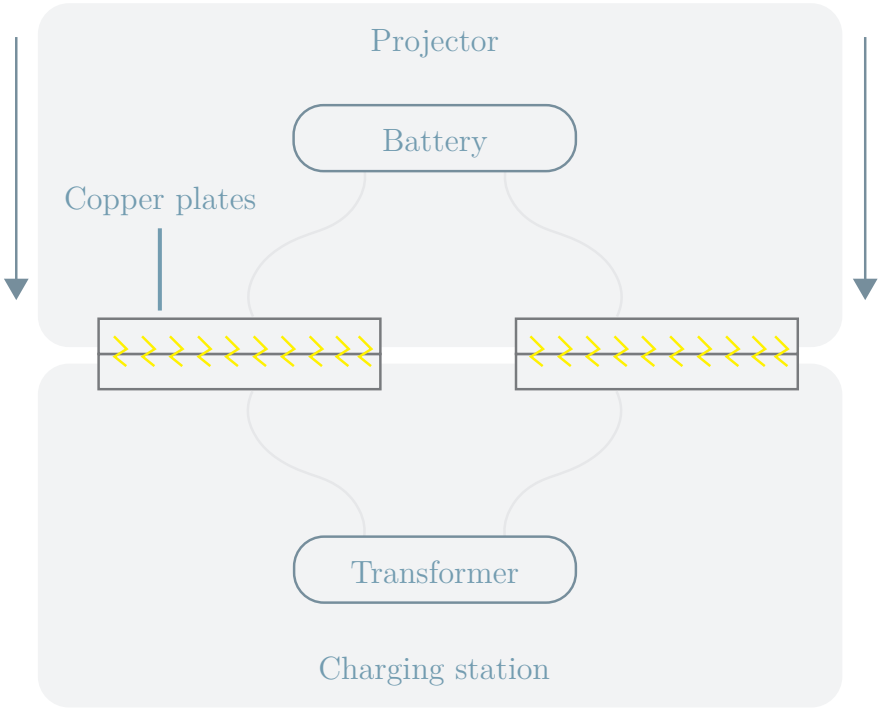
The product needs two transformers. The first one is placed outside the product on the power cable to the homestation. This should convert the wall outlet voltage from 230V to 19V 6,4 A. [Alibaba, 2020e]

Another transformer should be placed in the product and connected from the battery to the other components and convert the 19V output voltage from the battery to 5V 3A.[Alibaba, 2020f]

Charging

To enable a single handed and quick setup of the product, charging of the product should be non-wired, thereby avoiding the need for inserting and removing a power cable. The two most conventional methods of this, is QI inductive charging [Guy, 2019] and pogo pins [Pheteplace, 2018]. Inductive charging is far from as efficient as the wired charging at half the speed and the use of pogo pins require some range of precision in placing the product.

Therefore, an alternative charging technology was chosen; charging contacts, which is used in robot vacuums and lawnmowers. As it was hard to find literature and specific components, an electrician was contacted. He informed that the efficiency of these is largely the same as conventional wired charging and usually uniquely produced for each product, which makes it hard to find a standard component. The setup is rather simple (see image below) and costs around 0,25 DKK to produce.

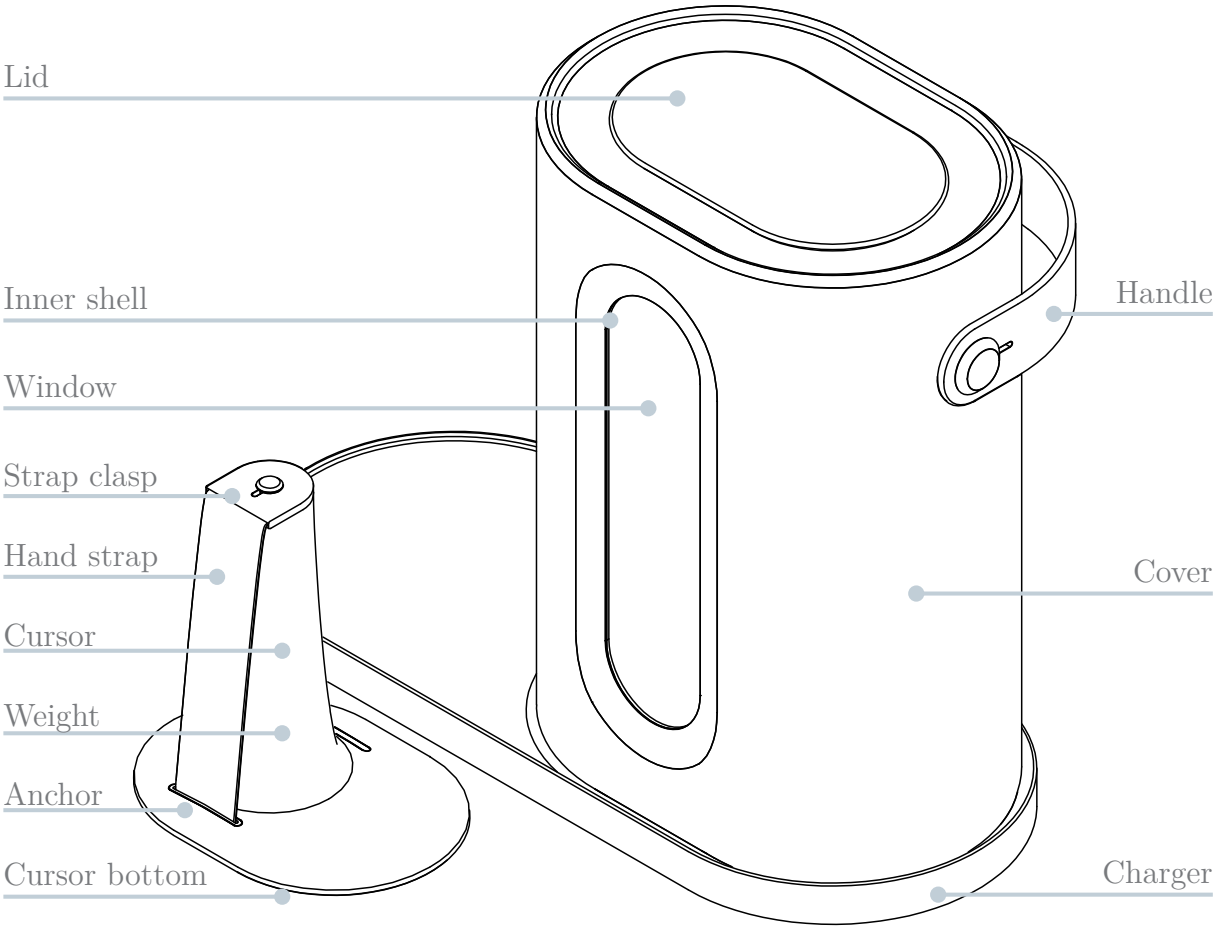


Illu. 164

Control unit with memory		Battery of 6235 mAh	
Bluetooth module		230V to 19V 6,4 A transformer	
19V to 5V 3A fransformer		A 4 ohm speaker	

PRODUCTION & MATERIALS

In this section, materials and production methods for the product's geometry, aesthetic and sensoric requirements are explored, to find the best suited way to produce the product. The choices are made with daily life in a home in mind. It is a product that should last for many years and survive small accidents common with everyday use.



Illu. 165

Construction

The body of the product has been sectioned into a sleeve and an inner shell to accommodate a soft touch surface and shock absorbent construction while still having a sturdy inner shell for mounting.

The construction of the inner shell has been parted in two, to accommodate a simpler mold (two parts instead of three) and to enable inner geometry for mounting electronics, and opening the projector for repairs.

The top lid has also been parted in two, to avoid complex undercuts and enable a simple two-piece mold.

Requiremnts

The following requirements have been taken into consideration for material selection:

Hard requirements

- Shock resistant/absorbing (projector)
- Scratch resistant
- Grip should have high friction surface
- Cursor should have low friction bottom
- Withstand cleaning with damp cloth, soap and sanitizer

Soft requirements (aesthetic/sensoric)

- Sturdy appearance

Injection molded ABS

Lid, inner shell, charger and cursor

The main part of the product consists of injection molded ABS. With injection molding, it is possible to make very detailed and complex geometry. It has a quick cycle time, making the cost per unit very low. Mold costs is however quite expensive for this type of molding.

The parts have many different geometries, but the same surface aesthetic and form stability requriements. Using the same material for all the parts makes it possible to produce them all in a single multi-cavity mold, thereby saving money in production time and mold costs.

The parts that dictates the choice of plastic is the Inner shells, which has the highest requirements to strength as they must hold and protect the inner components. ABS has a high impact resistance [Thompson, 2007] and scratch resistance, [plast.dk, 2020] and is generally cheaper than other alternatives like PC [Thompson, 2007]. ABS furthermore has the required chemical resistance to most alcohols [Kelco, 2008].

Compression molded natural rubber

Cover, strap anchor and clasp

To protect the product, the outer cover is made of rubber, which can absorb shock if the product is knocked over. Natural rubber is cheaper than silicone rubber, and has higher tensile strength and resistance to tearing than synthetic rubbers [coi rubber, 2016] . Natural rubber/Latex is also chemichally resistant to most alchohols. [Assurance, 2020]

The rubber is formed using compression molding, which is has moderate tooling costs, and low unit pricing [Thompson, 2007] and pulled over the inner shells, hiding anny lines or molding imperfections of the inner shells. The anchor and clasp for the elastic will also be made of rubber to relate aesthetically to the projector handle and will need to be cast as well.

Soft touch coating

Cursor

To give the cursor a slip resistant surface with a soft touch, that relates more to the rubber sleeve, it will be given a “soft touch” coating, which is sprayed on. The coating has a good chemical resistance and will withstand greasy fingers and sanitizing. [Material District, 2012].

Pre-made woven elastic band

Hand strap

The elastic band is made from woven elastic fabric, to provide a soft surface against the skin which cannot be obtained with a pure silicone/rubber elastic. It is cut from premade lengths and glued to the Rubber anchor and clasp.

Cut steel rod

Cursor weight

To achieve a cursor weight of 400g, a steel rod is added. The rod is produced by cutting a piece of premade extruded steel rod to size and sanding the edges. The calculations for requried size can be seen in worksheet 4.11.

Die cut felt

Cursor bottom

To make the cursor slide effortlessly over any surface, a felt layer is fitted to the bottom of the cursor. The felt is cut from a sheet, using die cutting. [Thompson, 2007].

Laser cut acrylic

Window

Acrylic is selected for the window as it is both clearer and cheaper than glass, making it the best choice for the job [JD, 2018]. It can be cut from sheet using laser cutting, with no tooling cost and only moderate unit costs. In the end the window will be glued to the inner shell.

Die cut natural rubber

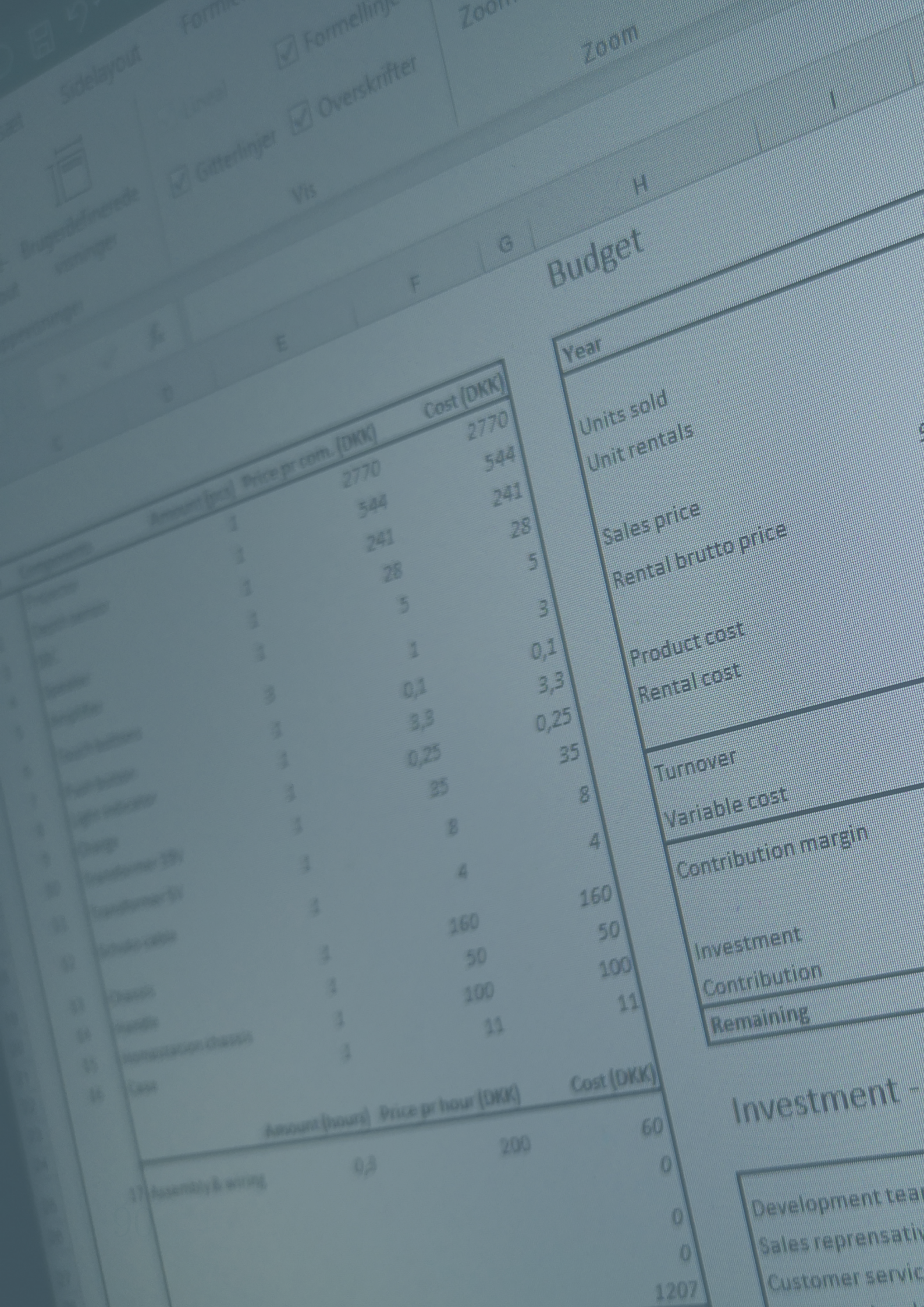
Handle

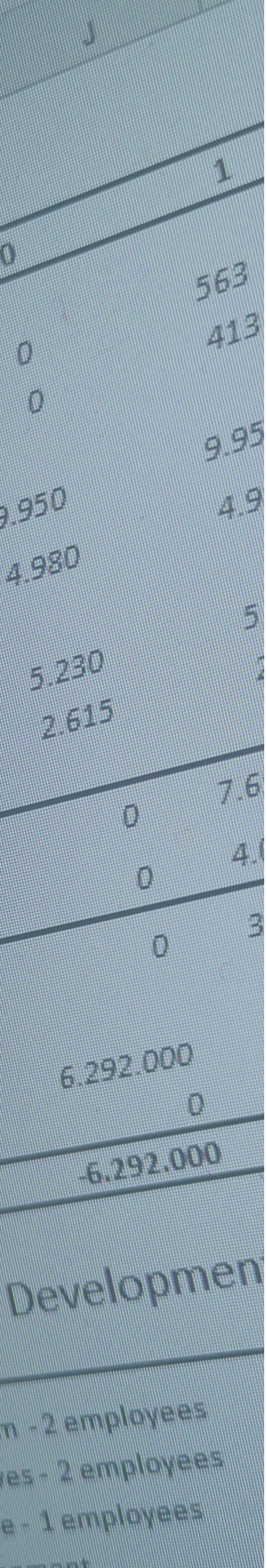
The handle needs to be tear resistant and slightly elastic to give a nice and soft handle. Again, natural rubber is a good choice. The geometry of the projector handle is simple and can be cut from sheet using die cutting.

PRODUCT SPECIFICATION

#	PRODUCT SPECIFICATION	MIN	MAX	TARGET	UNIT	PAGE	NEED #
PROJECTOR							
4.1	Brightness	200	-	450	lumen	76	2.12 2.15
4.2	Contrast ratio	1000:1	-	100.000:1	Ratio	76	2.12 2.15
4.3	Resolution	800*600	-	1280*720	Ratio	76	2.12 2.15
4.4	Throw ratio	-	0,29:1	0,29:1	Ratio	76	2.12 2.15
DEPTH CAMERA							
4.5	Should register an area of 60*100 cm 30 cm away			Yes	Binary	77	2.15 2.17
CURSOR							
4.6	Top grip diameter	25	30	25	mm	78	2.19
4.7	Bottom grip diameter	35	45	45	mm	78	2.19
4.8	Base diameter	85	100	90	mm	78	2.19
4.9	Lenght from grip center to wrist edge	70	85	75	mm	79	2.19
4.10	Weigth	350	400	400	g	79	2.19
4.11	Grip height	110	120	110	mm	79, 87	2.19
MATERIALS							
4.12	Outer materials should be scratch resistant			Yes	Binary	80 86 87	2.22

#	PRODUCT SPECIFICATION	MIN	MAX	TARGET	UNIT	PAGE	NEED #
4.13	Sleeve material should be shock absorbent			Yes	Binary	80 87	2.25
4.14	Case material should be shock resistant.			Yes	Binary	80 86	2.25
4.15	Grip material should be high friction			Yes	Binary	79 87	2.19
4.16	Cursor bottom material should be low friction			Yes	Binary	87	P. 65
4.17	All materials should be alchohol resistant			Yes	Binary	86 87	2.18
COMPONENTS							
4.18	Battery capacity	6235	-	6235	mAh	83 85	
4.19	Outer transformer - 230V to 19V 6,4 A			Yes	Binary	85	
4.20	Inner transformer - 19V to 5V 3A			Yes	Binary	85	
4.21	Speaker impendance	4	-	4	ohm	85	p. 66
4.22	Bluetooth module			Yes	Binary	85	2.16
4.23	Control unit with memory			Yes	Binary	85	2.1-11 2.16
4.24	Wireless charging			Yes	Binary	83 85	2.13
4.25	Handle			Yes	Binary	82	2.13
4.26	Cursor hand strap			Yes	Binary	83	2.19
4.27	RGB LED light strip			Yes	Binary	81 85	2.26


Budget
Year
Units sold
Unit rentals
Sales price
Rental brutto price
Product cost
Rental cost
Turnover
Variable cost
Contribution margin
Investment
Contribution
Remaining
Investment
Development tea
Sales reprensati
Customer servic
Amount (hour)
Price pr hour (DKK)
Cost (DKK)
Assembly & wiring
0,5
200
60
0
0
0
1207
Amount (pcs)
Price pr com. (DKK)
Cost (DKK)
2770
544
241
28
5
3
1
0,1
3,3
0,25
35
8
4
160
50
100
11



EPILOGUE

The next phase will explore the market approach and economical feasibility of the product. The phase will also define the last product specification and make a conclusion and reflection of the process.

KEY ACTIVITIES

DEVELOPMENT

Budgetting
Business model
Service blueprint
Reflection
Conclusion

Illu. 166

BUSINESS MODEL

Customer segment

The primary customers of the poduct is stroke rehabilitation clinics and stroke patients.

REA will, however, be marketed towards rehabilitation and training of any decrease in arm function broadening the market further.

Additional customers could be therapists who want to include the product in their practice.

Customer relations

Sales representatives
Before the purchase, potential customers can contact and meet sales representatives who will answer questions concerning the product and service.

Customer service
Customers will be able to contact the ReSync with any concerns or questions concerning their REA product.

Value propositions

"Optimal use of training session"
Targeted rehabilitation clinics. By enabling the user to perform arm exercises alone, the therapists at the clinics does not need to guide the user through each training throughout the day, leaving room for other tasks. Additionally, the progress data can be used to adapt the training session.

"Reach your maximum potential"
Targeted patients with decreased function in the arm. By enabling them to train their arm daily, the user is empowered to reach their full potential, which is the goal for them in their rehabilitation.

Key resources and partners

Projector manufacturer
To create a designated projector for the product.

Rehabilitation specialists
To ensure the best output of REA and validate the effectiveness of the exercises and interface.

Software development team
To develop the interface.

Financial
ReSync need external funding to start the further development and production of REA.

Key activities

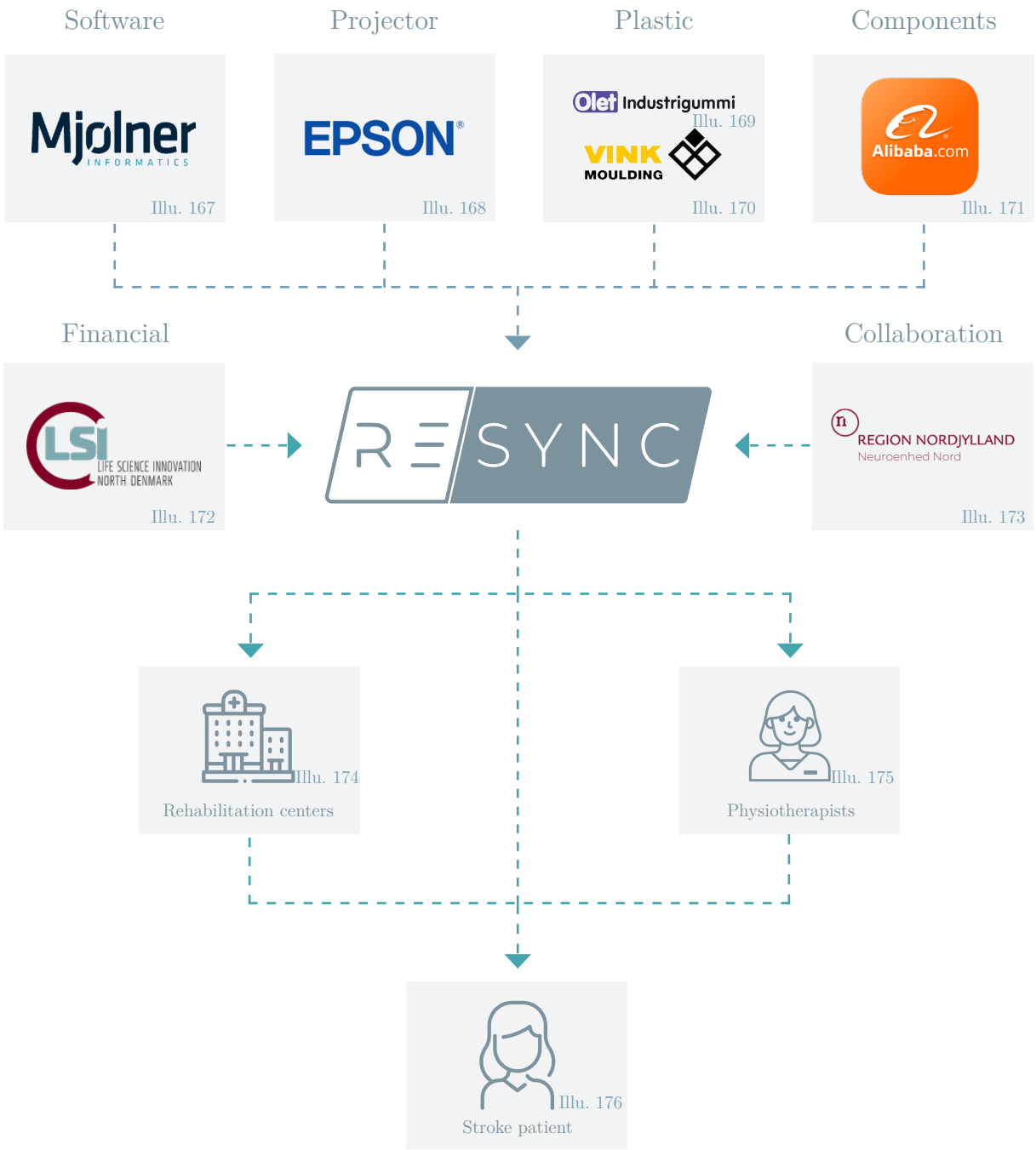
Product development
The most essential activity of ReSync is the continuous development of products, both in improving REA and expanding the product line.

Sales & rentals
Facilitating the sales and rentals by establishing and maintaining a solid customer base through sales representatives and marketing.

Support
Maintaining a support team for inquiries after purchase and during rental.

Business model

The model below shows the manufacturers and collaborations in the development of REA and the how the product reaches the stroke patients.



Illu. 177

Revenue stream & channels

Sale to rehabilitation centers

The product is sold both directly to private rehabilitation centers and through the municipality to public rehabilitation centers for 9.950 DKK for a single unit.

The market share focus will from the start include european rehabilitation centers and patients.

The contact will be facilitated by sales representatives within ReSync. To facilitate contact, ReSync need to ensure a presence on the market through articles, development collaboration with therapists and funding from innovation funds. A service blueprint of this can be seen in worksheet 5.2.

Rental to patients.

The patients can rent REA through ReSync for 690 DKK on a monthly basis. After ended treatment, the user can choose to buy the product, but this is not the targeted sales approach.

Collaboration with physio- and occupational therapists in the larger cities should be consolidated through the same tactics as the sales to rehabilitation clinics.

These will recommend the product to the patients and help facilitate the contact between ReSync and the patient, receiving a complementary kit and a commission for each completed rental.

PRODUCT SALES PRICE		
Product cost		5.233 DKK
ReSync Contribution	90%	4.717 DKK
Sales price		9.950 DKK

Illu. 178

PRODUCT RENTAL PRICE		
Product cost		5.233 DKK
Life expectancy		24 months
Monthly depreciation		218 DKK
Resync Contribution	90%	197 DKK
Brutto rental price		415 DKK
Therapist contribution	25%	460 DKK
Administrative		175 DKK
Tax	25%	470 DKK
Rental price		690 DKK

Illu. 179

Cost structure

The first year the investment will be spent on development of the product with the investments in subsequent years being mainly operational until a profit is reached and the development of new products continue.

Funding

To start development of REA, ReSync need a funding of 6.900.000 DKK from external sources. A founding of this size could be obtained from healthcare oriented finds lige Life Science Innovation North or from an investor.

Feasibility

Before developing REA further and introducing it to the market, it is important to know whether it is feasible or not in terms of economical profit and return. Therefore, a break-even forecast has been estimated based on the sales an rental price.

The second year, ReSync will sell to european private rehabilitation centers, danish public rehabilitation centers and physiotherapist clinics and additionally rent the product to users. Starting with a relative low market share that will increase the next five years, as seen on the table below.

Year	1	5
Danish public rehab. centers	5%	25%
European private rehab. centers	1%	5%
Physiotherapist clinics	0,1%	1,6%
Rentals for patients	0,2%	3,2%

Illu. 180

As shown in the tables below, the break even occurs within the first three years of sales, creating the opportunity for further product development next year and to pay back potential investors same year. Thereby, making the project feasible.

The calculations is rough estimations made in collaboration with the collaborating therapist. More detailed budget and calculations behind can be seen in worksheet 5.1 .

BUDGET	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
Units sold	0	563	1.126	2.177	4.207	8.196
Units rentals	0	413	825	1.650	3.300	6.600
Sales price DKK	9.950	9.950	9.950	9.950	9.950	9.950
Unit rental price DKK	4.980	4.980	4.980	4.980	4.980	4.980
Product cost DKK	5.230	5.230	5.230	5.230	5.230	5.230
Yearly depreciation DKK	2.615	2.615	2.615	2.615	2.615	2.615
Variable profit DKK	0	7.658.590	15.312.200	29.878.150	58.293.650	114.418.200
Variable cost DKK	0	4.024.485	8.046.355	15.700.460	30.632.110	60.124.080
Contribution DKK	0	3.634.105	7.265.845	14.177.690	27.661.540	54.294.120
Investment DKK	6.292.000	4.249.000	4.249.000	4.249.000	6.824.000	6.824.000
Balance DKK	-6.292.000	-6.906.895	-3.890.050	6.038.640	26.876.180	74.346.300

Illu. 181

CONCLUSION

This master thesis project has centered around stroke patients and their rehabilitation process. The ambition of the master thesis was to create a product, which motivates stroke patients to perform daily exercises targeted the arm.

This ambition emerged as a result of an analysis of the recommended rehabilitation approach, the current rehabilitation process within the municipalities and a discussion of the dilemmas the collaborating physiotherapist and users experience through the rehabilitation process.

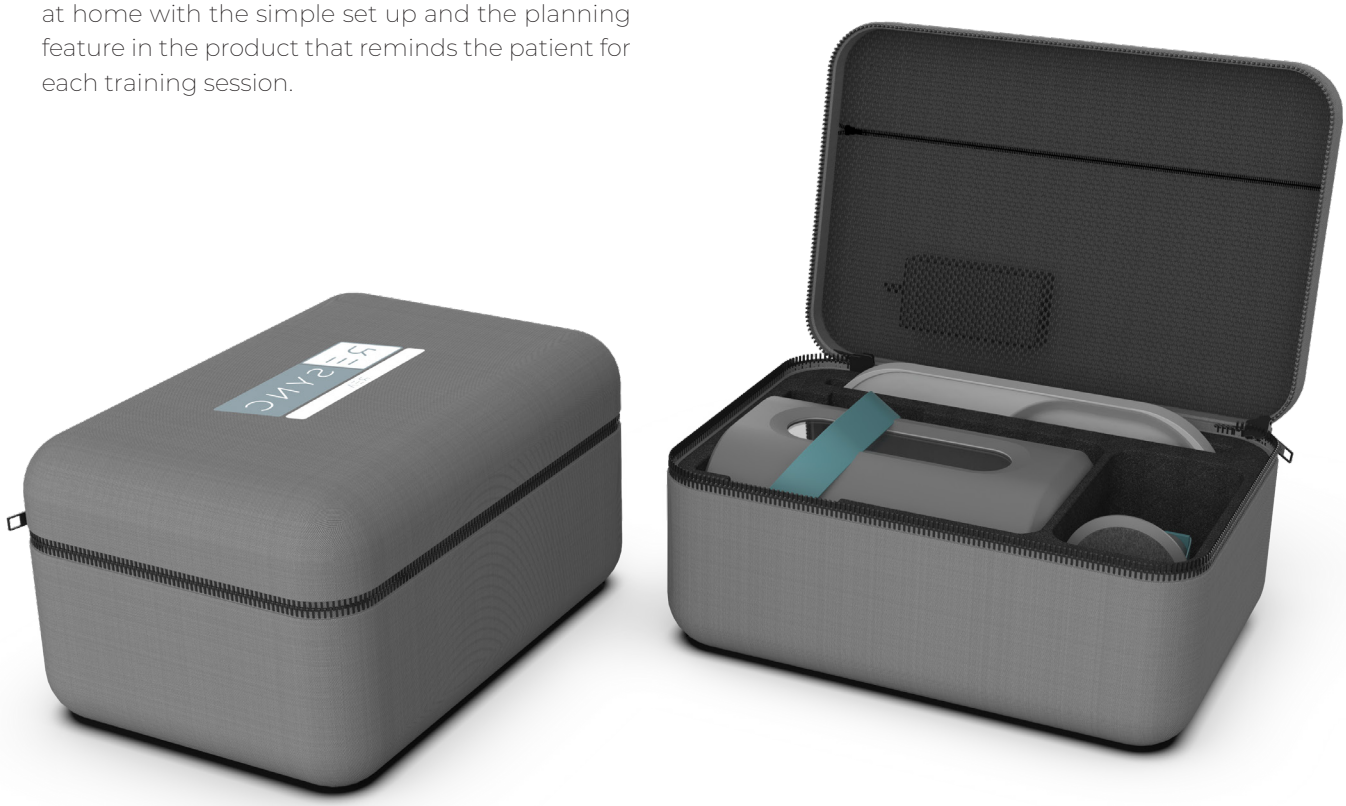
Through the project, a close collaboration with therapists and involvement of users has led to REA by ReSync. REA motivates the patients by showing the physical and game progress and guiding the user through arm exercises with the use of an interface with gamification elements.

REA ensures that the workout can be performed daily by enabling the patients to use the product at home with the simple set up and the planning feature in the product that reminds the patient for each training session.

REA fits perfectly in everyday life as it can be adjusted specifically to the individuals everyday life and capabilities, which will give the best possible training output.

REA by ReSync is a system design, that enables expansion of the product to accommodate more than just gross motoric skills of the arm. Through simple changes in the interface and development of alternative cursors, REA can expand to a large range of exercises from fine motoric movements of the hands to strength exercises of the arm.

Thereby, creating a product with continuous opportunity for development, not only for the patients , but also for ReSync, to ensure a stable economical increase in any foreseeable future.



Illu. 182

REFLECTION

Process

Corona

One of the biggest challenges we faced in the process was the implications of the corona virus, which shut down Denmark including the university throughout the project period.

Collaboration with users and rehabilitation centers established before corona, was terminated due to health risks and limited time available at the centers as result of corona. This created a barrier, hindering us from contacting users in the early stages living at the centers. This led to an unintended, but necessary, focus on the later stages, establishing contact to these users through online media.

As the main communication with the users could only occur online, experts like therapists became one of the main sources of feedback and information. This prompted a strong collaboration with the physiotherapist from Neuro Rehab, ensuring a well-argued product, but also a more one-sided focus of a two-sided situation. In the future development, the process should embrace the users in a broader scale, as Denmark is starting to open up again.

In addition to the affect on the user contact, the shut down affected the creative process and development. With no access to the university, the creative unfolding of the product was compromised without the opportunity to create prototypes at the facilities nor discuss and explore the framings and solutions with co students and in milestones.

Development duality

The development of the product was divided into two different phases; the digital interface and the physical platform. This duality elongated the product development as the interface and platform were looked into as two separate parts and not integrated. This created confusion on what the focus throughout the process should be, leaving some areas of the product explored deeply while others are processed superficial. As motivation was an essential part of the product, the interface had a larger focus, leaving less focus on the physical platform.

Product

Projector black boxing

As of now, the projector, which together with the depth camera is the essential component of the product, is black boxed. A suitable projector was found, which could be used to create an estimation of the size and prize, but in the further development a projector should be created specifically for the product, which might lead to changes in the prize and the sizing or design.

The prize changes would most likely lead to a decrease due to the age of the projector in the estimation and the decrease of components used. The changes in size or design will likely not affect the functionality of the product in a significant degree as the main functionalities lies in the interface itself.

Healthcare development

Even though the process has been influenced greatly by healthcare professionals, there has been limitations founded in the lack of experience within healthcare.

A basic knowledge of terms and an initial understanding the dilemmas in relation to stroke patients combined with personal experience, laid a foundation for the development of the product.

Yet, a lack of deeper undstanding of the medical side of the user group, created limitiations and pushed the team to base choices on simplified assumptions like the physical and cognitive charts. In the further development, there should be a close collaboration with health care professionals to ensure a validated output of the exercises, which is lacking at the current time.

BIBLIOGRAPHY

Ackerman, P. M. et al. (2009) 'Activities of Daily Living', in Spinal Cord Injuries: Management and Rehabilitation. Elsevier Inc., pp. 210–236. doi: 10.1016/B978-032300699-6.10009-7.

Adafruit (2020) Mono Enclosed Speaker - 3W 4 Ohm. Available at: https://www.adafruit.com/product/3351 (Accessed: 17 May 2020).

Alibaba (2020a) Single Channel Audio Amplifier 2.5 W Class D. Available at: https://www.alibaba.com/product-detail/PAM8302-single-channel-audio-amplifier-2_62576297445.html?spm=a2700.7724857.normalList.14.7abb1214wg4Zm1&bypass=true (Accessed: 17 May 2020)

Alibaba (2020b) 5mm Rgbw Led Strip. Available at: https://www.alibaba.com/product-detail/Dream-Colour-5mm-sk6812-rgbw-led_62012463060.html?spm=a2700.gallery_search_cps.normalList.5.f8c35fc3eSzx72&bypass=true (Accessed: 1 June 2020).

Alibaba (2020c) Ttp223b Module Capacitive Touch Switch. Available at: https://www.alibaba.com/product-detail/Digital-Sensor-TTP223B-TTP223-Module-Capacitive_60721930970.html?spm=a2700.7724857.normalList.52.553afe819JiUOf&bypass=true (Accessed: 17 May 2020).

Alibaba (2020d) Tactile Switch Push Button. Available at: https://www.alibaba.com/product-detail/_60742841652.html?spm=a2700.details.pronpeci14.3.1d9ajWlbjWlb7W&bypass=true (Accessed: 17 May 2020).

Alibaba (2020e) Oem Charger 120w 19v 6.32a Ac Adapter. Available at: https://www.alibaba.com/product-detail/OEM-Charger-120W-19V-6-32A_62326241334.html?spm=a2700.7724857.normalList.90.73d02ecaytxi6G&bypass=true (Accessed: 17 May 2020).

Alibaba (2020f) Dc-dc 3v-35v To 4v-40v Step Up Power Module. Available at: https://www.alibaba.com/product-detail/Dc-dc-3v-35v-To-4v_62073873890.html?spm=a2700.galleryofferlist.0.0.b2bd7421CKM6Yv&bypass=true (Accessed: 17 May 2020).

Andersen, C. T. et al. (2012) Neurorehabilitering i praksis. 1st edn. Edited by T. T. Møller and L. Petersen. Gads Forlag.

Anthony, S. (2012) Using Kinect to turn any surface into a multi-user, multi-finger touchscreen - ExtremeTech. Available at: https://www.extremetech.com/computing/137630-using-kinect-to-turn-any-surface-into-a-multi-user-multi-finger-touchscreen (Accessed: 6 May 2020).

Assurance (2020) CHEMICAL RESISTANT CHART. Available at: http://webfiles.ehs.ufl.edu/Assurance.pdf (Accessed: 2 June 2020).

Careware (2019) Armeo Therapy Concept. Available at: https://careware.dk/om/tidligere-arrangementer/aal-forum-exhibition/products/armeo-therapy-concept-by-hocoma/ (Accessed: 13 May 2020).

Celluon (2020) Magic Cube – Celluon Inc. Available at: https://celluon.com/magic-cube/ (Accessed: 6 May 2020).

Christensen, J. (2019) Apopleksi (slagtilfælde), Sundhed.dk. Available at: https://www.sundhed.dk/borger/patienthaandbogen/hjerte-og-blodkar/sygdomme/apopleksi/apopleksi-blodprop-eller-bloedning-i-hjernen/ (Accessed: 16 February 2020).

coi rubber (2016) Natural Rubber vs Synthetic Rubber. Available at: https://www.coirubber.com/natural-rubber-vs-synthetic-rubber/ (Accessed: 11 May 2020).

Crow, J. L. and Harmeling-van der Wel, B. C. (2008) 'Hierarchical Properties of the Motor Function Sections of the Fugl-Meyer Assessment Scale for People After Stroke: A Retrospective Study', merican Physical TherapyAssociation. Oxford University Press (OUP), 88(12), pp. 1554–1567. doi: 10.2522/ptj.20070186.

Csikszentmihalyi, M. (1990) (PDF) Flow: The Psychology of Optimal Experience. Available at: https://www.researchgate.net/publication/224927532_Flow_The_Psychology_of_Optimal_Experience (Accessed: 11 March 2020).

Danish care supply (2020) Oppustelig træningshjælpemidler: Oppustelig håndtræner - Dr. Winkler. Available at: https://www.danishcaresupply.dk/dagligstue/øvrig-træning/oppustelig-træningshjælpemidler/håndtræner-dr-winkler-detaljer (Accessed: 11 March 2020).

Egenfeldt-Nielsen, S., Smith, J. H. and Tosca, S. P. (2019) Understanding video games : the essential introduction.

Eponn (2018) 'Correct', Freesound. Available at: https://freesound.org/people/Eponn/sounds/421002/?fbclid=IwAR0kpb3XnN0Zf-lRg5eMeF1udRSE0Od44DwMeEDDtQcB6h-dsD4qWhmTzFI (Accessed: 31 May 2020).

Farnell (2020) RPI4-MODBP-2GB - RASPBERRY-PI - Single Board Computer, Raspberry Pi 4 Model B, BCM2711 SoC. Available at: https://dk.farnell.com/raspberry-pi/rpi4-modbp-2gb/raspberry-pi-4-model-b-2gb/dp/3051886 (Accessed: 17 May 2020).

Flachs, E. M. et al. (2015) Sygdomsbyrden i Danmark - Sygdomme. 2nd edn. København: Sundhedsstyrelsen.

FoolBoyMedia (2016) 'Alert Chime 1', Freesound. Available at: https://freesound.org/people/FoolBoyMedia/sounds/352659/?fbclid=IwAR00WGQmdnzClwN0RJGheL7VIqb3Cqz_pCYCaA79KRnBlNiYWz2_Hkm8Zg4 (Accessed: 31 May 2020).

Forchhammer, H. (2019) Genoptræning gavner. Available at: https://www.hjernesagen.dk/om-hjerneskader/genoptraening/generelt-om-genoptraening (Accessed: 5 March 2020).

Guy, N. (2019) How to Choose Between Wired and Wireless Charging - The New York Times. Available at: https://www.nytimes.com/2019/03/12/smarter-living/wirecutter/how-to-choose-wired-wireless-charging-phone.html (Accessed: 17 May 2020).

Hatem, S. M. et al. (2016) 'Rehabilitation of motor function after stroke: A multiple systematic review focused on techniques to stimulate upper extremity recovery', Frontiers in Human Neuroscience. Frontiers Media S. A, 10(SEP2016). doi: 10.3389/fnhum.2016.00442.

Hjernesagen (2019) Genoptræning efter en hjerneskade. Avail-

able at: https://www.hjernesagen.dk/om-hjerneskader/genoptraening (Accessed: 5 March 2020).

Hocoma (2020) Arm & Hand - Hocoma. Available at: https://www.hocoma.com/solutions/arm-hand/ (Accessed: 13 May 2020).

Hoffman, H. (2018) Stroke Recovery Timeline, Saebo.com. Available at: https://www.saebo.com/blog/timeline-stroke-recovery-2/ (Accessed: 13 May 2020).

Intel (2020) Depth camera SR305 – Intel RealSense Depth and Tracking Cameras. Available at: https://www.intelrealsense.com/depth-camera-sr305/ (Accessed: 6 May 2020).

JD (2018) Differences Between Acrylic and Polycarbonate. Available at: https://www.theplasticpeople.co.uk/blog/the-differences-between-acrylic-and-polycarbonate/ (Accessed: 11 May 2020).

Kelco (2008) CHEMICAL COMPATIBILITY CHART ABS.
LG (2016) LG PH450UG Projector.
Material District (2012) SofTouch paint. Available at: https://materialdistrict.com/material/softouch-paint/ (Accessed: 11 May 2020).

Mayo, N. E. et al. (2002) 'Activity, participation, and quality of life 6 months poststroke', Archives of Physical Medicine and Rehabilitation. Elsevier, 83(8), pp. 1035–1042. doi: 10.1053/apmr.2002.33984.

Mitii (2020) Om Mitii. Available at: https://mitii.com/om-mitii/ (Accessed: 11 March 2020).

Oppland, M. (2019) 8 Ways To Create Flow According to Mihaly Csikszentmihalyi [+TED Talk], PositivePsycology.com. Available at: https://positivepsychology.com/mihaly-csikszentmihalyi-father-of-flow/ (Accessed: 11 March 2020).

PANat (2020) Home - PANat-Laptool. Available at: https://www.panat-laptool.ch/cms/ (Accessed: 11 March 2020).
Pheteplace, D. (2018) Pogo Pins: A 40-Year-Old Technology - Keyssa. Available at: http://www.keyssa.com/pogo-pins-a-40-year-old-technology/ (Accessed: 17 May 2020).

plast.dk (no date) Polycarbonat. Available at: https://plast.dk/det-store-plastleksikon/polycarbonat-pc/ (Accessed: 11 May 2020).
Proshop (2020) LG Projektor MiniBeam PH450UG - 1280 x 720 - | Billig. Available at: https://www.proshop.dk/Projektor/LG-Projektor-MiniBeam-PH450UG-1280-x-720/2576301 (Accessed: 6 May 2020).

Reha-Stim (2020) Arm Training Archives - Reha-Stim. Available at: https://reha-stim.com/product-category/arm-training/?gclid=CjwKCAjwmKLzBRBeEiwACCVihruw0Ihl1I2_PLtWc9rT8sXYg7V85YcTif9xqUKonbljr9RMOemW9hoCzE0QAvD_BwE (Accessed: 11 March 2020).

Rehabilitate | Meaning of Rehabilitate by Lexico (no date). Available at: https://www.lexico.com/definition/rehabilitate (Accessed: 1 June 2020).

RICHERlandTV (2016) 'Pingding', Freesound. Available at: https://freesound.org/people/RICHERlandTV/sounds/351550/?fbclid=IwAR2R0y8xN4moLGl0dFcU8D3ltS8xEaONgfxUkc68D-6VgUYNtvVvLtVNReM (Accessed: 31 May 2020).

Sackley, C. M. (1990) 'The relationships between weight-bearing asymmetry after stroke, motor function and activities of daily living', Physiotherapy Theory and Practice. Informa Healthcare, 6(4), pp. 179–185. doi: 10.3109/09593989009048293.

Schneider, E. J. et al. (2016) 'Increasing the amount of usual rehabilitation improves activity after stroke: a systematic review', Journal of Physiotherapy. Australian Physiotherapy Association, 62(4), pp. 182–187. doi: 10.1016/j.jphys.2016.08.006.

Sporlastic (2020) MOBILAS® II das Handlagerungs- und Mobilisationssystem - Sporlastic. Available at: https://www.sporlastic.de/produkt/artikel/mobilas-ii/ (Accessed: 11 March 2020).

Stroke Association (2018) A complete guide to cognitive problems after stroke.

Sundhedsstyrelsen (2019) Guide til henvisning til vederlagsfri fysioterapi.

The Verge (2020) A closer look at Microsoft's new Kinect sensor - The Verge. Available at: https://www.theverge.com/2019/2/25/18239860/microsoft-kinect-azure-dk-hands-on-mwc-2019 (Accessed: 6 May 2020).

Thompson, R. (2007) Manufacturing Processes for Design Professionals. Thames & Hudson.

VitaMind (2020) VitaMind | Applikator - udvikling og implementering af velfærdsteknologi. Available at: https://applikator.dk/vitamind/ (Accessed: 11 March 2020).

LIST OF ILLUSTRATIONS

Illustrations not mentioned in the list are created by the team.

NOTES


AD NYE VEJE
AALBORG UNIVERSITET